A MODEL OF CONTINGENCY FACTORS AFFECTING CONTRACTORS' ECONOMIC ORGANISATION OF PROJECTS

ANDREW DAVID ROSS

Research Institute for the Built and Human Environment,
School of Construction and Property
University of Salford, Salford, UK

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DECLARATION

This is to certify that;

1. This thesis embodies the author's research
2. The originality (and contribution to knowledge) rests solely with the author.

Signature of candidate:.....

Date:11 May 05.....

ABBREVIATIONS

Abbreviation	Definition
ABC	Abridged Building classification
ANOVA	Analysis of Variance
BCIS	Building Cost Information service
CAWS	Common arrangement of work sections
CIB	International Council for Building Research studies and documentation.
CBC	Construction Building Classification
CCPI	Coordinating committee of project information
CIDB	International council for building documentation
CIOB	Chartered Institute of Building
CMM	Capability Maturity Model
DTI	Department of Trade and Industry
DV	Dependent variable
IBCC	International Building Classification Committee
IT	Information technology
ICT	Information communication technology
ISO	International standards organisation
KPI	Key performance indicator
KMO	Kaiser-Meyer-Olkin
KS	Kolmogorov-Smirnov
KW	Kruskal Walliss test
M & E	Mechanical and Electrical
MC	Main Contractor
OGC	Office of Government and Commerce
S/C	Subcontractor
PCA	Principal component analysis
PFI	Private Finance Initiative
PPP	Public Private Partnership
PRE	Proportional reduction error
PRAM	Project Risk analysis and management

R & C	Roofing and Cladding
RIBA	Royal Institution of British Architects
SPICE	Standardised Process Improvement for Construction Enterprises
SPSS	Statistical package for social sciences
UK	United Kingdom
USA	United States of America

Abstract

A model of contingency factors affecting contractors' economic organisation of projects

The identification of factors that affect the performance of temporary multi disciplinary organisational teams has been a central aim of management research in the construction industry for over 40 years. This study contributes to what is known about the formation of a construction project organisation by identifying the contingent factors that affect contractor's gathering and analysis of price information from supply chain organisations during the ex ante processes to contract formation.

The research methodology adopted a combined approach to data collection and analysis, and used a theoretical framework adapted from transaction economics to identify and explicate a model of contingency factors. The research method for data collection in the dominant quantitative first phase used a postal survey of 760 estimators working for contracting organisations in the United Kingdom in December 2003. The resultant data set was analysed using descriptive statistics. A multi variable general linear model and principal component analysis defined the parameters of a model that informed the second phase of data collection and analysis. This model was explicated using a multiple case study approach that gathered and analysed interview data from estimators working for organisations that had been purposively selected.

The findings of this research identified the contingency factors that affect contractors', seeking, gathering, analysing and synthesising of supply chain price data, that can be grouped into four categories, which are; external environment, project environment, task environment and inter-organisational relations. The research also found that the existence and strength of effect of the contingency factors was differentiated by organisational size, and identified the factors that may be influenced by the intervention of the client procurement system, (or the organisation) in the ex ante process of supply chain organisation team development.

CHAPTER 1: INTRODUCTION

1.1 Introduction

Construction projects are designed and constructed by temporary multi organisational teams (Cherns and Bryant, 1984) that are usually geographically distant and functionally disparate (Eccles, 1981; Murray et al., 1999). The formation and inter-organisational dynamics of these teams has been a field of study for over 20 years since Cherns and Bryants' (1984) call for more empirical research. They posited a series of hypotheses that suggested that the management of a construction project was a function of the temporary multi-organisational team's formation and structure, and that the earliest decisions taken in the context of the clients procurement system have more of an influence over the performance of such a team. The field of study developed to include organisational structures (Shirazi et al., 1996), the influence of project environmental variables (Hughes, 1989), social factors (Jennings and Kenley, 1996) and the role of transaction costs (Winch, 1989). The importance of developing robust theories upon which practice is based is recognised by the United Kingdom (UK) government, which has invested considerably in research into the performance of the construction industry. The construction industry of a country is of strategic importance, in that it designs, constructs and maintains its built environment, which is essential for economic and societal stability and growth. It is an industry that is affected by macro-economic, organisational and technological forces that serve to bring about change to its structure, practices and products. The external environment in the UK is a key factor in the contingent organisation of projects (Moore, 2002) and has changed dramatically over the last 20 years particularly with the increase in work outsourced or subcontracted.

It is however, also an industry that is blighted by disputes, poor delivery of its product to time and budget, and has a craft based image. In order to construct projects, organisations need to transform raw materials into products and eventually projects. Along this value chain organisations undertake a range of transactions with other organisations that are informed by the context of their market sector, the product or service they produce or provide, the resources

used, and their procurement processes. This thesis aims to develop a theoretical model to assist in the explanation of influencing factors that affect how construction organisations structure and organise the information arising from these transactions, for the financial management of their projects. The identification of these factors will also facilitate intervention by client procurement systems, to develop more effective temporary multi-organisational teams.

Before discussing the specific theoretical areas that are related to this aim, an introduction to the general field of study is useful in providing a context to the study of construction organisations and their transactions with client and supply organisations. Section 1.2 provides a background to the UK construction industry, the procurement approaches used, the role of information in organisational transactions and the processes adopted for project cost estimation. An outline of the thesis is presented at the end of this chapter.

1.2 The Construction Industry: Context

The construction industry accounted for approximately 8% of the UK's gross domestic product in 2003; new orders placed in the UK were £33.95 billion (DTI, 2004). The industry's clients include the public sector that commissioned approximately 35% of new construction in 2003, and was recorded by the Department of Trade and Industry's annual report in 2003 as placing approximately £1.0bn orders for new housing, £8.0bn in infrastructure, and £2.0bn in other new works. The industrial and commercial private sector clients accounted for approximately £24bn of the industry's turnover. The industrial sector accounted for £7.80bn, and the commercial sector £4.4bn of contractor's turnover in 2003. Infrastructure (£5.0bn), housing (£7.0bn) and other new work account (£19bn), account for the balance of recorded work.

The industry employs approx 1.5 million people, including professionals and operatives (Fellows et al., 2002), of which 632,000 are operatives. The majority are employed by organisations that employ less than 24 people, and firms classifying themselves as specialist trades, employ approximately 60% of the overall workforce and are considered an important sector for improvement

(Holti, 1999). It is mainly a project-based industrial sector with projects designed and constructed to clients bespoke specifications. A differentiating characteristic, when compared with manufacturing industries, is that the finished product is generally assembled on sites that are geographically some distance from both the construction management and supply organisations. It is also an industry that suffers from well-documented variable demand (Hillebrandt et al., 1995), which also gives it a unique nature. It is an industry which has also been called fragmented (Higgin and Jessop, 1965;Egan, 1998;Latham, 1993), not only in terms of the market sectors that have been classified as building, infrastructure, repairs and maintenance, and materials manufacture, but also, in the dispersion of the organisations that carry out the work and the sub-division of their markets. These markets have been identified as being characterised by the size and type of project, the complexity of the work undertaken, and the geographical location of the project (Langford and Male, 2001). There are also entry and exit barriers to these markets that exist in a range of forms, which particularly relate to an organisation's technological capability, including the capital funding that is required to compete. The markets for an organisations product are also differentiated with organisation size, technology and geography, and client demand being identified as influencing factors (Lansley, 1987). The industry's clients use contractual arrangements that are structured to incorporate performance, design and production information in order to procure organisations to provide the necessary resources to meet their requirements. This area of investigation has been termed construction procurement (Masterman, 1992) and has been considered as a central means of affecting improvement in the industry. It has been a focus of study by an International council for building research studies and documentation (CIB) working commission, W92 since 1989.

1.3 Procurement Approaches: Clients, Contractors and Supply Chains.

Procurement can be defined as an amalgam of activities undertaken by a client in order to obtain a new building (Rowlinson et al., 2000). This includes processes that seek to place risks and obligations on the various parties to the project. There is currently little agreement upon terminology, and the development of procurement taxonomy has been proposed in order to provide

a better foundation for research (Rahman and Kumaraswamy, 2001). Generally, procurement approaches have been categorised by Masterman (1992) as being separate/cooperative, which includes the so called "traditional" approach that uses open tendering with a bill of quantities, integrated management (Design and Build), and "management oriented" such as management contracting. There have been significant changes in the popularity of these approaches over recent years. The drivers for these changes are varied and have been identified as: the risk aversion of clients; the need for compliance with public sector initiatives identified as Egan compliance; improvement of information flow; integration of the design and construction activities (Rowlinson and McDermott, 1999; Tookey et al., 2002; Walker and Hampson, 2003). One significant recent development that has been used to improve the effectiveness of organisations working together, and to facilitate more trusting relationships has been partnering.

Construction partnering has become an increasingly popular form of business relationship in construction since its first formal introduction after the publication of the Egan report. The Egan report (Egan, 1998) and Sir Michael Latham's reports (Latham, 1993,1994) provided an impetus for organisations to improve their relationships with one another however, it has been recognised that many organisations were partnering by another name prior to its introduction into the construction lexicon (Jaggar et al, 2002).

Protagonists of the partnering approach such as Hellard (1995) have identified many benefits from clients and contractors working together, most of which have been quantified through key performance indicators (KPI). These relate to a reduction of the need for design changes; reduction in disputes; integration of the supply chain; replication of good practice from earlier projects; encouragement of the contractor in contributing to efficient and effective designs and the improvement of the projects performance over its lifetime. An essential component for the development of performance indicators is reliable information to assess variance from recognised norms. The current KPI's used by the industry are at a high level of abstraction due to the difficulties in collecting meaningful data consequently their usefulness has been questioned (Ross and Jaggar, 2005). In order to develop indicators that are grounded in

data it has been suggested that a more integrated and shared information system that provides greater transparency and specificity for the various parties involved should be developed (Jaggar et al, 2002).

One of the central challenges to the development of such an information system is the number and diversity of organisations involved in a construction project. The importance of subcontractors to the construction industry was recognised by the CIOB in 1989 when they commissioned research by Gray and Flanagan (1989) who suggested that; *"The performance of the subcontractor is now critical to project success...."*. The reasons for the rise in subcontracting in the UK that are cited are that it is a means by which contractors can manage a volatile workload, the evolvement of contractors into market traders, the increased technical specialisation of the construction process and the reduction in the ability of professional firm to complete designs (Nobbs, 1993).

The importance of the subcontract sector was also highlighted by strategic industry reports prepared by Sir Michael Latham (1994) who recommended *"arrangements (between main contractors and subcontractors) should be the principal objective of improving performance and reducing costs for clients."* The need for improvement in the industry's involvement with this sector was also highlighted by Sir John Egan's report that suggested that partnering throughout the supply chain was critical to the industry and would result in innovation and sustained incremental increases in performance. The approach that contractors took to the development of their project teams based on subcontractors was highlighted by a number of researchers (Abdel-Razek and McCaffer, 1987; Nobbs, 1993) who suggested that main contractors had become mainly management contractors providing only management resources and that their principal activity was one of coordination of subcontract organisations. The consequent increased dependency on subcontractors has lead to increased complexity of construction processes; inter organisational relationships and multiple systems for economic governance.

The normative development guides for the evolution of partnership arrangements are reported by Humphreys et al (2003) and include the internal alignment, identification of potential partners, screen and selection of the partners, the establishment of relationships and the evaluation of these relationships. It has been recognised that the measurement of the effectiveness of governance systems used by purchasing organisations is problematic and required more empirical work (Kadefors, 2003; Kale and Arditi, 2001). Cox and Thompson (1997) identify that there is no optimum buyer-supplier relationship and suggest that a contingent approach is used by contractors. However there have been a number of studies that have identified that economic benefits of partnering the supply chain have accrued to the buying organisation. Humphreys et al (2003) in their research with a major contractor identified that semi project partnering was in place, which utilised a "limited form of competitive tendering", the results, which were not validated by any form of triangulation, suggested that greater discounts were being offered by the subcontractors for future work.

Many academic researchers have identified that there is a lack of theoretical and empirical research (Anumba, 2000; Bresnen and Marshall, 2000; Cox, 2004; Cox and Thompson, 1997; Cox and Thompson, 1998; Cox and Townsend, 1998; Dainty et al, 2001; Greenwood, 2001; London and Kenley 2001) within the construction community that considers the structural, economic and organisational nature of the industry's supply chains and have identified that there is a need to develop a better appreciation of the role of subcontractors in supply chains in construction. Anumba (2002) identified that there is a growing need to integrate all members of the supply chain in order to unlock the innovation that is presently kept isolated by current procurement and management practices. There has also been little research that has investigated the communication between supply chain organisations, which has sought to develop a theoretical basis for better economic relations between these organisations. This thesis explores the applicability of transaction economics as a theoretical framework for this study in chapter three.

A fundamental problem remains at the core of the procurement process, which is the specificity of information. The traditional view incorporated into most

contractual arrangements is that construction project information generated to support the administration and coordination of construction activity reflects the product of the activity rather than the process itself. This weakness was highlighted by Brandon (2002) who identified that procurement systems should move to a better reflection of the risks inherent within the construction process and seek to communicate these in a more appropriate manner to the recipient of the information. The information used by current procurement delivery systems is not capable of transition from one manifestation to another and therefore specific information needs, at a specific point in time, for specific purposes, by a specified party remain unachieved (Jaggar et al., 2002). Over many decades there have been numerous reports and recommendations for changes to the way information is used to communicate within construction (Banwell, 1964; British Property Federation 1983; CCPI, 1987; Council for Building Research, 1986; Egan, 1998,2002; Emerson, 1962; Forbes and Skoyles, 1963; Higgin and Jessop, 1965; HM Treasury, 2000; Latham, 1994; RIBA, 1997; Simon, 1944; Tavistock Institute, 1966). They all acknowledged that opacity exists between parties and that improvement to establish more effective communications and greater transparency, between the various parties should be established. It has also been suggested that to underpin successful partnering that there is a need to improve communication and information flow (Rowlinson et al., 2000). The procurement information infrastructure has been the focus of research that has sought to apply a manufacturing approach to the improvement of processes during the early stage of construction projects and protocols have been developed by Aouad (Aouad and al., 1999) and published as generic guides for the standardisation of good practice (Kagioglou et al., 1998). The first stage of the generation of project information is the design stage and recent work by Fortune (Fortune, 1999; Fortune and Lees, 1996; Fortune and Lees, 1998) has looked to explain and predict how cost models and early cost advice is generated.

This study takes a perspective that considers the recipient of information, the contractor, it does this in recognition that the recent changes in construction procurement have placed the contractor in a central role to design cost management and supply chain coordination (Ross and Fortune, 1998). One of the main factors limiting the development of cost modelling research is the

availability of resource information in an appropriate level of detail to support analysis. As a consequence it has been argued that cost modelling has not taken the paradigmatic shift suggested by Brandon (1996). Brandon (2002) also argued that until procurement delivery systems develop to allow organisations to exchange resource cost data that the current practice will be limited to the modelling of price data and that the potential for the employment of sophisticated methods of analysis such as data mining and expert systems will remain an aspiration for researchers. The processes closest to the resource modelling fall under the generic term of estimating.

1.4 Estimating

It is beyond the scope of this thesis to present a history of the development of the practice of construction estimating however crudely stated organisations have developed a specialist role of an estimator to provide clients with prices for their projects. The role requires a good knowledge of technologies, supply chain markets and an understanding of how procurement approaches allocate risks to the various contracted parties. A key aspect of the estimator's role is the identification and response to price risks that their organisation may be exposed to (Abdel-Razek, 1987). They procure prices from the organisations supply chain and synthesise these prices with the management or transaction costs into an estimate, which is then transmitted to another party.

The use of communication metaphors to investigate the transmission of price information was considered by Bowen and Edwards (1996) who suggested that the estimate was rich in symbolism over and above the financial information contained in the message and that the sender had preconceived notions of the symbolic criteria to be used by the receiver. Their research based upon interview surveys of quantity surveyors, clients and architects was limited to cost planning in a client domain. The communication research in the contracting domain has been limited and reported by Emmitt and Gorse (2003) as to mainly focus upon the client/contractor interface. The form, use and content of an estimate in a contracting organization however is different from that of an estimate going to a client. However the communication metaphor of the estimate as a message being transmitted to a group who will then make an economic decision is a useful one and is central to the Institutional economics

approach of transaction economics. Ross and Fortune (1998) found in a Royal Institution of Chartered Surveyors (RICS) funded research project, that after surveying 100 of the leading design and build organisations, that the estimator was central to the development of a financial response to a client and that very little cost planning was undertaken however the study did not consider the reasons for the lack of design cost management during the estimate development.

The construction estimate is used as the basis for a tender. The Code of estimating practice (1997) suggests that tendering is " *a separate and subsequent commercial function based upon the net cost estimate*". This function sometimes called adjudication can involve two processes; the first, identified as the review requires the estimator to substantiate the estimate, the second is market driven and adjusts the estimate for general overheads and profit. This second process, the conversion of an estimate into a tender has been found to be very subjective and involves qualitative information that is often vague, difficult to structure and quantify and is based on past experience (Tah et al., 1994). Statistical and probabilistic methods to enhance the tendering process were considered (Tah et al., 1994) to be "*too difficult, time consuming and expensive to implement*". Their study was limited to a small sample of organisations and they recognised that the difficulties of gathering good quality research data were due to the confidential nature of the process and the commercial sensitivity of decisions taken.

The format, quantity and quality of project information upon which the estimate is based reflect the procurement route adopted by the client. Although the estimate can be considered as a price, it has an explicit and implicit structure that influences how a contractor organises the project. It contains assumptions regarding resource productivity, programme requirements, subcontract price risk and ex post financial governance approaches. It also has an information structure that is not homogeneous. It has been recognised that if the industry can develop a common project information system that captures and structures information in a manner that allows for future retrieval, it will make greater use of the developments in information technology. The format of communications between the construction organisation and client have been investigated and a

number of theoretical models and protocols proposed that would support strategic industry learning and potentially inter organisational learning through the effective communication of information (Bindslev, 1995a; CCPI, 1987b; CCPI, 1987a; CCPI, 1987c; CIB W58, 1973; Ray-Jones and Clegg, 1976; RIBA, 1997). The essential difference between the theoretical models and the practical protocol used is that the former aim to capture information on the construction process whilst the latter is based upon construction product information. There has been however little uptake of the theoretical models for project information structuring and there continues to be an urgent need to understand the factors that influence the communication protocols adopted by the industry.

This thesis considers the domain of contractors as organisations that collect and analyse resource cost data. The approach taken reflects the recent changes in the structure of the UK construction industry and considers their use of supply chain organisations in providing data during the ex ante processes of project estimate development.

There has been little empirical work uncovered during this study that has considering the ex ante processes used by contracting organisations to collect information from their supply chain or to the use to which it is put during the estimating stage. The tendering environment is difficult to research due to commercial sensitivity and limited access to stored information. However an organisation's approach to its supply chain and how procurement and supply chain technology influences communicative behaviour should assist with a theoretical understanding of the contingency factors that affect contractors project organisational structures. This understanding may help also appreciate the antecedent processes towards the formation of temporary multi disciplinary teams. The theoretical area of institutional economics provides a theoretical underpinning to organisational economic behaviour and includes transaction economics. This requires explication in order to elaborate the theoretical framework for this study. The key conceptual difference when considering an organisation using a transactional framework is to consider it not in neoclassical terms as a unit of production but in organisational terms as a series of governance structures. This is considered as being appropriate given

the increasing dependence on subcontractors and will be developed in chapter three. An investigation into the ex ante processes used by construction organisations will help consequently develop a better understanding of the governance structures that are used and the types of relationships that exist between organisations.

1.5 Transactional Frameworks

It has been strongly suggested that despite many efforts to develop a better understanding of procurement systems, that they lack an economic foundation (Ambrose, 2000; Chang and Ive, 2002; Cox and Townsend, 1998) and that a transaction economic approach may assist in the understanding of the causal relationships that exist between contracting parties (Turner and Simister, 2001; Winch, 2001). The area of transaction cost economics arose from early foundations of work by Ronald Coase (Coase, 1937) concerning how resource allocation took place in market economies and which suggested that it was not only based on market prices but also through entrepreneurial decision making unrelated to prices. Coase's work suggested reasons for why the firm existed, which were that in certain circumstances, it was a more efficient means of resource allocation than the market place. Coase used the term marketing costs (the cost of using the price mechanism) to mean the costs of discovering the relative prices of suppliers and agreeing separate contracts with each supplier. It was suggested by Dietrich (Dietrich, 1994) that the costs of contracting could be reduced if a factor of production (a contractor) did not have to place a series of contracts each time with other factors of production but in fact replaced them with one long term contract with agreed limits. This reduction in the use of the spot markets reduced the cost of contracting and increased the efficiency of the firm.

The field of study of institutional economics was developed to include Coase's searching and contracting costs but also built on the work of Simon (1957) to explain costs in terms of human and environmental factors. These were identified as bounded rationality (limits to the acquisition and processing of information), opportunism (self-interest seeking with guile) and asset specificity (the investment on specific assets by agents that lock them in to agreements). Oliver Williamson (1981) developed the work of Coase and introduced a new

term to replace marketing costs and defined it as transaction costs. *A transaction occurs whenever " a good or service is transferred across a technologically separate interface*" (Williamson, 1981, p552) and he suggested, " *institutions have the main purpose and effect of economising on transaction costs*". Williamson also asserted that the hierarchy (firm) could reduce problems through a reduction in the number of exchanges, which increased frequency leading to learning and suggested that the use of authority to end prolonged disputes also economised on transaction costs. This area is developed within the context of construction in chapter three of this thesis.

1.6 Transactions and Procurement

Procurement systems have been differentiated into upstream procurement strategies or downstream procurement delivery systems (Palaneeswaran et al., 2005) can be considered to structure an organisation's response. They allocate risks, prescribe protocols for communication and identify processes that are required to be complied with. The processes incorporated by different procurement approaches have been considered to suggest a range of responses by contractors (Chang and Ive, 2002). For each procurement approach there are differing types of contract completeness[1] when dealing with risk and uncertainty, and the information provided and expected from parties used to manage the financial implications of contract incompleteness varies. Where there is a higher level of product uncertainty at the commencement of a tender this would imply that contractors need to develop closer links with their subcontractors during the estimating period in order to bilaterally develop a proposal that recovers the committed cost of tendering therefore it could be suggested that the specificity of the subcontractor would be higher than if there were low requirements for product development which would imply that subcontractor specificity would be lower. Transaction asset transfer ex ante and ex post could consequently be suggested as being affected by the procurement route, where a subcontractor is carrying out a design, in order to ensure that the asset is not appropriated by the main contractor and used to replace the subcontractor at a later stage it is suggested that there may be a limit in the information that is exchanged. The use of financial information for

[1] Contract completeness is defined as the extent of the contract conditions and information to allow parties to identify their risk exposure. This is developed further in section 3.2.

governance ex post may also affect the extent of ex ante information exchanged. If as may be the case where there is direct alignment of interests of the parties, the information asymmetries that may exist would have less of an impact to the contracting parties if a misalignment occurs.

The specificity of a contractor to a client may be considered to be different in nature from that of a subcontractor to a contractor, in that once contracted, it is generally more expensive to replace a contractor. The thesis takes as a central focus the main contractor/subcontractor transaction. The contractual position with subcontractors is more ambiguous in that contracts are generally not placed until after the main contract has been signed. The consequential contractual status of the communicated subcontract quotation is therefore uncertain. This has been suggested as leading to power differentials between contractor and subcontractor which are not present between client and contractor (Swan et al., 2002). It is also suggested that the specificity of a subcontractor relates also to the complexity of project, the level of subcontract technology and the relationship that exists with the main contractor (Ross and Jaggar, 2005). This thesis adopts as a central argument that organisations estimates are structured by factors that are outside its control and that a contingency approach is taken. This approach is informed by contingency theory. Contingency theory has developed since its early development in the 1960's in response to the rapid changes in structure and technology used by industries.

Scott (1987) suggests that;

" ...previous definitions tend to view the organisation as a closed system, separate from its environment and comprising a set of stable and easily identifiable participants. However organisations are not closed systems sealed off from their environment but are open to and dependent on resources from outside."

Walker (2002) identified that managers working for organisations have to respond to the environment that they work in by designing systems and organisational structures that are defined by and are contingent on factors within their environment. He suggested that one of the fundamental issues within management research is to separate the processes and needs of the organisational system from the manner by which the "organisational units" are formed.

Walker (2002) concurred with Thompson's (1967) classification of the systems approach that suggested that management theorists who advocated that organisational design had moved from the behavioural approach to a systems approach was too simplistic. Thompson identified four eras of systems thinking, closed-rational (1900-1930), closed-natural (1930-1960), open rational (1960-1975) and open-natural (1975-present). The contingency theory and transaction approach to construction is within this last category and can be considered as relevant theories that can be appropriated by researchers when investigating the antecedent process of the formation of temporary organisational subcontract units within construction project organisations.

1.7 Construction Organisation: Information as a Structuring Resource

One of the critical tasks of construction professionals is to design project organisational structures that are suitable for a project environment (Moore, 2002). The organisational[2] structure has to take account of the technology of the project, the procurement arrangements of the clients, the internal environment of the contractor and the supply organisations involved in the project (Hughes, 1989; Murray, 1999; Shirazi, 1996). The use of governance mechanisms to gather price data, the bounded rationality of the contractor's agents and the content and format of the transactional information and the contractors general management costs are synthesised into an informational model that is used for tendering as well as economic organisation of projects. The specificity of the subcontractor, the price risk accepted, the extent of risk due to lack of control of misalignment could also suggested as being affected by the structure and content of the information collected and analysed during the estimating process.

The role of information within a project structure is consequently an essential one and is used for formation of contracts, coordination of parties inputs and outputs to processes and also the economic control of organisations should misalignment occur. The estimating process can be consequently considered

[2] The term organisational has two different meanings in this context, which relates to the process of organising (the way the work is arranged and allocated amongst the group so that the goals of the organisation are achieved) and the type of organisation structure, which relates to how responsibility is divided.

as a system of structured information flows and can be considered to influence an organisational design (Murray et al., 2000). Organisations effect the structuring of the information gathered from the supply chain and subsequently incorporated into the estimate, which is then used for tendering and post contract control and coordination consequently an investigation into this aspect of behaviour may shed light on important pre contract team structuring processes. Lansley (1994) in reviewing recent organisational theory and its application to construction also suggested that the study of how information was used for the control and integration of organisations was essential in order to develop a robust theory for inter organisational relations to be based upon.

There have been a number of other studies (Dainty et al., 2001; Greenwood, 2001; London and Kenley, 2001; Nicolini et al., 2001) that have considered contractors and their supply chain's however no recent empirical studies were uncovered during this research that considered cost and price communicative behaviour.

1.8 Outline of the Thesis

The central research proposition that this thesis adopts is, that organisations, when responding to price risks within their environment, develop a contingent approach to the collection and structuring of their project economic information that is influenced by identifiable and measurable factors. Its overall aim is to contribute to the theoretical underpinnings of the formation of the temporary multi organisational structure in a UK context by determining the contingency factors. It limits its focus to construction organisations development of price commitment from subcontractors. To achieve this aim contractor's behaviour to the collection of price information from their supply chains using three differing procurement strategies will be examined. The decision taking by organisational specialists, estimators, who have bounded rationality, which is due in part, to the information asymmetry that exists between the parties and the specialist's propensity to learn will be examined. The specificity of the organisations that provide the price information will be considered by collecting data about the governance approaches that contractors use to secure their involvement with the ex ante processes during project estimate development.

The need for more integrated inclusive approaches to the supply chain has been recognised as being essential by many researchers in order for the construction industry to improve its performance. Industry has also identified that the development of trust between organisations is essential if the innovation and knowledge held by the supply chain is to be used effectively. Procurement systems that lead to improved intra organisational knowledge flows are essential for the industry to develop however for this to happen they need to encourage a more transparent approach to project financial governance by reducing the information asymmetry that exists between the parties.

To this end, a model of the factors that affect a contractor's economic organisation of construction projects is generated from quantitative data, and is validated using a sequential qualitative method. This model will contribute to the theoretical base for construction procurement information systems, and inform the areas for improvement. A diagrammatic representation of the approach taken in presenting the study is presented in Figure 1.1 below.

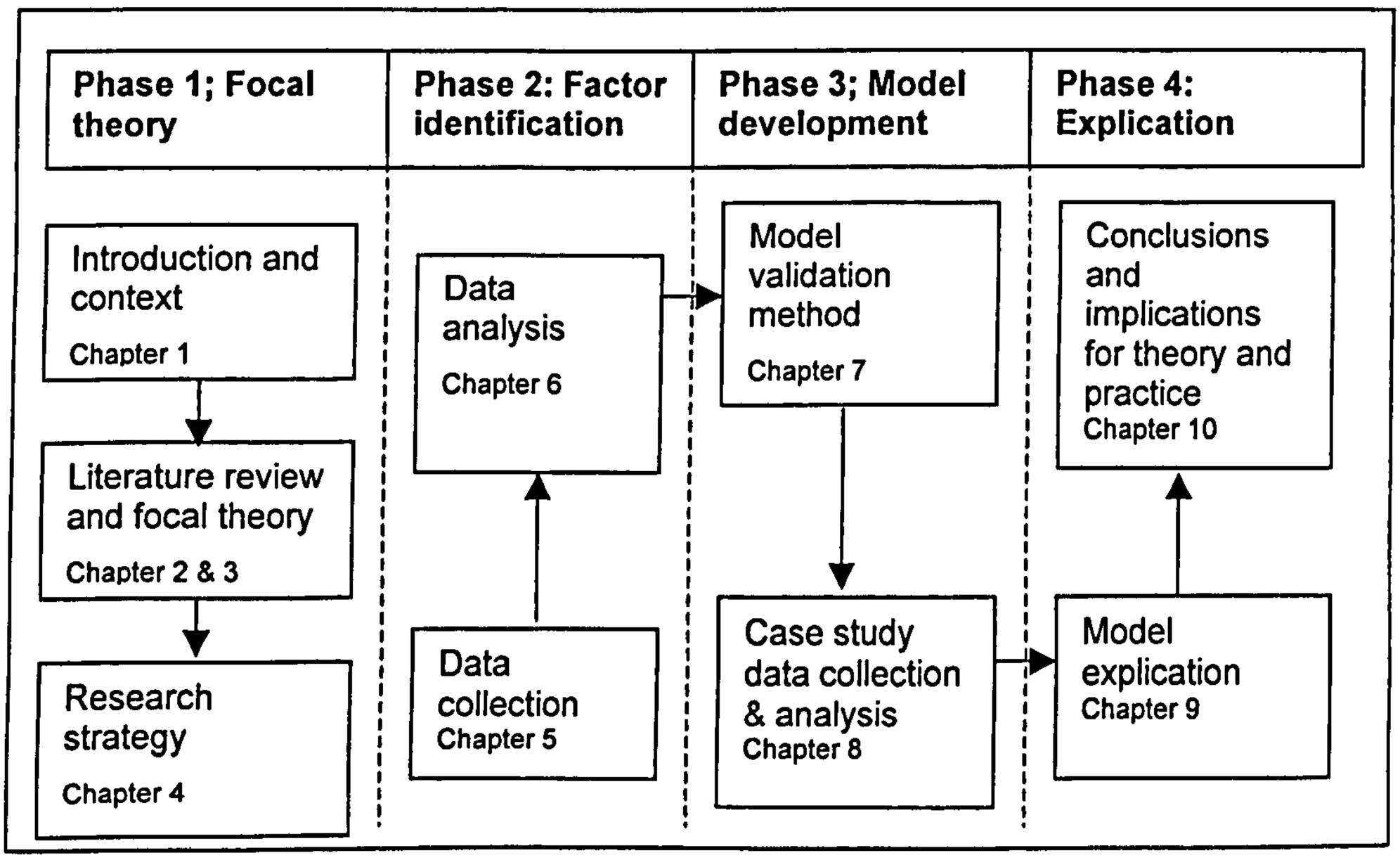

Figure1.1 Thesis structure

The theoretical foundations for the research are presented in Chapter Two and Chapter Three. Drawing upon the research in construction estimating, procurement and transaction economics, the concepts of information, risk and organisational relationships will be defined, and the boundaries and relationships between them will be explored. Previous studies examining the construction estimating processes, informational exchange and transaction economics applied to construction will be reviewed and evaluated in Chapter Three. This review forms the theoretical framework for the present study, and the research questions are described in the latter part of Chapter Three.

Chapter Four consists of two sections, the philosophical justification for the research stance, which draws from researchers work on the epistemology of construction theory. This is then followed by the development of a research strategy, which concludes by identifying that a mixed methodological approach is suitable for this study.

Chapter Five considers the design of a measuring instrument to collect data on operationalised constructs, and identifies an approach to the administration of the questionnaire to a population sample of construction estimators who are members of a professional body. This chapter concludes by describing an approach to the analysis of the quantitative data using bivariate and multi variate analysis techniques. A general linear model and principal component analysis are used on the data set to identify factors that are categorised, and that can be used to explain ex ante organisational behaviour in the collection of price data.

Chapter Six reports upon the descriptive statistical analysis of the data set, and identifies significant differences that can be drawn from the analysis. A general linear model identifies the effect that the independent variables of procurement and supply chain technology have upon dependent variables of ex ante organisational behaviour. It concludes by using a principal component analysis approach to identify the structure and dimensions of factors that affect an organisations information structure for a project estimate.

Chapter Seven and Chapter Eight report on the validation and explication of the model. Chapter Eight reports upon the analysis of the qualitative data, and provides "thick" descriptions of the data collected from the semi-structured interviews. It concludes by carrying out a cross case analysis. The data supporting the analysis is coded using an open and selective approach, which supported the naming of the contingency factors.

Chapter Nine considers how the two approaches compliment one another and the converged data analysis form a factor model of contingency factors, categorised by level and high level processes.

The theoretical contribution of the study and the research findings are discussed in Chapter Ten, which also considers the limitations of the work and suggests an agenda for future research.

CHAPTER 2: THE EXTERNAL ENVIRONMENT: PROCUREMENT AND INFORMATION

2.1 Introduction

The overall aim of this study was to determine the contingency factors that affect UK contractors' economic organisation[1] of construction projects which inter alia considers organisational behaviour in the gathering of information from the supply chain in response to price risk. The external environmental factors that influence organisations behaviour originate, in part, from the interrelationship between procurement approaches and information. This interrelationship affects the processes that construction organisations adopt to manage price risk. To place this study into context there is a need to define the concepts of construction procurement, procurement information systems and estimating and by considering published research, explore the relationships between them. The concepts that combine to form the research area of construction procurement are considered first.

2.2 Construction Procurement

Procurement can be defined as an amalgam of activities undertaken by a client in order to obtain a new building (Rowlinson et al., 2000) and includes processes that seek to place risks and obligations on the various parties to the project. There is little consensus on the terminology to be used when defining procurement, procurement systems (Cheung et al., 2001), procurement route (Tookey et al., 2001) and procurement strategy (OGC, 2003) have all been used to describe similar processes. The re-examination of the terms, assumptions and categories that procurement research adopts has been undertaken over the last four years by Palaneeswaran (2005). This study adopted the Office of Government and Commerce's (OGC) (2003) terminology which defined procurement strategy as the means of achieving project objectives and value for money by taking into account the risks and constraints, leading to decisions about the funding mechanism and asset ownership for the project. This is differentiated from the procurement route that delivers this

[1] The term economic organisation is used to represent the systems and information that buying firms use to select and financially control selling organisations.

strategy. This includes the contract strategy that will best meet the clients needs. The contract strategy determines the level of integration of design and construction for a given project by considering the risks allocated, incentives offered and control mechanisms used. In the absence of a well-defined taxonomy of terms (Palaneeswaran et al., 2005), this study conflates the constructs of procurement delivery systems and procurement route and uses the latter term in this thesis. There have been significant changes in the way that procurement routes have been used over recent years, the drivers for changes are many and have been identified as the risk aversion of clients, the need for compliance with public sector initiatives so called Egan compliance, the improvement of information flow, integration of the design and construction activities (Rowlinson and McDermott, 1999; Tookey et al., 2002; Walker and Hampson, 2003).

A diverse range of clients who have been categorised simply as public sector or private sector clients commission construction projects, however with new initiatives such as the Private Finance Initiative (PFI) and Public Private Partnerships (PPP) (identified as accounting for £25bn in education alone over a four year period (DTI 2003)), this distinction is seen as being too polemic (McDermott, 1999). The construction industry's clients have been dissatisfied with the performance of the industry, particularly in its ability to meet targets for time, cost and quality. In 2004, over 50% of public sector projects failed to meet their construction cost, design time or construction time targets DTI (2004) which were defined by key performance indicators introduced in 1999 following Sir John Egan's reports. The UK Government departments, who have been responsible for construction, have recognised its strategic importance and have sponsored twelve major reports over the last sixty years whose aims have been to enhance its performance.

These commenced with the Simon report in 1944 which aimed at examining the placing and management of building projects in order to improve the efficiency of large and medium sized building organisations. The most recent report was Modernising Construction (2002), which still had as its central aim the development of approaches that facilitated efficient and productive working. It has been argued that the central message has not changed over the period

of time between Simon and Modernising Construction, some 60 years, in that construction project teams must work together in a partnership that embraces not just the professions but also their subcontractors (Langford and Murray, 2003). The use of construction procurement routes as a driver for improvement has been the recent focus of researchers and the industry.

The change in the procurement environment of construction is illustrated by the figures shown in Table 2.1 below which identifies that the use of procurement routes with specified products, bills of quantities and complete designs has fallen significantly over the last twenty years.

Procurement route	1985 %	1987 %	1989 %	1991 %	1993 %	1995 %	1998 %	2001 %
Lump sum-firm Bill of Quantities	59.3	52.1	52.3	48.3	41.6	43.7	28.4	20.3
Lump sum- spec and drawings	10.2	17.7	10.2	7.0	8.3	12.2	10.0	20.2
Lump sum – design and build	9.0	12.2	10.9	14.8	35.7	30.1	41.4	42.7
Re measurement-approx BQ	5.4	3.4	3.6	2.5	4.1	2.4	1.7	2.8
Prime cost plus fixed fee	2.7	5.2	1.1	0.1	0.2	0.5	0.3	0.3
Management contract	14.4	9.4	15.0	7.9	6.2	6.9	10.4	2.3
Construction management	-	-	6.9	19.4	3.9	4.2	7.7	9.6
Partnering agreements	-	-	-	-	-	-	-	1.7

Table 2.1 Contracts in Use survey RICS (2001)

The Royal Institution of Chartered Surveyors (RICS) survey in 2001 of professional practices, which obtained information on £3.3bn of project value, indicated that most building projects used a standard form of contract, with the vast majority (91%) utilising a Joint Contracts Tribunal form of contract. The survey also indicated that clients approached the procurement of their projects significantly differently than a decade ago. The change in the use of the lump sum contractual arrangements with bills of quantities (prescribed definitions of the building product) was down from 59% to 20% when measured by the value of contracts placed. The two forms of procurement route that had as a consequence become more popular were the lump sum design and build form and the use of the drawings and specification form. The rationale for

procurement route selection has been found to be not well defined, as the industry's clients and their advisors selection of arrangements has been demonstrated to be illogical and rarely systematic (Skitmore and Marsden, 1988). However this can be considered not to be a result of a lack of normative advice, which is plentiful (Egan, 1998,2002; H.M.Treasury, 2000; Holti et al., 1999; Latham, 1993,1994; Reading Construction Forum, 1998, 1995).

The Government, as a client, required improvements and, in 1994, sponsored Sir Michael Latham to report on the industry, the findings were that the industry could improve significantly and these findings were reinforced by Sir John Egan's report in 1998 entitled Rethinking Construction, which suggested that five drivers were required to achieve better construction. These drivers were committed leadership, a focus on the customer, integration of the process and the team surrounding the process, a quality driven agenda and commitment to people. Four key processes were identified that were needed to affect such change, these were partnering the supply chain by establishing long term relationships based on continuous improvement, the development of a sustained programme of improvements for production and delivery of components, integration and focus upon the construction process and meeting the needs of the end user and an elimination of waste in the construction process.

These drivers were considered in the follow up report, Modernising Construction (2001), which suggested that six essential requirements should be in place in order to effectively procure and manage construction projects. These were identified as relating to integrated design and construction procurement approaches, better planning, project management, benchmarking and an underpinning information system. The criterion for contractor selection process was no longer lowest price.

2.2.1 New Approaches to Procurement

Construction partnering has been advocated as being the most appropriate approach to integrate the team and is the prescribed arrangement in the public sector. Local authorities and registered social landlords have to demonstrate compliance with the so-called Egan principles when letting their contracts. The

approach has become an increasingly popular form of business relationship in construction since its first formal introduction post Egan. The commonly used definition of a partnership cited is:

> *"... a long term commitment between two or more organisations for the purpose of achieving specific business objectives by maximising the effectiveness of each participants resources. This requires changing the relationships to a shared culture without regard to organisational boundaries. The relationship is based on trust, dedication to common goals, and an understanding of each individual's expectations and values."*
>
> Construction Industry Institute, 1991

This definition has been refined to reflect the level of the partnership; project partnering, which is undertaken for one project or strategic partnering, which relates to a number of projects (McDermott, 1999). The importance of the maturity of relationships was reflected in the Reading Construction Forum's (Reading Construction Forum, 1995; 1998) approach that identified seven "pillars" of partnering that were required in order for second generation partnering to take place. These were identified as strategy, membership, equity, integration, benchmarks, project processes and feedback. For third generation partnering their normative advice was the development of a virtual organisation with its supply chain.

Supporters of the partnering approach have identified many benefits from clients and contractors working together most of which are quantified through agreed performance indicators. The partnering approach has been supported by a number of new contractual arrangements such as PPC 2000 and the New Engineering Contract, however it has been suggested that this area lacks a strong theoretical basis upon which to build better arrangements (Cox and Townsend, 1998; Davis, 2004). There has been little empirical analysis of the effectiveness of the differing arrangements (Bresnen and Marshall, 2000) and the majority of the focus of academics procurement research has been descriptive action research focusing upon the contractor/ client interface. The need to develop a stronger theoretical understanding of the role that the supply chain plays in project teams has been highlighted by Holti (1999) in the quotation below.

> *"There is ample evidence that the foundation of construction industry reform must come from importation of supply chain management techniques and strategic supply chain partnerships that have been the foundation of success in other industries"* (Holti et al., 1999)

Most tools available to clients and their advisors for the selection of the optimum procurement approach have focused upon quantitative methods, which are based on how contracts control time, cost and quality (Ambrose and Tucker, 2000; Love et al., 1998; Skitmore and Marsden, 1988). The unit of analysis of these approaches has been the contractor/client relationship and the impact that change has upon project outcomes. Crudely stated, if clients require ex post change, in order to protect the price they have gained through competition, the most effective control on the impact that a change has is to have high project information specificity and clearly defined rules as to how change is defined and managed. Consequently this favours the traditional procurement route if clients require extensive post contract amendments to design. If clients require an arrangement that allocates a high proportion of risk to a contractor and have a clear conception of their performance requirements, design and build has been perceived as the optimum approach and is advocated as the preferred arrangement by Modernising Construction (HMSO, 2001). The low information specificity and consequent difficulty in managing the result of design changes, however makes this approach susceptible to poor ex post control. Drawings and specification, management contracting and construction management are arrangements that fall between the two extremes of routes represented by the design and build approach and the traditional approach.

The control of change is managed by mediating parties within procurement routes who can be considered as third parties and have been identified as contributing to transaction costs (Chang and Ive, 2002). The third parties to the procurement arrangement have also been referred to as control actors[2], who Winch (2001) identifies as having three roles; the verification of satisfactory performance, facilitation of negotiation when necessary i.e. if changes occur

[2] The control actors in relation to a contractor's organisation are internal and external to the organisation. In relation to the supply chain the internal financial control actor is the contractor's commercial manager and site agent. The procurement routes generally prescribe the external control actor's identity and remit. A traditionally procured project would have a quantity surveyor appointed, the design and build procurement route has a clients representative as does the drawings and specification route.

and thirdly to provide a first line of dispute resolution. Their role can be considered to manage the implications of contractual incompleteness. In traditionally procured projects, the contractual incompleteness is usually manifested in one or more of three categories, either at the contract formation stage as prime cost sums, provisional sums or provisional quantities which are adjusted ex post or as contractual mechanisms that enable variations to be made ex post without effecting contract breakdown or as ambiguities that occur due to errors or omissions in the documentation which require ex post adjustments. There has been little empirical research uncovered during the course of this study, in the area of construction procurement, that considers the influence that the client's procurement route has upon contractor's behaviour to their supply chain, as identified earlier, the assumption has been that contractors will develop a contingent approach to the management of their supply chain and there has been little investigation into the factors that influence this approach. This was identified as a clear gap in current knowledge and a better understanding of these factors will assist in the design of procurement routes, which take account of the main units of production, the supply chain, and their relationship with the management organisation, the contractor.

2.3 Construction Procurement and the Supply Chain

Traditionally, the main contractor would execute most of the work on a project using a directly employed workforce, however over the last 20 years, subcontractors have undertaken increasing amounts. Gray and Flanagan (1989) first considered the central importance of the role played by subcontractors within the construction industry in research commissioned by the Chartered Institute of Building (CIOB).

Gray and Flanagan (1989) classified subcontractors into four types;

1. Design/manufacture/supply/fix
2. Design/supply/fix
3. Supply/fix
4. Fix only

They also identified an accurate blue print for the future of subcontracting which identified that the market would become structured into large national subcontractors that would be specialised by niche and who would have control over their business. They also identified that there would be a large turnover of smaller organisations that would be used as a buffer to the volatility of varying workloads. They identified that contractor's attitudes to subcontracting should also change to ensure risks were shared appropriately, an assertion that has found little contemporary support (Dainty and Moore, 2000; Greenwood, 2001). The importance of the subcontract sector was also highlighted by Latham (1994) and Egan (1998) who identified that partnering throughout the supply chain was critical to the industry and would ensure that innovation and sustained incremental increases in performance would occur (Anumba, 2001; 2002).

The approach that contractors took to the development of their project teams based on subcontractors was highlighted by researchers considering the change to the structure of the industry (Abdel-Razek and McCaffer, 1987; Nobbs, 1993) who suggested that main contractors had become mainly management contractors, providing only management resources and that their principal activity was to coordinate subcontract organisations. The relationships that an organisation has with its supply organisations have been suggested to be a function of its management strategies. The size of organisations has also been identified as a factor that influences their management strategies, (Langford and Male, 2001; Lansley, 1987) as large firms have access to resources which enables them to dominate the production and market environments and occupy favourable positions along industry value chains. In this way they have been considered to act as market makers for their supply chains (Lansley, 1987). The smaller firms lacking the capital and skills needed to compete in more sophisticated segments of the market are consequently limited to strategies that are focused upon price competition and cost reduction (Hillebrandt et al., 1995).

This makes the implementation of pan sector initiatives problematic, as differing communities of practice are present. The main focus of past

government initiatives has been upon large organisations with the objective of disseminating good practice. It is only relatively recently, within the last four years that the focus of procurement research and practice has been upon the supply chain. The current position of construction procurement research is that clients have to be aware of the nature of the structural characteristics of the supply chain and develop procurement approaches that reflect their nature (Cox and Townsend, 1998). The limiting factor to better awareness is a lack of understanding of the structural characteristics of the industry itself as well as the current practice within the subcontractor markets that exist.

2.4 Defining Supply Chains

There is an abundance of terms that describe supply organisations and their relationship with the buyer of their resources. The term subcontractor has recently been replaced in management literature by supply chain organisation and the management of these organisations has been referred to as supply chain management. This thesis adopts the term supply chain organisation. Christopher (Christopher, 1992) gives a simple definition of supply chain management as;

> *"... the management of upstream and downstream relationships with suppliers, distributors and customers to achieve greater customer value at less cost."*

London and Kenley (2001) identified two ways of conceptualising supply chain management.

> *"Supply chain management is a continuously evolving management philosophy that seeks to unify the collective production competencies and resources found both within the enterprise and outside in the firms business partners located along intersecting supply channels into a highly competitive customer enriching supply system focusing on developing innovative solutions and synchronising the flow of market products, services and information to create unique, individualised sources of customer value."*

Pryke (2004) in a more recent work considering a social network analysis of a series of case studies concluded that supply chain management was too simple a term to describe the approach taken by organisations and suggested supply network as a more appropriate one. The boundaries of such a network[3]

[3] The definition of a supply network is given by (Pryke, 2004) as *"A dynamic network of interdependent organisations that can collaborate more efficiently to satisfy specific needs of a customer".*

are loosely defined and the type and extent of relationships being impossible to capture accurately.

This was refined by Pryke (2004) who identified four categories of supply chain, internal supply chain, dyadic –exclusive relationships, management of a chain or the management of a network of businesses. Pryke identified that networks had information exchange relationships that related to cost management activities and that trust between the network parties was essential if integration was to take place. He suggested that integration requires the sharing of sensitive cost and process information and creating unique investments. A high degree of idiosyncratic investments, dependence and product saleability have been identified as antecedent requirements to raise the affective commitment, continuance commitment and normative commitment of supply chain parties in software industries (Wu et al., 2004). These requirements particularly for idiosyncratic investment in processes or products are lower in construction than other industries consequently adapted models are required. A theoretical study of supply chains in construction undertaken by London and Kenley (2001) concluded that situations conducive to supply chain management were recurrent transactions requiring moderately specialised assets and recurrent transactions requiring highly specialised assets and operations under moderately high-to-high uncertainty.

Trust has been considered to be an essential factor in construction relationships (Bennet and Jayes, 1995) and, in order to develop trust in supply chain relationships three factors were identified by Holti (1999) as being essential during ex ante processes, they were that the client organisation will place an order with the supplying organisation, that the client organisation won't use the supplying organisation's estimate information for purposes other than assessment of the specific tender and that there is a mutual recognition of bilateral dependence between organisations. This bilateral dependence requires a proximity of relationship that is difficult to maintain between construction organisations due to the project nature of the business environment however the benefits that are derived from increasing the proximity of relationships with suppliers can be economic and related to the quality of service. Contractors have embraced this approach with their clients,

Green (1999) suggests that this was a rhetorical device in order to win work, a view which was supported by Akintoye et al (2000) who identified in a survey of 40 companies, that construction firms did value the connections they made with their supply chain organisations, however suggested that contractors were more oriented towards clients than their supply chain.

Akintoye's (2000) survey identified that the benefits identified by the contractors were benefits to the client, improved customer service, reduction in paperwork, increased profitability, cost reductions within organisations and increased market competitiveness. The benefits to the supplier and quality assurance were the objectives to developing supply chain collaborations. Dainty's (2001) conclusions concurred with this orientation and identified that there was a great deal of suspicion amongst the 20 subcontractors interviewed about the motives of the main contractors to enter into partnerships. He identified that open book accounting was perceived as a means of driving down profits and that competitive tendering remained the principal approach to a subcontracting organisations selection. He also suggested that programming was a difficulty with little or no time given to subcontractors and that risks were passed down in an un-equitable manner. The data that was passed to the subcontractor was identified as being of poor quality and estimators were perceived to lack an understanding of the demands placed on subcontractors. He also found that there were significant barriers to supplier integration and to the development of supply chain alliances. These were rooted in mistrust and he suggested that clients were required to provide leadership to drive the integration process and also to move towards a more transparent approach to the governance of supply chain relationships. Greenwood (2001) also identified that despite the recommendations of Latham (1994) for a code of practice for subcontractor procurement and the consequent publication of such a code by working group no 3 (CIB, 1997) that few contractors were complying with the code. Greenwood concluded by stating that there was little evidence of subcontractor partnering and that the traditional arms-length, cost driven approach was adopted from the commencement of trading. Kale and Arditi (2001), however, found in their study of inter organisational relationships between contractor and subcontractors, that there was a positive and strong association between economic performance and quality of relationship, with attributes of longevity,

openness of communication and mutual trust. They posited that these relationships were strategic assets to a contractor.

2.5 Construction Information and Procurement

Information technology has improved the speed and efficiency of communication between parties however the structure and content of financial information that is at the core of the process of procurement has been resistant to change despite strong efforts to develop better information systems. One of the central challenges to researchers in construction information systems is the differing ontologies that exist between designers and constructors of a project. The project information generated to support the administration and coordination of construction activity reflects the product of the activity rather than the process itself. It has been stated as being not capable of transition from one manifestation to another, and therefore specific information needs, at a specific point in time, for specific purposes, by a specified party remains unachieved (Jaggar et al., 2002). There have been numerous reports and recommendations, as indicated earlier, all acknowledging that opacity exists between parties, that poor structuring of information exists and that improvements to establish more effective communications and greater transparency, between the various parties should be established.

The consequence of the ontological differences that exist between the designers and constructors is that designers find it difficult to model the resources required, and consequently sub optimal models are produced as the dynamics of the process are masked by ineffective information communication protocols (Vincent, 1995). Constructors, when developing their process models, also have difficulty in identifying accurate solutions and make financial estimates based on incomplete information. There have been many attempts to categorise construction information and use classification systems to attempt to provide the informational "architecture" in order to bridge this ontological divide (Atkin, 1995; Bindslev, 1995a; Bindslev, 1995b; Ray-Jones and Clegg, 1976; RIBA, 1997). The classical view of classification is that categories are defined in terms of necessary and sufficient feature. When some 'thing' has all the necessary features it is a member of the category (which has clearly defined

boundaries) and that all members of a category share the necessary features. Such features are binary i.e. an entity either possesses an attribute or it does not.

This view has recently been challenged with the results of behavioural experiments during the 1970's indicating that members of a category vary in how good an example they are in their category. This use of exemplars was highlighted in cost modelling research by Newton (1991). While there has been considerable evidence from behavioural studies to support the notion of an exemplar it is has proved to be difficult to formulate a structure for exemplars which requires that the method for the degree of correspondence between candidate and exemplar determined. The approach of using exemplars with defined features and searching a Euclidean space for nearest neighbours is at the core of the case based reasoning approach used in artificial intelligence and has been used relatively successfully in representing perceptual objects. The theoretical problem of how to establish similarity for construction activities has yet to be resolved and as all forms of information analysis require a codification system that is based on well defined constructs; the search for a comprehensive and inclusive codification system for construction information which has been underway for almost sixty years remains a work in progress.

2.5.1 Historical Developments of Codification of Information in the Construction Industry

The start of a search for a unified codification system commenced in 1947, the International conference on Building Documentation led to the Economic commission for Europe supporting the development of the International council for Building documentation (CIDB) whose aim was to develop International cooperation regarding information exchange. The first system adopted the UDC (Universal Decimal classification). In 1953, the International Building classification committee (IBCC) published the Abridged Building Classification for architects and builders and civil engineers (ABC), which was a composite classification system, based upon the evaluation of 19 countries construction filing systems. In 1966 CIB report No. 6 Building classification practice supported the adoption of the above system.

Bindslev (1995b) succinctly made the case for integration of construction information within a product model

> *"It is the task of administrative research to provide information systems which can help increase the quality of products within the building industry. It is a characteristic of building administration that it comprises the building project as a totality. It is not limited to individual professions, trades or contracts but aims at an overall coordination of work performance."* Bjorn Bindslev (1995)

The central assertion by Bindslev above and Karlen (Karlen, 1995) was that there should be a connection between the design information generated and the recording information used during the construction process. The product model that is consequently developed should be independent of the divisions by trade and contracts, and allow for the collection of data in order to develop standards. In taking a Fordist perspective, they stated that without systematic coordination of information that control and regulation are impossible. They suggested that it would be impossible to control (a material, a construction, a finished product) unless the "standards" by which the control are stated. The standards act as benchmarking that forms the basis for comparison and correction if the observations are at variance with that which has been predicted.

In 1960, the RIBA accepted the CIB recommendation that a unifying information system was required and published the first version of the building filing manual. The system had a short life span as it was restricted in scope and was difficult to use. This, one must appreciate, was prior to computerisation. Two consequent developments emerged which were the CI/SfB (RIBA) and CBC/SfB system

The CBC system evolved, Bindslev, its designer, was in agreement with the object-oriented approach, which saw modelling and the creation of logical classification tables as important conditions for rational systems analysis. The use of symbolic logic was important for the inclusion of cost concepts such as cost *bearers* and cost *places*, direct and indirect costs, cost summaries and also for expressing the distinction between spaces for *use* and spaces for construction *activity.*

The CBC/SfB system was a dynamic one, it allowed users to reflect the level of information to be stored depending on the stage that they were at. It was a product data model that uses three tables. 1. Space function, open spaces or Elements, 2. Combinations of resources (called constructions) to fill (materialise) the elements, and 3. Resources. The use of the tables represented both process of construction, i.e. finding resources, combining them into constructions and then elements and also the design of construction identifying the elements, considering how they were to be constructed and then the resources required. The system had well-defined faceted contents, which were coded. Each code was known to have a constant meaning and the principles for the establishment of an information classification system were laid down, however the RIBA and CBC couldn't agree upon the systems implementation.

The editing of a national specification was vigorously resisted by those who had relied upon the standard method of measurement for the description of the building product. The professional bodies protecting their interests had consequently constrained progress towards a unified standard. The notion of information systems in organisations being subject to individual biases and the use of power is not a new one as illustrated in the quotation below.

> *"The importance of power shouldn't be underplayed when considering information systems in contemporary organisations. Divergent interests and perspectives are normally present... and information systems are one of the key areas for political action".* Walsham (1991)

In order to develop a system that was more pragmatic and reflected the organisational structures within the industry, the coordinating committee for project information (CCPI) was set up in 1979 and developed a common arrangement of work sections (CAWS). The first two factors (used for the grouping of objects) were responsibility for design and performance and methods of working (relating to subcontracting practice). These were related to construction according to SfB, but were different from the attributes used by SfB for the main definition of the objects (the constructions).

The main problem that was now inherent within the informational architecture of the new system of classification in the UK was that the CAWS structure of design information passed to the contractor, was based on work sections that reflected the subcontracting practice of the industry, i.e. who does the job. The original idea of SfB to separate the design elements from the constructions, (i.e. who does the job) and from the materials was no longer used. It was suggested by Karlen (1995) that this simplified the editing of the specifications and bills of quantities, however gave little information retrieval potential on the performance of materials and components to support alternative design decisions. The principle of a product model that was independent of the parties that used the data contained within the model had been fundamentally compromised.

The latest attempt was the Uniclass system, which aimed to integrate civil engineering and building into a single unified system. The wide spread usage of IT also allowed common standards for design to develop the most recent being the International Alliance for Interoperability (IAI) standard for interoperability and the publication of industry foundation classes.

Consequently an aspect of the current problem is that rules are required that can be implemented into product models that appear in language recognisable by the project actors. The traditional approach towards a centralised classification system appears to have lost some momentum however codification of information is central to a project to integrate parties. ISO/OR 9007 identified that "*databases in the future will not just be integrated, they will be distributed, integrated via a sophisticated classification scheme that takes into account of data, information, experiences, virtual reality (historic reality).*" This is a massive challenge to classification as objects require not just classification of functional and resource requirements but also a set of historical attributes that will be added to over a period of time.

Resource productivity and cost information can be considered to be out of view and distributed in the supply networks and in order to capture this data information systems that take account of these organisation's processes are required. The implication of the development of theoretically elegant

classification systems that ignore the social and economic embeddedness of the parties using them is that they will remain theoretical and the opportunity to utilise computing technology for process and product modelling will be delayed.

A related aspect of construction information research that has looked to adopt a manufacturing philosophy and has had arguably more success that the classification approach above has been to consider a process approach. The SPICE (Standardised Process Improvement for Construction Enterprises), (Kagiaglou et al., 1998; Sarshar and al, 1999) project, based on the Capability Maturity Model (CMM), model of process improvement, which was used within the software industry, provided a framework to consider organisational capability by considering the maturity of its processes. The process research also yielded new models of procurement, (Aouad et al., 1999) which reflected the sequential and interdependent nature of construction processes but also identified a series of approaches to overall improvement, such as identification of hard and soft gates, clear process measurement, identification of inputs and outputs and a proposed protocol.

Critics of the process models generally consider the human agency aspect of the process and highlight the problems of taking a Taylorist approach when designing processes. Tinaikar et al (1995) suggests that contemporary process thinking emphasise the task related aspects of processes and ignore the people performing the task. They suggest that the lack of consideration of the human aspects of organisational processes serve to mechanise the activities involved in a process and trivialise human agency, and identify that inflexibility in the characterisation of organisational processes and that the technical image of processes ignore the social or organisational context that they are undertaken within. This opposes the view that processes can be viewed as a sequence of antecedent-consequent relationships and that the simple efficiency measures used as criterion for process improvement are naive. The adoption of well-defined processes has, however, worked well in other industries such as car manufacture and shipbuilding and it is also a central method for the development of lean techniques of manufacture. Information technology forms a central support for management control and measurement of processes and provides a technological protocol for their implementation.

This requires however a consistency within the environment within which processes operate. Such environmental stability for processes in construction organisations is difficult to achieve, projects that form the throughput of an organisation are significantly variable in nature (procurement arrangement, project teams, technology, specificity of supply organisations and geographical location). This has been recognised by the research teams in construction who have identified that the approach may be to identify top down or bottom up i.e. high level processes which provide a broad framework for interpretation or to identify the environmental factors that affect the processes at a detailed level.

The process infrastructure can be considered to be developing though research on the development of protocols (Aouad et al, 1998; Construct-IT,1999) and lean construction techniques, which whilst not allaying the doubts of researchers, who consider agency as central to improvement, have been adopted by industry. The classification systems that have been incorporated into the procurement routes have lost some of their coherence through the involvement of professional groups, they are currently rarely used and a reason for their lack of use in practice is that they have been developed without due regard to the inter organisational relationships that exist. This study looks to investigate the relationships that exist at the earliest stage of a project between a construction organisation and its supply chain. These relationships yield a model of factors that influence how a construction organisation structures its project information. It was considered that the estimating process was an appropriate domain for the research and that the focus of the study was to investigate from the construction organisations perspective, the information gathered that supports estimator's decision-making when analysing and synthesising subcontract price data into an estimate.

2.6 Price Risk- Organisational Processes

A review of the published research on the estimating process was undertaken during 1999-2004 and focused on peer reviewed academic journal papers in order to critically consider empirical and theoretical contributions made by academics in the field of construction management. The area can be divided into three basic themes, which are organisational processes that considers the

organisation as a unit of analysis, decision making which considers the extent of autonomy and agency that the estimator exhibits in the development of the estimate, and seeks to explore the role of judgement that is used to adapt organisational processes and the product which considers how the product of the estimating process is used to make tendering decisions. Central to all these themes is that the estimating process and the estimator must identify and manage a project's price risk. Risk management has been a feature of construction research for approximately 40 years. A lot of the publications (Akintoye and Black, 1999; Al-Bahar and Crandall, 1990; Chapman and Ward, 1997; Flanagan and Norman, 1993; Godfrey, 1996; Perry and Heyes, 1985; Simister, 1994; Tah and Carr, 2000a; Tah and Carr, 2000b) have taken a prescriptive approach to risk management and have taken as their starting point the objective approach to risk identification and analysis. In a recent review of risk and risk management in construction by Edwards and Bowen (1998), they categorised risk into a dichotomy of natural and human risks, the latter was then further subdivided into nine sub-themes; social, political, economic, financial, legal, health, managerial, technical and cultural. The themes are a useful means of reviewing literature however are in essence a simplistic approach to the study of risk. Their review and findings concur with the recent Royal Society report reported by Weyman (1999) that the perception/identification of risks is an important area that has not been adequately addressed by the literature in construction. This would also appear to support the Royal Society's central axiom that the study of risk has been dichotomised into two areas that of objective risk which takes as a central assumption that risk can be measured and analysed using statistical techniques and subjective risk which has been considered to relate to the psychological dimensions associated with risk events.

The subjective economic risk perception research has been undertaken for approximately a decade considering both the cognitive paradigm, which is rooted within economic models of rationality and rational decision theory, and the psychometric paradigm that has drawn from the cognitive research and has sought to investigate the subjective criteria used in the assessment of risk. One of the most significant findings from this research is that perceptions of risk are multidimensional in terms of the range of qualitative variables that people

consider important and that they are also to some extent culturally defined. This aspect of the role of risk in transactions between parties is considered in chapter three of this thesis.

The Royal Society's report (1992) also draws from some recent research by sociologists considering risk which highlights the presence of plural rationalities, differing perspectives or world views and suggest that risk communication should be sensitive to the frames of reference used by the target audience. An observation of the earlier Royal Society report (1983) was that risk communication was a key area of concern and that further work was required. This was taken up by the later report that suggested that a "more social" technique of investigation be used when investigating risk and risk communication and then to consider appropriate means of framing risk information based on these insights. This issue supports the assertion made by Edwards and Bowen (1998) who stated

> *"...there is now a need to investigate different risk attitudes among project participants, how risk learning takes place and the ways in which the inter organisational communication of risk takes place in temporary multi-structure organisations of construction projects."*

The conceptual framework of Kasperson et al, (2000) who considered the communication of risk from a perception perspective is useful They suggested that although there were theoretical difficulties with the source-receiver model for communication that it is a powerful metaphor for considering risk perception as suggested by Figure 2.1 below.

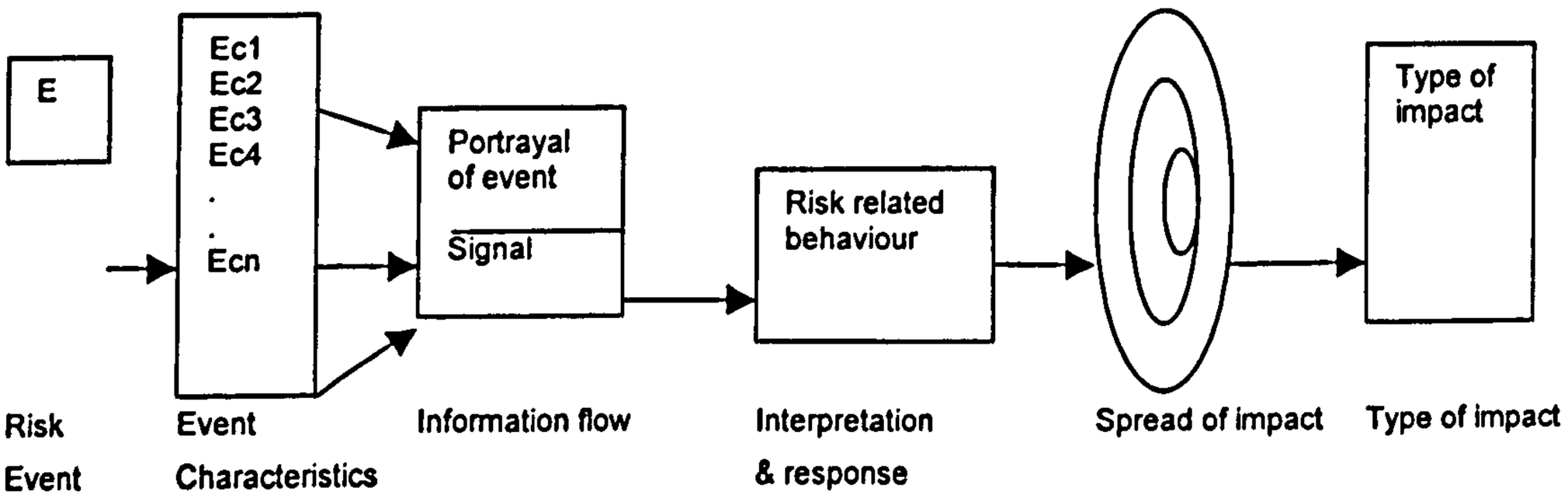

Figure 2.1 Simplified representation of risk communication and impact

They suggested that a message contains factual, inferential, value related and symbolic meanings. They also identified that symbols are key factors in triggering the attention of receivers, these symbols can not only relate to the message itself but also the sources of the communication and their perceived credibility. They identified that the social amplification of risk denotes the phenomenon by which information processes, institutional structures, social group behaviour and individual responses shape the individuals experience of risk. To put this into a construction context, construction organisations and their supply chain have to manage price risk in a procurement environment that currently has few protocols for price risk communication and a better understanding of the risk perceptions are required in order to develop systems for the communication and shared negotiated meanings of risk. The consequences that flow from a better system of communication of risk are great; as technology facilitates effective communication channels it has been suggested that procurement arrangements are require to move from the traditional method of communication of prices based on opaque information practice to practice that reflects risk and resource price (Brandon, 2002).

The summary of current thinking is that risk is rarely objective, usually subjective and relates to how the message is communicated, the expectations of the various parties to its response and also to the norms that operate within the social and organisational grouping that arise. One of the fundamental issues to investigate is how risk is communicated across the supply chain, the meanings individuals and organisations ascribe to the symbols within such communications and how these meanings affect organisations processes. The focus of this study was the economic transactions that take place between the constructor and its supply chain, these inter alia are informed by the risk perceptions of the parties however a detailed investigation into the phenomenological aspects of risk are outside the scope of this study. The significance of economic risk and price information is related to transaction economics and is discussed in chapter three.

2.6.1 Estimating Processes

A considerable body of research has been undertaken considering the processes involved in the production of an estimate (Akintoye and Fitzgerald,

2000; Azzaro et al., 1987; Gray, 1982; O'Brien and Pantouvakis, 1993; Oteifa and Baldwin, 1991; Skitmore and Wilcox, 1994). The four high level processes that most academics agree upon are the establishment of an estimating programme, the collection of information relating to a project and the calculation of direct and indirect costs.

There exists some disagreement over the rationality of the group and individual contribution to the process which the Chartered Institute of Building (Chartered Institute of Building, 1997) defines as "the technical process of producing the costs of construction" in contradiction Fine, (1974) and Ashworth and Skitmore, (1991) consider that whilst the processes are logical, the application of judgement by individuals and a pre- contract team to a project's variables that range from production outputs to estimates of non-direct and direct preliminary costs can lead to irrationality being introduced into the estimate.

The process of estimating has however changed radically, whereas it was once considered as primarily unit rate build-ups in response to bill of quantities items, it has now moved to one of coordination and synthesis of numerous subcontract quotations. Researchers have identified that the process of estimating has adapted in response to the changing methods of construction and the increasing reliance on subcontractors (Abdel-Razek and McCaffer, 1987). This early work did not consider the effect that changing procurement practice had upon the estimating process.

Prescriptive literature within the UK considering the process of estimating abounds (Chartered Institute of Building, 1987; Chartered Institute of Building, 1989b; Chartered Institute of Building, 1989a; Chartered Institute of Building, 1993; Chartered Institute of Building, 1997), the extent of such literature is also highlighted by researchers who suggested that one of the major problems in investigating estimating practice is that the use of terminology in an unreflective manner by estimators consequently caused difficulty in investigating anything other than normative practice (Akintoye, 2000; Skitmore and Wilcox, 1994). The lack of investigation into estimating practice was also highlighted through a questionnaire survey of estimators in a range of contracting organisations carried over by Akintoye and Fitzgerald (2000). They highlighted that the major

cause of inaccuracy within estimates was due to a lack of estimator's knowledge of the construction processes adopted by the supply chain and concluded that the practice of estimating was largely judgemental rather than analytical and that despite respondent's knowledge of range estimating and parametric techniques, little evidence was found of their use in practice. The main factors identified that influenced the practice of cost estimating were project complexity, technological requirements, project information, project team requirements, contract requirements, project duration and market requirements (Akintoye, 2000).

The technological support for the estimating current estimating practice relies upon low levels of transaction processing software and no evidence has been found of the use of expert systems or knowledge based decision support systems (Oteifa and Baldwin, 1991; O'Brien and Pantouvakis, 1993). Computer aided estimating systems (CAE) use a database/library approach of rates and outputs that are adjusted through the use of judgement to develop project related data (Sher, 1996). The technological support provided by the CAE system can be considered to structure an organisations response to a request for a tender and prescribes a logical set of processes to be used, these form the basis for communication to the client. This is often constrained by the communication protocols prescribed by the procurement arrangement, which has moved towards a less structured informational environment. Sher also noted that little use is made by estimators of the facility to record the rationale behind the judgements made during the development of the estimate. The estimator's role in developing the estimate is considered in section 2.6.2.

2.6.2 Estimating Decision Making

The processes adopted by the pre contract price forecasters estimators in arriving at a judgement on price have been investigated and it was suggested that the technique, the forecaster and the forecaster's knowledge of the market determined the accuracy of an estimate (Skitmore and Patchell, 1990). The judgement of the estimator and heuristics has also been investigated and using the psychometric decision making theory of Tversky and Kahneman (Tversky and Kahneman, 1982), Mak and Raftery (1992) tested the three heuristics of representativeness, availability and anchoring and adjustment using an

experimental study of undergraduates. They found that the majority of subjects did discriminate between high and low quality data and exhibited the availability bias when arriving at judgements. Mak and Raftery qualify this finding and suggest that further work be carried out in the field to investigate the use of heuristics and bias. This was developed to assess the link between learning style and heuristic bias and it was found that there was no association (Fortune and Lees, 1998).

The role of the estimator in forecasting the future cost of construction would imply that feedback on the accuracy of judgements would be actively sought to allow for adaptation of individual heuristics. However, in a survey it was found that only one builder had a system of feedback (Skitmore and Wilcox, 1994). This supported the notion that estimating systems could be considered as being essentially closed (Green, 1989) with little external input. The reasons suggested for few construction organizations having effective feedback mechanisms (Newcombe, 1999) were that part of the problem was individual's lack of learning from projects was due to their lack of receptivity, a lack of transparency between parties and also a low intent to learn. The estimator must consequently make a great use of personal knowledge that is developed from experience on past tenders when arriving at judgments regarding the forecast of future costs, this judgment could be suggested as lacking calibration due to the lack of effective feedback on the outcome of past judgment and in order to improve, needs to be augmented by a range of information sources from within the organization and from external organisations.

2.6.3 The Estimate

In a similar fashion to the risk perception research identified earlier, the estimate has been considered as a message to another group. Using a communication metaphor, Bowen and Edwards (1996), suggest that the estimate is rich in symbolism and that the sender had preconceived notions of the symbolic criteria to be used by the receiver of the estimate. Their research focused upon cost planning in a client domain and was based upon an interview survey of a sample of quantity surveyors, clients and architects.

The form, use and content of an estimate in a contracting organisation is different than that of an estimate going to a client, however the communication metaphor of the estimate as a message being transmitted to a group who will then make a tendering decision is a useful one. The estimate is used as the basis for a tender that will encompass an organisations response to perceived risk. The estimator can therefore be considered as being central to the communication of price risk information to the tendering adjudication group who make a final decision upon the levels of contingency and profit to be included in a competitive tender. This consequent process is particularly difficult to research due its the confidential nature. The antecedent processes of collection, analysis and synthesis of the supply chain price information during the estimating stage is more accessible and an analysis of the information collected and analysed can illuminate the price risk behaviour of the contracting organisations.

The above review of the literature has highlighted the lack of research investigating the supply chains involvement with the estimating practice of construction organisations and few authors, other than Bowen and Edwards whose work investigated professional practice quantity surveyors in South Africa, have considered the communication aspect of estimating. The essential role of the estimator is one of forecasting costs that are closely related to risks, this forecast is based upon the project information received from the client and the price information returned from the supply chain organisations.

The research on estimating practice is considered in Table 2.2 and can be traced back to 1982.

Date	Authors	Title	Data	Data analysis	Findings
1982	Gray, C.	Analysis of the Preliminary Element of Building production Costs	Estimate analysis with a single contracting organisation	Descriptive statistics	
1987	Abdel-Razek, R.H.	Analysis of estimating Inaccuracy and Tender Variability	Government statistics and theoretical information model	Secondary Analysis	Need study into judgement that relate to different interpretation of information.
1987	Abdel-Razek, R. McCaffer, R.	A change in the UK construction industry structure: implications for estimating	Government statistics	Secondary analysis	Estimators task made more difficult due to structural change within the industry i.e. more subcontractors.
1987	Azzaro, D. Hubbard, J. Robertson, D.	Contractors Estimating Procedures, An Overview	Qualitative data from a 11 contractors and 2 subcontractors	Descriptive, problem with data collection.	Reliance on unit rates and constants.
1987	Eastham, R.A.	The Contractors Tendering Process-Some	Qualitative data	Descriptive analysis of factors.	Variance between the academic group and estimating group.
1989	Green, S.	Tendering: ptimization and rationality	Six case studies, three with contractors and three with consultants	None stated	Range of factors that influence the pricing of unit rates.
1991	Ashworth, A. Skitmore, M.	Accuracy in Estimating	Report on historical tender studies	Secondary descriptive statistical analysis	Difficulties in establishing a measure of estimating performance.
1991	Oteifa, S. Baldwin, A.	Estimators' tasks and computer aided estimating systems: A surevy of FCEC member companies	83 questionnaires to civil engineering contractors	Descriptive statistics	Estimator's expertise a key aspect, a ranking of tasks requiring high expertise. Main focus was whether the CAE package was supporting the estimator.
1992	Mak, S. Raftery, J.	Risk Attitude and systematic bias in estimating and forecasting	62 Questionnaires to undergraduates	T test and chi squared tests	Some biases are found when analysing decisions.
1993	O'Brien, M.J. Pantouvakis, J.P.	A new approach to the development of computer aided systems for the construction industry	None identified, a theoretical model	Demonstration s, a conceptual model.	An integrated database approach to information storage and retrieval based on trad. Practice.

Table 2.2 Estimating process research

Date	Authors	Title	Data	Data analysis	Findings
1993	Shah, A.A.	Factors considered in tendering decisions by top UK contractors	85 questionnaire responses to 300 contractors.	Descriptive statistics	Reliance on judgement when making bidding decisions, no use of formal models.
1994	Skitmore, M. Wilcox, J.	Estimating processes of small builders	6 Structured interviews with small building organisations	Statistical multi variate analysis	Little risk appraisal, reliance on judgement rather than analytical methods and use of programme rather than docs. To identify preliminary allowances.
1994	Tah, J.H.M. Thorpe, A. McCaffer, R.	A survey of indirect cost estimating practice.	Questionnaire to 6 organisations	Descriptive tables, no statistical analysis due to sample size.	Tendering process examination, little use of risk analysis.
1998	ConstructIT	Benchmarking best practice, Cost estimating and bidding.			
2000	Akintoye, A. Fitzgerald, E.	A survey of current cost estimating practices in the UK	Questionnaire survey, 84 returns	Parametric statistical analysis	Conventional approach to estimating practice, tended towards an overview rather than detailed analysis of approaches.
2000	Akintoye, A.	Analysis of factors influencing project cost estimating practice	Questionnaire survey, 84 returns	Parametric statistical analysis based on data collection from first stage	Factorial analysis of factors that influenced practice, the issues of procurement were not taken account of.

Table 2.2 Estimating process research (Cont'd)

There has been little empirical work uncovered during this study that has considering the ex ante processes used by contracting organisations to collect information from their supply chain and how the organisation uses this information during the estimating stage. The tender environment is difficult to

research due to sensitivity and access to information however the organisations approach to their supply chain, how procurement as an external environmental factor and how the supply chain technology influences communicative behaviour should assist with a better theoretical understanding of contractors and their project organisational structures. The organisational theory that underpins organisational economic behaviour is transaction economics and it requires explication in order to further elaborate the theoretical framework for this research.

2.7 Towards a Framework for the Investigation

A theoretical framework was required in order to study the factors that affect the information exchange between the supply chains and contractors and the use of such information. This chapter has suggested that the domain of investigation that may usefully identify factors that affect the structuring of project organisations from an economic perspective should be the construction estimating process, and that an appropriate informant for the research should be the professional construction estimator. The main focus for the study was to consider the role that client procurement routes had upon the flow of economic information and the effect this information had upon price structure. This required an examination of organisational economic theory, which considers the behaviour of firms in industries that primarily adopt a transactional approach to their relationships with their supplying organisations. This is considered in chapter three.

CHAPTER 3: TRANSACTIONS AND ORGANISATIONS

3.1 Introduction

As stated in the introduction to this thesis, the area of transaction cost economics arose from early foundations of work by Ronald Coase (Coase, 1937) concerning how resource allocation took place in market economies. He suggested that hierarchies existed to economise on resource allocation and that they were more efficient than the market. His term market cost was replaced by Williamson (1981), who suggested that transaction cost was more appropriate. Williamson was vague in defining transaction costs however defines that a transaction occurs "*whenever a good or service is transferred across a technologically separate interface*" (Williamson, 1981). The operationalisation of the concept of a transaction cost is difficult and is one of the central criticisms of Williamson's work, it has been suggested that bargaining costs may be a better definition and Hodgson (1993) suggests that Arrow's (1969) (as noted in Williamson, O.E and Master, S. E. (1999)) definition as the "*costs of running the economic system*" could be considered an appropriate definition. In fact, Williamson identifies it as a concept "*in want of a definition*" and uses an analogy from physics to elaborate it *"transaction costs are the economic equivalent to friction in a physical system".* Hodgson (1993) suggested that in order to assist with the operationalisation of the concept of transaction economics, that three types of costs are involved, which correspond to three different sequential phases of a transactional exchange. These relate to "*search and informational costs, bargaining and decision costs and policing and enforcement costs".*

The theoretical work of Williamson (1981) focused upon the transactions that take place between organisations and he identified that in order to develop more meaningful economic theory that the transaction between organisations be the focus for research. "*The ultimate unit of economic activity should contain within itself the three principles of conflict, mutuality and order. The unit of analysis should be the transaction "(Williamson and Masten, 1999).* Transaction theory developed to include Coase's (1937) searching and contracting costs but also built on the work of Simon (1947) to explain costs in

terms of human and environmental factors. These were bounded rationality, opportunism and asset specificity. Williamson asserted that the firm could reduce problems through a reduction in the number of exchanges i.e. increased frequency leading to learning and the use of authority to end prolonged disputes. He identified the three main factors that consequently underlie transaction costs[1], firstly that individuals are limited in their ability to predict the future based on incomplete information and knowledge, secondly that if perfect planning were possible it would be difficult for contracting parties to negotiate around these plans due to different languages associated with different communities of practice, and thirdly, assuming that a contract could be developed to take account of the differing contingencies that exist, it would remain very difficult to translate it into terms that a third party could enforce. The economic implications for contract incompleteness are that when parties encounter circumstances that weren't originally envisaged they undertake negotiations in order to protect their interests. The conditions of the ex post negotiations rely heavily on the information provided ex ante and consequently parties can be subject to ex post opportunism. The difficulty the buyer has due to the bounded rationality of his agents is that it is difficult to identify those individuals or organisations that may be opportunistic.

To safeguard against opportunistic behaviour organisations use governance structures, (governance "*is a means by which to induce order, thereby to mitigate conflict and release mutual gain*"). They must attempt to match the governance structure with the market within which they are procuring the resource. Simple use of governance such as the spot market is inappropriate for complex transactions as the risk is that the contract breaks down whereas complex governance is too costly for simple transactions. The governance structures can be considered to vary in discrete ways in terms of administrative controls, incentive intensity and contract law regime (Turner and Simister, 2001; Williamson and Masten, 1999; Winch, 1989; 2001). It has been argued that it is impossible to compare the costs of one governance structure associated with low transaction costs with another due to the rejection of the idea of an omniscient calculation which is a result of bounded rationality

[1] These costs are determined by the propensity of the market place to provide information and the value and costs are different for different supply organisations.

(Hodgson, 1993) however governance forms do have discrete structures. The distinction is due to risk and uncertainty, (risk can be considered as parametric uncertainty, true uncertainty is un-quantifiable). Transaction costs are consequently associated with uncertainty and the firm can be said to exist to take account of this uncertainty when gathering resources. An unstructured examination of the construction industry identifies that there are a wide range of hierarchies, some with more internal resources than others, and it is impossible to assert that one structure is better than others. The transaction can consequently be considered as a unit of economic activity and that an analysis of the processes and events surrounding such a transaction could inform theory rather than the calculation of the optimum governance form.

Different governance forms such as markets, hybrids and firms have specific attributes. The hybrid modes can be considered to be more integrated and include joint ventures, relational contracting (at the core of relational contracting are the social guidelines between the parties which are the main influence on the governance of a transaction rather then the specific contract conditions (Rahman and Kumaraswamy, 2001)) and bilateral governance. More integrated governance modes have been associated with a higher degree of asset specificity, greater uncertainty, more complex transactions or more frequent exchange (Dow, 1987). Transactions, which differ in their attributes, are aligned with governance structures and can result in a transaction cost economising result. A central feature of this study attempts to uncover the factors that influence transactional exchanges and identify how these relate to the task of estimating.

3.2 Informational Uncertainty

A clear problem identified by Williamson (1996), is that given pervasive informational uncertainty, and complexity that ex ante alignment, created by..."*specifically designed systems*," means that efficient resource allocation is not possible. Emphasis has been shifted to ex post bargaining. He conflated ex ante and ex post information asymmetries[2] into a general category of

[2] There is an important distinction between ex ante and ex post asymmetries. Ex ante problems occur when one party to a transaction has less information than the other but the disadvantage

information impactedness, upon which his important assumption of opportunism is based. These information asymmetries are important as they are linked to power differentials. These relate to information, and the relative value of information to the organisation can be considered similar to other economic resources in that consumption is optimum when the marginal cost of information search and acquisition is less than its expected marginal return. Consequently a central issue informing market making firms information strategies, relates to the amount of information that the firm decides to collect, codify and diffuse amongst its managers. When information is costly to produce and manage, there is a trade off between the costs of collection on one hand and the quality of decision making on the other. One way of economising on information is to choose the appropriate level of aggregation at which to analyse the problem. The firm has to decide if it should collect information on individual subcontractors in order to generate a detailed picture of the market or should it simply form estimates of aggregate market trends.

Transaction economics suggests that specialisation occurs within the organisation to handle specific information. The extent of specialisation may be dependent upon the size of the organisation, however communication of the analysis of supply chain price information is carried out from the specialist to the adjudication group making a tendering decision. Some information is particularly costly to communicate as it has a tacit, contextual element that requires the specialist to negotiate meanings with the decision-making group. This is based upon an interpretation of project requirements and supply chain prices. If either of these contexts is unclear, a lot of effort is required to communicate the meaning of the information.

This study takes as a central aspect of the estimating process that the efficient synthesis of information involves functional specialists reporting price information to a synthesiser who handles the tendering process. The role of the functional specialist is likely to be similar within organisations, however it has been found that the larger the organisation, the more likely its employees were to work in a specialised function (Pugh and Hichson, 1976). A decision on price

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is eliminated once the transaction is completed. Ex post asymmetries occurs when one party to the transaction has less information than the other even after the transaction has occurred.

can be considered as relatively explicit whereas the synthesis is likely to be tacit and given the sensitivity of the tendering process identified above, difficult to research. The research will consequently seek to gather information upon the information requested and received by the estimator in order to explicate current practice.

3.3 Transaction Costs and Construction

Transaction cost economics has been considered in construction by a number of authors (Eccles, 1981; Reve and Levitt, 1984; Turner, 2004; Turner and Simister, 2001; Winch, 2001) whose work, with the exception of Eccles (1981) work in the USA, has been predominantly conceptual. As argued above, a theoretical framework of transaction economics can assist in the understanding of the communication that exists between parties prior to the formation of a contract, the focus being on the behavioural approaches firms take to the collection of price data, the "search and informational" processes suggested by Hodgson (1993). The relative costs of the differing governance structures is beyond the scope of this thesis as a method of assessing governance costs has yet to be established.

The recent conceptual work of Winch (Winch, 2001) and Turner (Turner, 2004) considering the relevance of transaction cost economics and the governance of construction projects provides a useful framework for the understanding of relationships between organisations, their communicative behaviour and their treatment of uncertainty[3]. Winch (2001) elaborates on Williamson's (Williamson, 1996) earlier work by identifying three fundamental elements that effect organisations relationships during an exchange of a good or service across a technologically separable interface. The factors identified were contingency (which related to a transaction and includes uncertainty, frequency and asset specificity), behavioural (that include bounded rationality, learning and opportunism) and context.

[3] Construction price and cost information are considered in this study as transaction specific assets between contracting organisations and their supply chain organisations. Construction price information is communicated ex ante from the supply chain organisation to the contractor who considers this information as cost information for onward communication to a client. Supply chain cost information is considered as the costs of the supply chain resources net of on-costs of overheads, profit and contingency.

Williamson (1981) identified that goods and services can be produced more efficiently if parties invest in transaction specific assets, which cannot easily be put to other uses if the buyer/seller relationship breaks down. These assets can include human capacity specificity (development of knowledge or skills), physical asset specificity (development of specialist equipment), site or location specificity (location), dedicated capacity (to protect from surge) or brand name (this can relate to franchises), temporal specificity that has been identified as being similar to sequential interdependence. The value of the transaction specific asset depends on the continued existence of the buyer/seller relationship; consequently one party that hasn't invested in the relationship may appropriate value by using the asset in another context. This means that if the investor is unsure as to the safety of the value yielded from the relationship, the investment may not be made. Winch (2001) suggested that the most appropriate choice of governance mode occupies a three dimensional space as a function of contingency factors i.e. learning (related to frequency), asset specificity (related to opportunism) and uncertainty (related to bounded rationality). The operationalisation of this framework was not completed and the work remained abstract. When it was applied in a project context he suggested that projects start with very high levels of uncertainty at inception until the completion of the project when all the information concerning the project is assembled and embodied within the project. Winch identified that this can be considered as similar to Porter's value chain (Porter, 1985) that identified both vertical and horizontal dimensions.

As suggested in the introduction to this study, project organisations can be viewed as temporary organisations (Cherns and Bryant, 1984; Turner 2004) via which a client assembles resources and motivates them to achieve an objective. In complex systems such as construction, clients tend to interact with multiple actors and although Winch (2001) suggests that their "line of visibility" is deeper than that in manufacturing, it could be suggested that their line of influence is not. Winch (2001) argues that contracts are written to:

> *"specify authority systems to facilitate change, provide incentive systems to motivate project actors, use administrative systems to handle uncertainties, provide conflict resolution procedures."*

It has been suggested that the only way of economising on transaction costs in construction is to increase the contractor's economic incentive to cooperate. This could be done through procurement arrangement, lengthening relationships, sharing risks in alliance agreements, increasing the importance of reputation and cooperative skills in relation to price in procurement.

Williamson (1996) identifies a spectrum of governance structures that influence the transactions of organisations, these range from the open spot markets through simple, complex contracts, relational contracting to vertical integration. Turner (Turner and Simister, 2001) used these parameters to develop a three dimensional schema of reward, risk and safeguard to analyse contract types in their ability to align client and contractor objectives by providing incentives. They identified that, as uncertainty was an unavoidable aspect of contracting that incentive intensity, adaptiveness and reliance on monitoring could be considered as dimensions of a schema that could be used to analyse the governance mechanism.

Each governance mechanism has strengths and weaknesses, reliance on open markets has been identified as providing the most incentive to maximise the net value by economising on the units of production, however the low asset specificity means that the seller can be easily replaced and results in low levels of trust. Contracts provide protection to both buyer and seller, however as they are incomplete, parties may pursue potential gains through opportunistic behaviour. In this case, more complex governance mechanisms can be used to manage the uncertainty, settle disputes and adapt to new conditions. As identified earlier, the optimum governance structure is impossible to determine however the asset specificity of a selling organisation may help to understand the relationship that exists between it and the buying organisation.

3.4 Asset Specificity and Construction

Asset specificity relates to the ability to replace the supplying organisation, this is not usually an issue for a construction client, but it may be for a contractor who regularly enters into post-contract negotiations with subcontractors to reduce their price. It can be considered to differ in nature depending on the contractual relations that exist between the parties. Pre-contract, the specificity relates to the dependence that the organisation places upon the other; post-contract, it could relate to the temporal specificity[4]. Specificity can be considered to be both organisational as suggested by Kale and Arditi, (2001) or project related and is one of the constructs used by this study.

The greater the transactional uncertainty and uniqueness and the lower the transactional frequency, the potentially higher the transaction costs that are placed upon an organisation. A system of Web-based subcontractor rating considering asset specificity and bounded rationality was developed at Stanford CIFE centre. The rationale for using the Web was that a rating system used by all parties would reduce the potential for opportunistic behaviour, as ex post performance could be rated and made visible to other parties. Source credibility theory was used as a framework for the system, which is developed in Table 3.1 (Ekstrom et al., 2003)

The asset specificity of a supply chain organisation is likely to vary with the extent of organisational specificity, identified by Kale and Arditi (2001) in providing strategic advantage, and also the specificity that is due to the bilateral dependency required by projects. This will form a central component of this study; Table 3.1 suggests that the level and source of specificity can be defined and that trade will influence typical governance structures adopted by contractors. The influence that procurement routes have upon asset specificity and bilateral dependence were also investigated by the study, the operationalisation of this construct follows in the next chapter.

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[4] Temporal specificity- the ability of suppliers to hold up the programme and hence disrupt production. (The strength of this asset specificity will relate to the subcontractor influence/power, which must relate to their technology, who employs them and the governance mechanisms, which exist)

Type of procurement	Commoditi es	Subcontractors				
Examples	Concrete	Brickwork	Groundworks	Roofing and cladding	Structural steelwork	Mechanica l and electrical
Asset specificity	Low	Low	Medium/low	Medium	Medium/high	high
Source of AS	None	Human	Locational	Locational Human	Locational Human Temporal	Locational Human Temporal
Typical governance	Free Market	Free Market	Free market	Hybrid	Hybrid/ integrated	Hybrid/ alignment

Table 3.1. Asset specificity and subcontracting after Ekstrom et al (2003)

The transactional economic framework was used in order to develop a more detailed understanding of how organisations behave under ex ante conditions of uncertainty in exchanging price information. The framework required operationalisation in order to inform data collection and subsequent analysis. The aim was to discover some key transactional attributes that differentiate organisations, their supply chains and the procurement approaches identified above. This operationalisation is considered in chapter five.

3.5 Organisations and Information

One of the difficulties faced by organisational theorists when trying to predict the structure of the firm is that organisations take a contingency approach to their structuring (Lansley, 1994) (the structure is contingent on the factors that influence it). Lansley (1994) suggested that it was difficult to measure technology in such a way that comparisons could be made across a large range of organisations and that researchers should not only focus on the technology but also on the environmental constraints that surround the firm. Referring to the work by Stinchcombe (1990), Lansley identified that general contractors were identified as having attributes of simple structures and a power culture and suggested that a study of an organisation's use of information would provide insights into project and organisational structures.

Walsham (1991) notes that information, which excludes certain alternatives, is a form of social power, which involves the forcible transformation of undecidability into decidability.

1. Any piece of information is based on a division of a whole into parts, eg designating a person as a man or a woman and the choice of the boundary for the division excludes other alternatives.
2. The person making the division is exercising a form of social power in choosing that particular boundary.
3. The infinite variety of life is essentially undecidable and that our boundaries and differences, our information, forcibly transform the undecidable into something concrete and decidable.

Walsham (1991) illustrates the above in the context of accountancy information systems, which provide

> *"information of the past performance of the business, current operating conditions and future projections. They are used as a basis for setting targets, for monitoring performance and for identifying and correcting deviances. They are however only one way of looking at the world, which institutionalises certain boundaries and ascribes a privileged position to particular numeric data. Thus accounting systems and their privileging of certain types of information can be though of as instruments of domination".*

3.5.1 Project Organisational Structure

The extent of research into the organisational structure of projects is limited due to the extent of variety of environmental factors as reported by Moore (2002). There is less variability when the economic information that forms the transactions between parties is considered. The role of information within a project structure is an essential one and is used for formation of contract, coordination of parties inputs and outputs to processes and also the economic control of organisations should misalignment occur. The role of information to manage uncertainty is not a new one, management theorists such as Galbraith (1973) argued that information processing increased when task uncertainty increased. Williamson (1981) has adapted this into information impactedness as discussed earlier under conditions of bounded rationality. Casson (2001) suggests that it is only recently that information had become a central focus for investigation by economists and suggests that many theoretic perspectives will be derived from the economics of information once theory becomes better developed. He suggested that the economy could be considered as a system

of structured information flows, the structuring of which is effected by institutions, and in particular, firms, which specialise in information needed to allocate resources properly. The costs of information collection and storage are changing dramatically and consequently information access has been suggested as changing the institutional structure of the industry.[5]

One of the critical tasks of construction professionals is to design project organisational structures that are suitable for a project environment. Studies into organisational structure tend to take one of two forms, those concerned with organisational behaviour and the environment and those that focus on physical organisational structure (Docherty and Langford, 1996). The former suggest that organisational structure has to take account of the external environment, the technology of the project, the procurement arrangements of the clients, the internal environment of the contractor and the external parties involved in the project. The project organisation has an elaborate administrative structure to take account of these factors.

The external environment in construction can be considered as a number of interacting factors upon such structures, Shirazi et al (1996) identified that the external environment can range from stable to dynamic, simple to complex and friendly to hostile. They assert that in a simple environment.

> *"Information can easily be consolidated and understood which enables the organisation to centralise control and coordinate at the top of a hierarchy with little reliance on liaison devices and mutual adjustment for coordination."* (Shirazi et al., 1996)

They suggested that the three other categories of variable that influence project structures were the certainty of the tasks associated with the project technology measured along an axis of certain to uncertain, the complexity of the required structure to take account of external parties measured along a continuum of complex (high requirement for external party input and potential for high maladaptation costs) to simple, and interdependence which was a function of the adaptability to meet future uncertainties.

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[5] The market maker can be considered as acquiring ownership of information and exploits the information in his possession. He can be considered as extracting rents from this information by buying and reselling the product. By doing this he covers his costs of collecting information out of the profits on trade.

Lansley (1994) in adapting recent organisational theory to construction suggested that the control-integration framework was a useful means of providing considering the role information played and suggested that the codification and diffusion approach of Boisot (1994) could be used to investigate organisations and information.

Boisot's (1994) approach to organisation and communication was to consider problem solving in an informational space. He adopted Shannon and Weaver's (1949) theory of communication and developed a codification diffusion (C-D) theory as illustrated in Figure 3.1. He suggested that in order to effectively communicate that resources need to be expended to; develop a communication infra structure which allows the physical transmission of messages at different levels of codification i.e. the technical process which is similar to the classification systems discussed in the previous chapter, implementation of a common coding system at different levels of codification which allows for better understanding, and the development of a shared set of values and beliefs which allows for diffusion and absorption of information and knowledge. He also suggested a means of tracking knowledge as it is used within organisations that is similar to those suggested by Nonanka (1994).

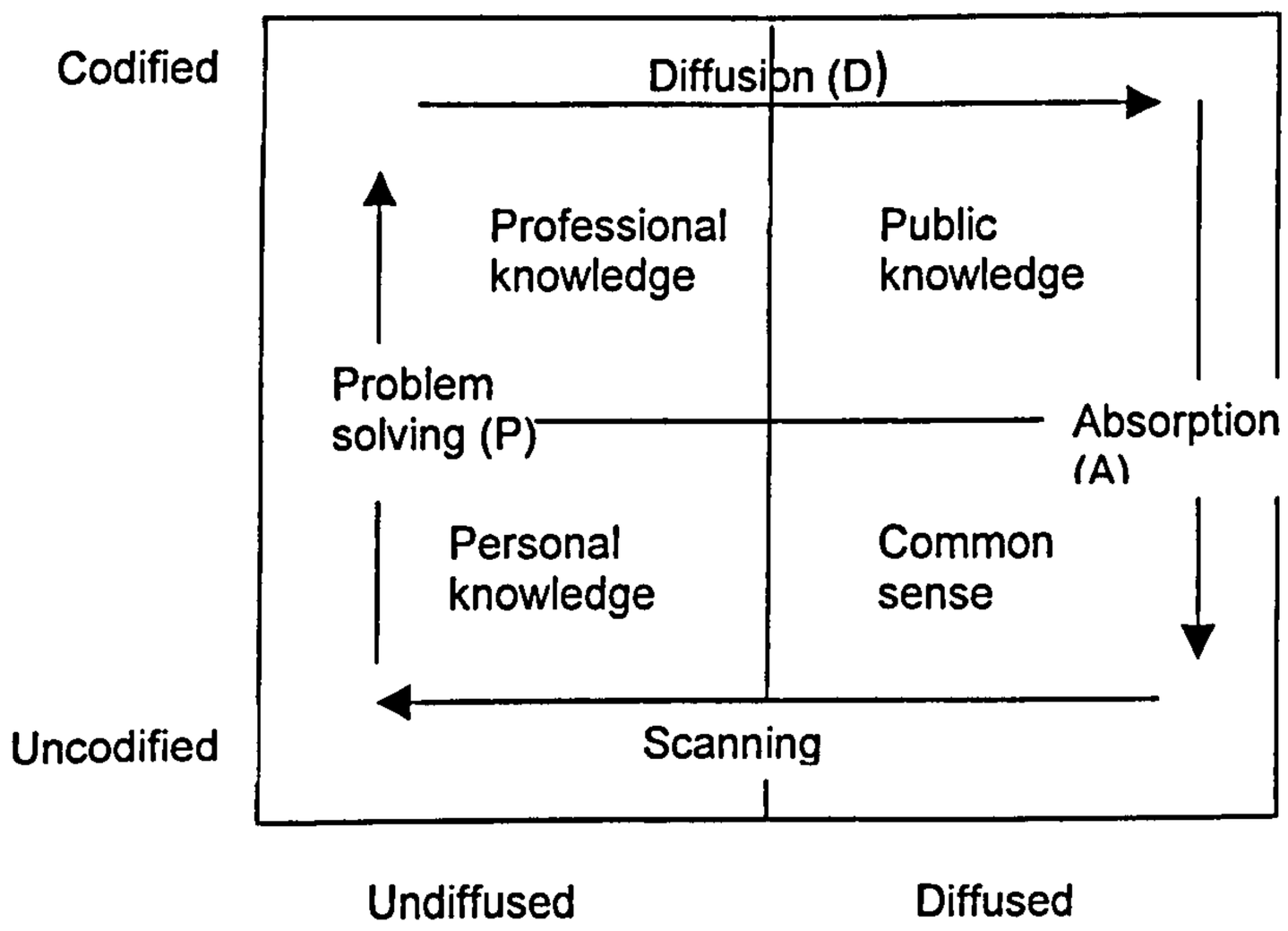

Figure 3.1 Information in organisations after Boisot (1994)

Boisot's (1995) theory of codification and diffusion was further developed to consider its application amongst different groups who have different cognitive stances towards knowledge and information however has never been empiricised within construction.

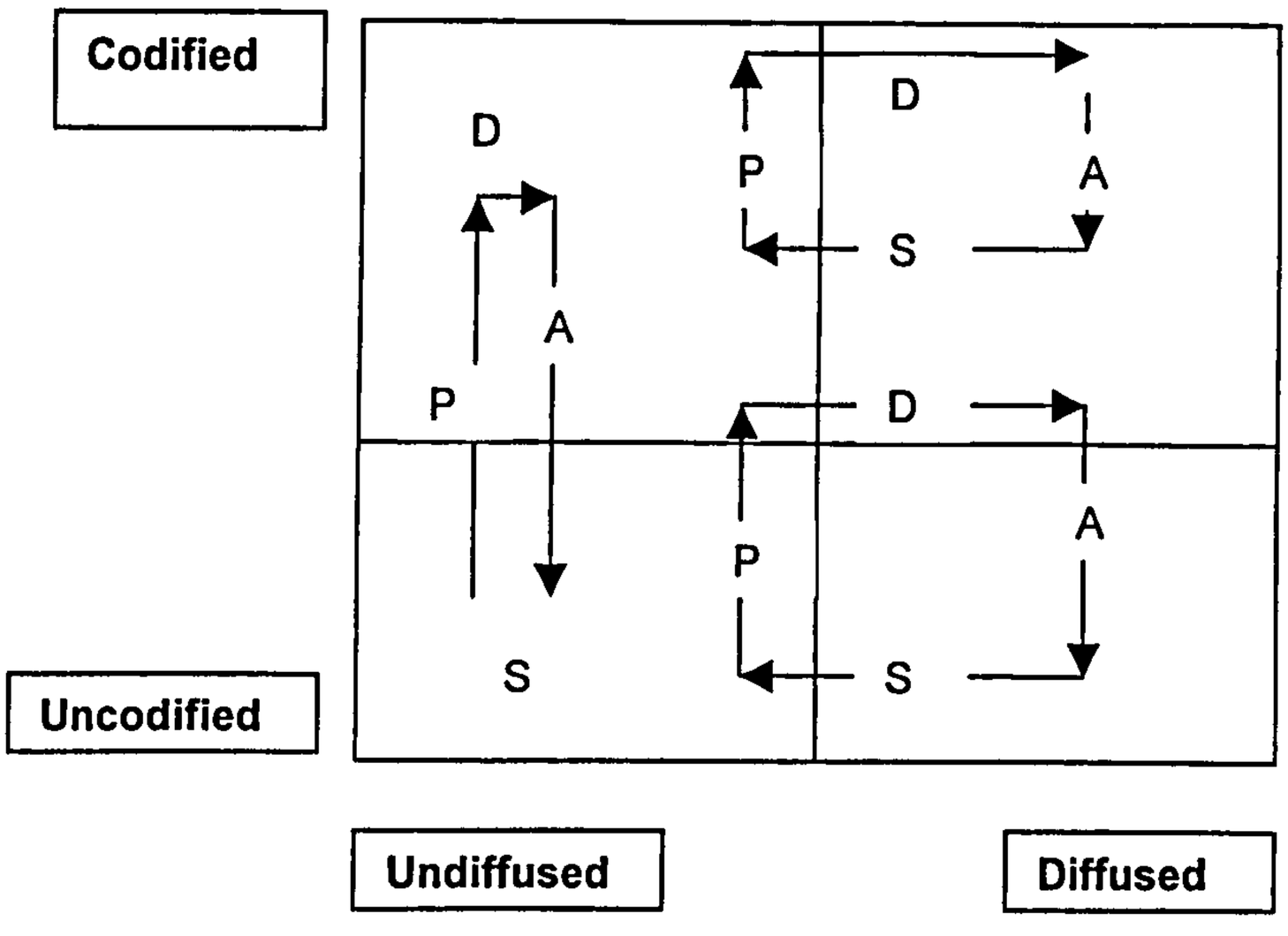

Figure 3.2 Codification and Diffusion amongst differing groups

He suggested that barriers to the completion of a cycle of codification and diffusion abound and identified that the scanning process, illustrated in Figure 3.2, may never achieve the leftward movement necessary as social and cognitive pressures stifle learning behaviour, problem solving may avoid the risks and conflicts incurred in selecting and eliminating alternative options, and diffusion may be blocked by an unreceptive audience and absorption may stall due to the inertia of existing values and attitudes. In a later work Boisot (1995) argued that organisational metaphors could also be classified into a two dimensional space as a function of integration and control as suggested in Figure 3.3 below.

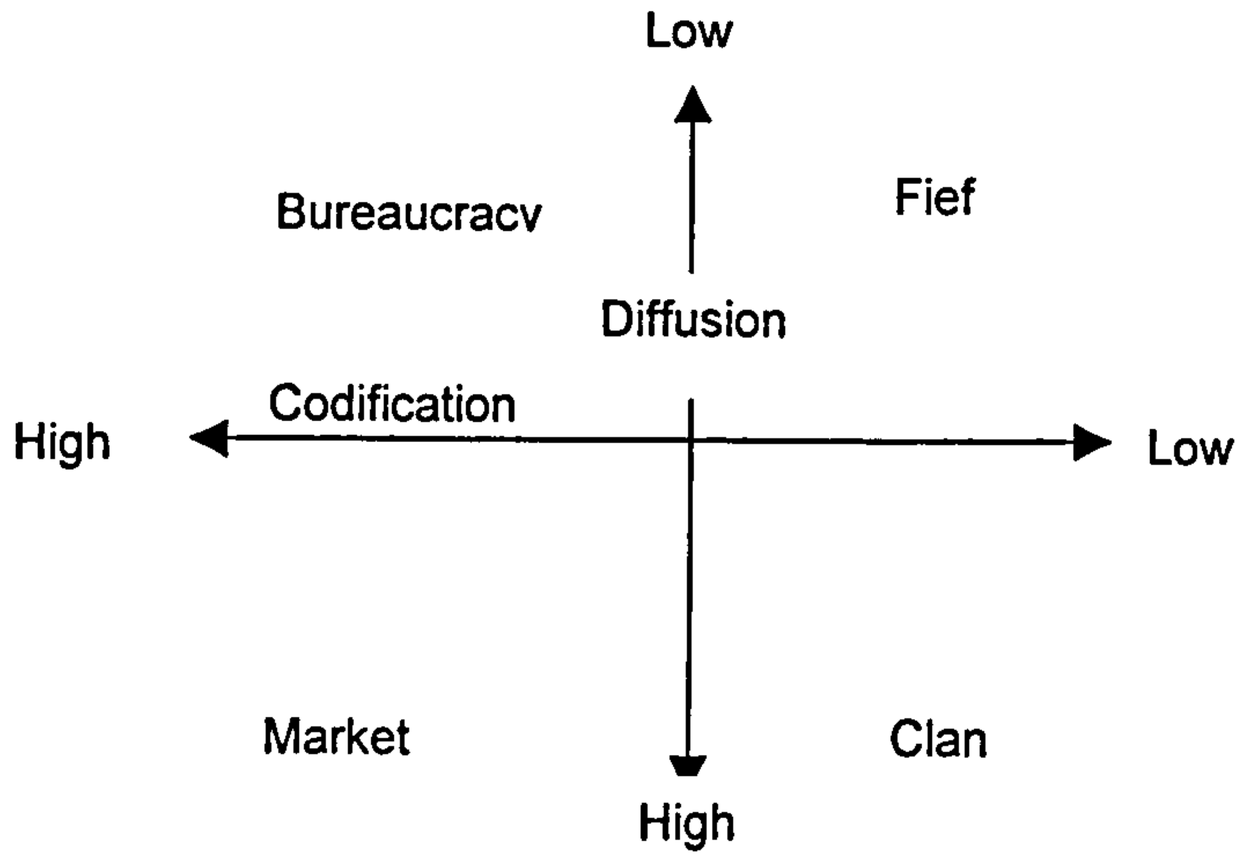

Figure 3.3 Organisational metaphors within C/D dimensions.

Boisot (1995) used the term bureaucracy to describe a hierarchy; clans were defined as small club like organisations with restricted entry, with boundaries to acceptable behaviour. Fiefs identified as tending to rely upon socialisation and an acceptance of legitimate authority. The market was defined in a similar way to that of Williamson (1981).

A high level of codification of information enables the development of clear expectations and standards of performance, which have been suggested as reducing conflict due to performance ambiguity, and also are associated with a high degree of control. This study will consider the extent of codified financial information collected and stored by organisations from their supply chain. The opportunity to diffuse information within organisations is also relative to its codification, where performance criteria are difficult to specify, it has been suggested by Boisot (1995) that diffusion is difficult to achieve.

One of the key characteristics of effective inter organisational performance is to reduce the information asymmetry between parties which allows for a reduction in performance ambiguity and also a reduction in potential for ex post opportunism. This study is also informed by the codification matrix adapted from Cox (2004) and illustrated in Figure 3.4 below.

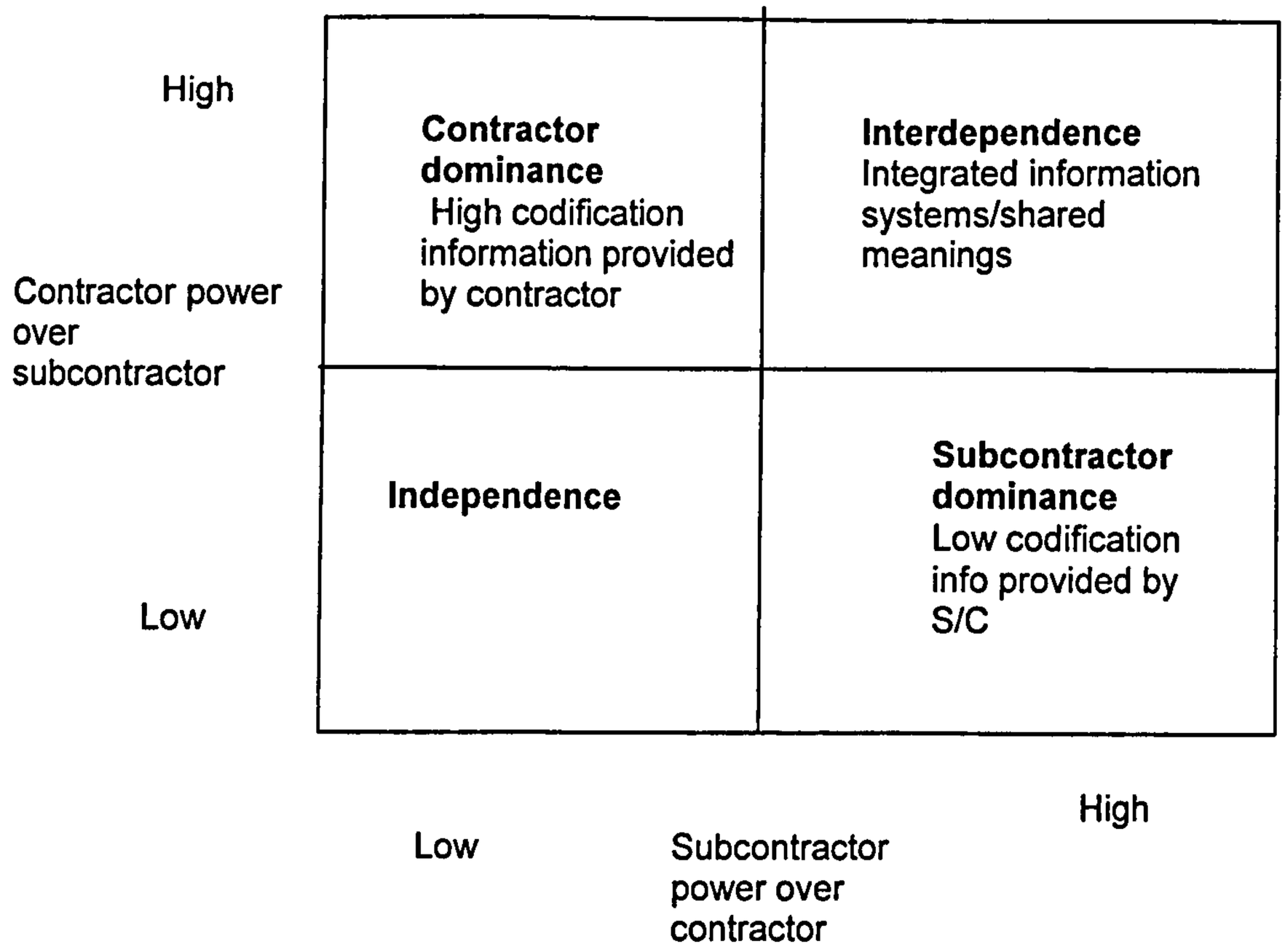

Figure 3.4 Power and supply chains adapted from (Cox, 2004)

Chapter two and three have reviewed the perspectives of researchers and practitioners on estimating practice, the way client procurement practice has changed over the last fifteen years, the increasing reliance on subcontractors and has suggested that a transaction framework could be used to develop a model that can be used to explain the estimators approach to estimate development through examination of the information they gather from the supply chain. The context of the model is presented below, followed by the research question, a series of indicative hypotheses and premises.

The factor model seeks to represent an organisational construct and as such in order to be useful, it has a context, is bounded, and seeks to demonstrate relationships between variables, and can be used to test and predict future events. The aim of this research was to develop such a model that represented the factors that affected how an organisation organised its economic information into an estimate. The price information sought and gathered from the supply chain has a provenance, level of codification and is analysed and

synthesised into an estimate. The contingent structure of this estimate is assumed to be affected by identifiable factors that can be modelled.

The variables that have been used in the study are derived from the literature search and table 5.2 in chapter 5 identifies their provenance. The variables process of critically reviewing the extant literature and piloting in the field has ensured that they are as comprehensive as practically possible in a study of this nature. A limitation is that there may be categories or measures of variable that fall outside those investigated during this study, these are reflected upon in chapter 10. The client procurement route has an effect on project estimate structure was the first proposition that the research aims to investigate. The procurement approaches have been shown to have increased in complexity over the last twenty five years however have been fundamentally categorised as integrated- design and build, sequential- traditional and sequential without financial prescription- drawings and specification. The requirement for all these forms is for a contracting organisation to converge the complexity of the project technology and inter-organisational transactions into a single deterministic price, usually in competition. In attempting to support this proposition the research will explore the underlying structure to the price. Project complexity was considered to be an intervening variable and was problematic in measurement; consequently organisational size was used as a proxy measurement. The use of proxies to represent underlying measures are used extensively in social science research however care has to be exercised when establishing the proxy to ensure it is reliable. The interviews carried out in the field during the pilot study suggested that turnover was a reliable proxy measure for project complexity. The difficulty of measurement of complexity of projects that organisations undertake remains and it can be considered as a limitation of this study. The measurement limitations are summarised in chapter 10.

As discussed in chapter 2, the external environmental variable of client procurement route has been found to have changed significantly. The influence this variable has upon the structure of the estimate will provide a dimension to the model that may assist in the explanation of the relative performance of the different procurement routes. The increased use of partnering with clients and

the supply chain over the last ten years was considered as another external environmental variable that influenced the contractor organisation's behaviour when selecting subcontractors to integrate into their project teams. The technology of the subcontractors was suggested to affect the extent of bilateral dependence and project specificity that occurs and was considered as a further independent variable that may influence the structure of the project estimate. The governance approach taken by contractors was measured by considering the extent of use of the market to gather price information.

The above variables relate purely to the external environment that the organisation operates within however the task environment of the estimator required examination as the estimator was central to the development of the structure of the estimate and makes decisions regarding the acceptability of supply chain information, in order to develop more sophistication into the model. The task environment variables related to the information complexity defined by Williamson (1996) as informational impactedness and encompassed the extent of transactional information provided by the subcontractors, the limits to the ability of the estimator to assess this information and the extent of organisation systems to support the decision maker. The intervention of the external environmental variables of partnering the supply chain to this task environment was also examined. The role the estimator played in the selection and analysis of the subcontractor's price and subsequent communication to adjudication was a further contextual factor that was suggested that may influence the estimate structure. Task environmental variables of risk perception and analysis were also be measured.

The research proposition, hypotheses and premises are stated in section 3.6 below, however the study is necessarily bounded due to the availability of resources, the difficulties in the measurement of variables and the methods of data collection employed. The study has not collected detailed information on organisational project complexity due to its difficulty of measurement, contractor's organisational governance structures and their interaction with the structure of the construction industry, all of which would require extensive resources beyond those available to a single researcher (this is the focus of a study by Stuart Green at Reading University), the impact of geographical

constraints on project team formation or attempted to measure the economic implications of the model. The study delimits organisations outside of the United Kingdom which is unique in terms of procurement routes, industry structure and client expenditure. The limitation of measurement of variables that are not necessarily exhaustive has been identified earlier as has the difficulty of using proxy measurements. The summaries of limitations of the study are presented in chapter 10.

3.6 Research proposition and Hypotheses

The central research proposition that this thesis adopts was, that organisations, when responding to price risks within their environment, develop a contingent approach to the collection and structuring of their project economic information that is influenced by identifiable and measurable factors. The justification for the methods used for data collection and analysis are presented in chapter 5 of this thesis.

The research proposition can be investigated by developing a series of indicative hypotheses, which are stated as:

- Organisations exhibit different behaviour towards the supply chain for different procurement techniques and supply chain technology has a significant affect (Hypothesis 1).

The factor structures of estimators working for organisations of a different size were explored separately. It has been argued in chapter three that provision of information from the supply chain and the technology of the supply chain influenced the estimator's ability to assess the veracity of price risk associated with these organisations.

- A statistically significant correlation will be found between supply chain technology and estimator's ability to assess:
    - Market price, (Hypothesis 2.1)
    - Technology price (Hypothesis 2.2)
    - The influence of technological change on price (Hypothesis 2.3)

- Similar but not necessarily identical components of the estimators informational environment will be a feature of different organisation sizes (Hypothesis 3).
- This was based on the premise that estimator's role in differing organisations was similar (Hypothesis 8).

If hypotheses 2.1,2.2 and 2.3 were supported (that the estimators informational environment was similar), similar sized samples would be drawn and combined to form one sample. Primary factors would be drawn from this sample as the first step to the production of a general model of contingency factors.

- Statistically significant and positive correlations were expected amongst these primary factors (Hypothesis 4).

- If hypothesis 4 was supported (i.e. the primary components exhibit patterns of correlation, it was expected that higher order factor structures would exist (Hypothesis 5).

- It was anticipated that there would be differences between the procurement, informational and organisational behavioural elements for organisations of differing sizes (Hypothesis 6).

- The higher-level factor model was expected to predict the organisational behaviour in seeking and utilising price information during the estimating stage (Hypothesis 7).

These are based on the following premises:-

Premise No.1

1. Individuals or groups of individuals have inevitable limits on their abilities to process or use information. This limited computational ability exists because of difficulties in understanding and manipulating the sense data that is available. Informational complexity exists. The rationality of

decision makers is also bounded by their competence and the information available to them

Premise No.2

2. Economic actors are faced with incomplete design and financial information, therefore economic uncertainty exists. Organisations will seek to gather as much information as possible in order to minimise errors as a result of such incomplete information.

Premise No.3

3. Contracts are incomplete and as a consequence organisations can be opportunistic in their use of the terms to gain commercial advantage.

Premise No.4

4. Theoretical explanations for organisational behaviour can run from individual to organisation. The individual adopts and conforms to organisational systems, however has an agency to act independently in the use of judgement. This agency is bounded by the market environment, the employing organisation's values and culture.

The next chapter considers the selection of an appropriate research strategy in order to investigate the research proposition.

CHAPTER 4: METHODOLOGICAL AND DATA DISCUSSION

4.1 Introduction

The introduction in chapter one gave a background to the imperatives for carrying out the study, and the literature reviewed in chapter two and chapter three identified the theoretical framework for the investigation. In order to investigate the stated hypotheses, an appropriate research strategy and design is required. The selection of the strategy is however constrained by factors that relate to the epistemological background to the area, the nature of the research question, the opportunity to collect and analyse relevant data, and the availability of resources that can be employed during the research process.

4.2 Epistemological Background

The debate upon what constitutes knowledge can be traced back to the fundamental axioms of philosophy regarding reason and observations. However, it is accepted that belief systems need foundations and that veracity (truthfulness) and reasoning are themselves part of the foundation. The assumptions made are philosophically imperfect and it is impossible to settle Cartesian doubt concerning an exact state of assurance and conviction on any subject. The central difficulty expressed by Hume, when considering scepticism, is that the harmony between minds and the world is due to the fact that the world is responsible for our minds. The minds function is to represent it however the things that the mind "knows" about the world, also serve to make that knowledge doubtful.

Consequently what is required is a coherent system of beliefs, and acceptance that there is no need to have an absolute starting point. The quotation below eloquently addresses this assumption.

> *"We are like sailors who on the open sea must reconstruct their ship but are never able to start afresh from the bottom."* Otto Neurath (1882-1945) Quoted in (Blackburn, 1999)

Epistemology has four schools of thought: rational foundationalism, based on a Descartes view that all knowledge comes purely from reason; natural foundationalism based on Hume's view that all knowledge comes from empirical data found in the world, coherentism that fundamental foundations are not required i.e. that although every argument requires premises there is nothing that is a premise to every argument; and scepticism, the view that there is no knowledge (Audi, 1998).

Methodologists when supporting competing paradigms for studying the social and natural world often cite the conflicting and competing perspectives on the philosophical nature of knowledge. The two main paradigms, positivism and interpretivism, have at their core, criteria for the evaluation and reliability of the knowledge that is derived from carrying out research.

The positivist approaches relate to a hypothetic deductive approach, in that reasoning is required takes place a priori with the development of a hypothesis that is to be tested. The testing procedure involves the operationalisation of the hypothesis or network of hypotheses, into constructs that are observable and have a corresponding set of indicators, which are used in the observation process. This allows the testing of the hypotheses by confronting them with empirical data that has been gathered under conditions that are well grounded and concur to criteria for reliability. The outcome of the tested hypotheses allows the researcher to corroborate the theory as a valid explanation of the observed data and to suggest that a causal relationship exist. The consequent advancement of science is due to the refutation of theories, the outcome being that there are only theories that are yet to be refuted. This logic of refutation is at the heart of the positivistic methodology. The theories that are stated, consequently, attempt to reduce reality to all encompassing laws that can explain and predict past and future events

The opposing view relates to a more interpretive approach to research, and one of its central axioms is that reality, particularly social reality is complex and situated in time and space, and that causal explanations can never encompass

this complexity and dynamic. The argument cited by many (Seymour et al., 1998; Silverman, 1997; Strauss, 1987) is that there is a discontinuity between the social worlds and the physical world, and that the tools that have served well to uncover laws relating to the physical world are inappropriate to the social world. This paradigm suggests that the hypothetic deductive approach to reasoning is inappropriate, and that an inductive approach should be taken to research. The inductive approach adopts an emic perspective, in that explanation is through the subjects meaning systems and understanding is central to the approach. A comparison of these two opposing approaches is given in Table 4.1 below.

Deductive methods	Inductive methods
Explanation via analysis of causal relationships	Explanation by subjective meaning systems
Generation and use of quantitative data	Generation and use of qualitative data
Use of statistical controls to allow testing of hypotheses	Commitment to research in everyday settings
Highly structured methods to ensure replicability	Minimal structure

Table 4.1 Comparison of deductive and inductive methods

The ordering of induction can be considered as the reverse of deduction as it involves moving from the place of the observation within the empirical worlds to the construction and explanation about what has been observed (Gill and Johnson, 1990). The data gathered in this approach are usually qualitative, however the use of quantitative data is not proscribed. The use of every day subjects and natural setting is considered where research is conducted and that a priori hypotheses are not appropriate. Advocates of a pure interpretive approach suggest that reality is constructed uniquely by individuals (Blumer, 1956), and in the specific situated contexts of their current time and space (Denzin and Lincoln, 2003). The philosophical roots of this are related to Hume and have given rise to many schools of "qualitative enquiry" that include:

ethnography, grounded theory, critical theory, Marxism theory, hermeneutics and post modernism (Guba and Lincoln, 1994).

Research approaches can broadly be classified into two typologies; these are based upon axioms that relate to study of the natural world and social beings within it. Guba and Lincoln (1994) identify that paradigms may be defined as worldviews or belief systems that guide researchers. Tashakkori and Teddie (1998) suggest that these can be categorised into two major social science paradigms. These are known as the positivist approach, which uses a hypothetic deductive approach to problem solving, or the interpretative approach, which suggests a more inductive approach to hypothesis development (Guba and Lincoln, 1994). The role of induction in hypothesis generation however, is also central to the positivist approach in that it arises from minds inducing connections between causal factors, the hypothesised causality being informed from the natural inductive properties of reasoning that is inculcated within individual's minds. The methods available to researchers are shown in Table 4.2 below and can be categorised as qualitative or quantitative. Although both can be used in positivistic or interpretive studies, the quantitative method has tended to be favoured by the former and qualitative by the latter.

Qualitative method	Quantitative method
Emphasis on understanding	Emphasis on testing
Focus on understanding from the informants perspective	Focus upon facts and/or events
Interpretive approach	Logical and critical approach
Observations and measurements in natural settings	Controlled measurement
Subjective "insider view" of the data	Objective view, distant from the data
Explorative orientation	Hypothetical deductive; focus upon hypothesis testing
Generalisation by comparison of properties and contexts of individuals	Generalisation by population measurement.

Table 4.2 Comparison between methods adapted from Cassel and Simon (1994)

In the construction community there has been considerable debate regarding the contribution that the two paradigms can make to theory development. The polemists in the debate claim superiority for their paradigm. Seymour et al (1997) suggesting that methodological purity is required and that the social world has within it social actors that require interpretive approaches and suggest that the objects of study are people who attribute meanings to what they do (Seymour et al., 1998) and identifies that "*some of the orders of knowledge that (construction managers) draw upon in their working lives can be considered as …common sense, practical reasoning and know how.*"

The positivist paradigm polemist, Runeson (1997), argued that the assumptions that were at the heart of the interpretive approach were essentially nihilistic, and that a rigorous positivistic approach was required to ensure that the theories that are applied to construction management are generalisable and useful.

> *"The use of the scientific method to investigate human behaviour is based on the premise that regularity exists…. Further investigation into the cause and effect relationship relates to the body of knowledge that provides empirical support for existing theory or discovery of new theory.*" (Runeson, 1997)

A more central ground suggested by Wing et al, (1998) and Raftery et al (1997), who urged researchers not to engage in "turf wars" regarding methodologies and that a pragmatic approach should be taken being aware of the shortcomings of the differing paradigms and also the ensuring that the methods used were implemented with rigour. This approach was also supported by many researchers in other fields of enquiry (Cassel and Symon, 1994; Cresswell, 1994; Dixon et al., 1987) who suggested that it is difficult to argue in favour of one single approach based purely on epistemological grounds as what constitutes knowledge was still an unresolved philosophical issue. Wing et al (1998) suggested that researchers in construction management avoid "paradigm wars" and suggested that construction management research should be in an era of methodological pluralism.

> *"it is important that the problem and associated key concepts are defined clearly and the methods used, underlying assumptions and limitations are transparent and defensible".*(Wing et al., 1998)

The central aim of this study was to attempt to develop a model of the contingent factors that can be used to predict or explain the structure and formation of temporary multi organisational teams constructing construction projects. The philosophy underpinning the thesis is that there are patterns to organisational behaviour and to collection of price information, which can be observed and modelled. The consequent model would have applicability beyond the sample of organisations that were used to form it; therefore, reliability is a key criterion for assessment of the selected methodology and method. This is a positivist criteria, and it has been suggested that three criteria are used when assessing the approaches: internal validity; whether or not what is identified as the cause actually can be interpreted as producing the response, external validity; whether the research findings can be generalised beyond the research sample and reliability; relating to the constancy of the findings. The assessment of how the methods meet these criteria is discussed later in this chapter and in chapter 7.

4.3 Selection of a Research Strategy

A research strategy was required which would be appropriate to the study of the problem. The approaches considered have been highlighted above, and the approach taken must access organisational data on organisational behaviour from informants who were authoritative and reliable. It was decided that a pragmatic approach would be taken, assuming that, whilst recognising that informants were individuals with an agency to make decisions that this decision-making would be informed by their social milieu and that their conduct would be intrinsically meaningful and capable of modelling. The research strategy should consequently aim to gather data that would have an ecological validity (Tashakkori and Teddlie, 1998) i.e. relating to the social context of the study and a population validity. There are three primary stances to the selection of a research strategy; proponents of a-paradigmatic stance argue that philosophical assumptions are useful however should not drive practical considerations, which are derived from the research problem being studied (Patton, 2002). The second stance is a dialectic position where the intentional mix of methods requires a mix of philosophical assumptions, which strengthen the outcomes (Green et al., 2005). The third stance is a pragmatic one, where

there is less emphasis placed on the philosophical traditions and has been considered as appropriate for the research in this study. The study adopted a series of indicative hypotheses and used a combination of positivist approaches to gather numerical data in order to provide a basis for further investigation and also gathered richer data. The general linear model used a factorial design to test hypotheses in order to provide a context for the identification and analysis of factors that were identified by the factor analysis approach. A factor analysis of quantitative data can be considered as an interpretative technique (Bryman and Cramer, 2001) and can be used to identify general concepts that bring together a range of correlated variables.

One of the constraining factors in carrying out any research is the resource available for its completion, such as the physical resources e.g. access to organisations, information, financial restrictions and the human resources, such as time available. These factors, whilst not being the main ones, had to inform the selection of the most appropriate research strategy.

The nature of the research problem required an examination of ex ante behaviour by constructing organisations that could be undertaken by either a survey method, in depth case study approach (with the researcher embedded within the case), a longitudinal analysis of an organisations behaviour, or a mixed methods approach. The advantages and disadvantages of each are illustrated in Table 4.3.

Method	Advantages	Disadvantages
Survey	Control over timing, content and target	Epistemological Difficulties in design Targeting
In depth case study	Realism	Access Availability of data Availability of researcher
Longitudinal study	Reliability	Availability of researcher Access to records
Mixed method approach	Triangulation Researcher control	Range of skills required Loss of purity

Table 4.3 Methods available to study problem

The advantages of a survey approach are that it can be carried out at a distance and at a time that is convenient to the researcher. The study was conducted over a period of six years, consequently, this approach could be integrated into the working environment of the researcher. However the nature of the research problem made the effective operationalisation of the variables difficult, and the study would be weakened by the difficulties the informants would have in providing authoritative data. The in depth case study strategy had advantages in that it would yield rich data from a naturalistic source, however the disadvantages were that is required the researcher to take an approach to gathering data that required large amounts of time within the organisation. This was not feasible from either the researchers employers' perspective, or the organisations being studied perspective as the behaviour under study was commercially sensitive, and it was also considered that the researcher would have an effect upon the data being gathered. The longitudinal approach was rejected due to the lack of availability of organisational records, which was explored during the initial round of the exploratory interviews. Any research approach involves a compromise; in this study, the compromise was the extent of the survey carried out in phase one and the pure compliance with the philosophical traditions of the nature of the paradigms.

In order strengthen the validity of the study, it was decided to combine both quantitative and qualitative approaches within the strategy. This involved the planned use of two data gathering techniques

4.4 A Mixed Method Approach

The mixed method approach has been successfully used in a number of recent studies (Fortune, 1999, Hall, 1999). It has its roots partly in the construct of triangulation in increasing the validity of a study by considering data from different sources, gathered under different conditions and using differing data gathering instruments (Thomas, 2003). The other underlying imperatives of using a mixed method approach are embedded within the earlier discussion regarding qualitative and quantitative methods and the underlying philosophical assumptions each of these methods embraces. Triangulation in the context of this study was considered appropriate as the literature review developed a

theoretical point of reference, this was used to develop hypotheses and operationalised constructs for measurement. These were developed a priori to the development of a measuring instrument. Although the measuring instrument was rigorously tested the weakness of this method was that the operationalisation may be flawed, the communication (internal validity) of the construct to the informants may be biased or unreliable and the analysis techniques may consequently be based on erroneous data. In order to counter these difficulties, a further point of reference was required using a different approach to data collection and analysis. This provided the third point for triangulation for this study. There has been a rapprochement, in recent times, between the construction research methodologists accepting that a pluralistic approach has credibility as suggested above.

The purpose of a mixed approach is to offer a better understanding of a social phenomenon. Green (Green et al., 2005) identified four forms of such understanding;

1. Understanding more defensibly with stronger validity and less bias
2. Understanding more comprehensively with completer pictures derived from multiple perspectives
3. More insightful understanding as fresh perspectives create concepts and meanings, as when findings diverge further analysis, reframing is required.
4. Understanding with greater value consciousness

There are two approaches to designing a mixed methods approach. The research can adopt an integrated, or component design. In an integrated design, the data from various methods inform the measuring instruments or sampling approaches of the other, and the data becomes merged iteratively. In this design, the data are no longer distinct or recognisable in origin. In the component design approach, the data retain their original form within the study, and the results inform the next stage of the research. This component approach has also been considered as a two-phase design (Cresswell, 1994). This type of design generally has a dominant and less dominant paradigm within it. The less dominant paradigm is used to enhance the results from the

dominant paradigm and also support the weakness of such a paradigm by taking an alternative or dialectic perspective.

In this study, a two-phase design was adopted which is illustrated in Figure 4.1. The first phase is the more dominant phase in the study, and adopted a quantitative approach to the collection and analysis of data. It used the results of a comprehensive literature review to inform the theoretical selection of a number of informants to be interviewed using a semi structured interview approach; the results of the data collected were used to design a measuring instrument that was administered to a sample. Multivariate statistical analysis techniques were used which to develop a model that informed the second phase of the study.

The phenomenological approach of the second phase sought to explore the worldview of the estimators within their environment, in order to gather a better understanding of the features and language used, with a particular focus upon the description and interpretation of social action through typification. This has been identified as a direct phenomenological approach that is differentiated from the indirect approach, which has been suggested as more suitable for the examination of the meanings the individual brings to a situated environment (Titchen and Hobson, 2005). The approach to the presentation of the analysis of the data in chapter eight adopts a "thick" description to allow the reader to see the description in the estimator's words of the factors in "vivo". The analysis borrows from the grounded theory approach in fracturing and rearrangement of nodes, through iterative analysis of interview data in order to 'converge' upon the common contingent factors.

The second phase of the work used a qualitative approach in order to explain the results from the first phase and used methodological triangulation as identified above. The model was consequently developed using multiple methods that allowed for richer meanings to be reflected within the factors. The main criterion to the assessment of the research strategy consequently was one of the approaches to develop inference quality.

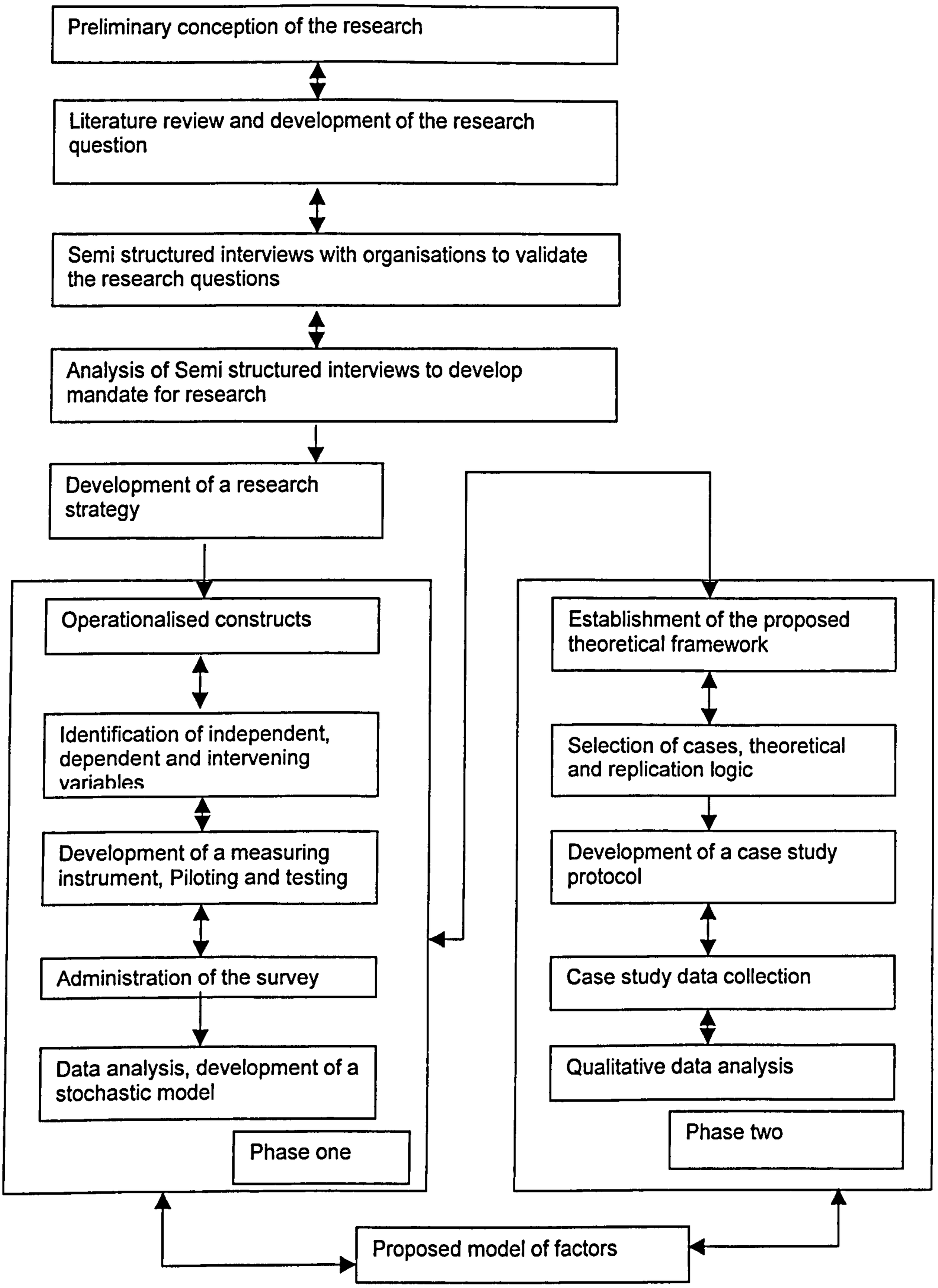

Figure 4.1 Two-phase research approach

CHAPTER 5: DATA THEORY – PHASE ONE

5.1 Introduction

As discussed in chapter five, a mixed methodological approach was identified as being the most appropriate to explore the research question. This chapter discusses the procedures followed in the design of a measuring instrument, administration of the survey and concludes by identifying the quantitative analysis techniques that are applied to the collected data in phase one of the study.

5.2 Preliminary Conceptualisation of the Study.

From the review of the literature undertaken In chapter two and chapter three, it was clear that a better conceptualisation of the study was required in order to inform the design of the instrument by which to collect data.

It was decided that the most appropriate approach was to carry out a number of semi-structured interviews with a number of senior estimators in order to get a better understanding of estimating practice prior to the development of the operationalised constructs for the study. As with all data collection methods, this approach had a number of strengths and weaknesses, the immediacy of the interview and the relational approach with the interviewer offered greatest flexibility in terms of the areas explored and also the direction of the discussion.

The central value of the interview as a research procedure is that it allows both parties to explore the meaning of the questions and the answers involved. There is an implicit, or explicit sharing and/or negotiation of understanding in the interview situation that is not so central, and not often present in other research procedures (Kvale, 1996). It was felt that this approach was appropriate as the issues being explored were conceptualised a priori, up to a point, and also it was resolved to use an approach advocated by Fortune

(1999), who suggested that a pragmatic approach was appropriate for the collection of data that reflects current practice.

5.2.1 Selection of the sample for the Pilot Interviews

To commence the evaluation of current estimate practice and to attempt to capture richer data than some of the quantitative studies discussed in chapter two, an approach to sample selection was required. As the research approach was focusing upon estimating practice in contracting organisations, it was felt that a purposeful and appropriate case be developed for the selection of information rich participants (Silverman, 1997). The participants had to have experience of the area being investigated and have an authority in the area in order to give accurate accounts. The sample, indicated in Table 5.1 was initially drawn from a range of contracting organisations with a turnover in the ranging from £8-90m based in the North West of England and Wales. A letter indicating the area of investigation was sent to the sample organisations and appointments were made to interview individual estimators two weeks after the initial contact.

Before data could be collected from the practitioners, it was considered appropriate to develop an initial proposition that would inform the data collection process. This was recommended as good practice and ensured a purpose to the discussion and also link back to the theoretical issues (Glaser and Strauss, 1967). The indicative proposition was based upon the literature review and was focused upon the estimator's role as a decision maker during the estimating processes and the structure of the estimate based upon factors influencing the task environment.

The interview schedule also sought information regarding the following areas:

- Experience of the interviewee
- Estimating processes and practice
- Information sources and communicative behaviour
- Risk perception and response
- Feedback systems

The interviews were conducted in each of the contractor's offices and lasted approximately one hour each. The researcher went to some length to develop a rapport with the subject as it was felt essential that an element of trust be developed between the parties, this is seen as being good practice and assists in the collection of reliable data (Darlington and Scott, 2002). The interview protocol was sent to the participants and their permission was sought to tape record the interviews for further analysis, the option was given for confidentiality however none of the participant requested that their transcripts remained confidential. All interviews were transcribed in order to assist in future analysis; the transcripts were copied to the interviewees for comment on their accuracy. The interviewees were willing and enthusiastic and it was felt that the information they gave was trustworthy.

Estimator	Organisation Turnover (pa)	Organisation type	Experience	Gender	Age
Peter xxxx	£55m	Main Contractor	28 yrs	Male	50-60
Ian xxxx	£8m	Main Contractor	20 yrs	Male	50-60
Nick xxxx	£90m	Main Contractor	25 yrs	Male	40-50
John xxxx	£40m	Main Contractor	15 yrs	Male	40-50

Table 5.1 Pilot Qualitative data collection: Schedule of interviewee's

5.2.2 Pilot Interview Data Collection

The interview protocol was considered carefully, as effective in-depth interviewing requires considerable skill in order to yield meaningful data and although not followed slavishly, gave a useful framework for the interview process. Descriptive questions were useful to encourage the estimators to describe their experiences and approaches to particular issues, however it was found that directly asking for a rationale i.e. using "why", was seen as being a little too interrogative and led to a loss of rapport. It was found that the use of clarification questions was particularly useful to open up areas for further explanation.

The phrasing of the questions was refined as the interviews proceeded from case to case and to ensure clarity and reliability of the questioning, the interviewer took great care to avoid the use of statements that may have biased the collected data. A research journal, as advocated by Glaser and Strauss (1967) was used collect the interviewers initial impressions, ideas reflections and observations after each interview. This was used as rich data was collected that was over and above the typable transcripts, and used to counter the criticism of qualitative data analysis that if its not typable isn't not analysable.

5.2.3 Pilot Interview Data Analysis; Qualitative Data Analysis of the Data

In order to carry out an analysis of the qualitative data generated by the interviews, the computer aided qualitative data analysis software tool Nudist 4 was used.

It is a key role of the researcher to interpret and explain the data gathered in qualitative research, and to develop an adequate and meaningful account (Strauss and Corbin, 1998). The data was broken down to enable it to be classified, and the concepts identified and created and the interconnections made between the concepts. These gave a basis for a fresh description. This was a series of related processes that involve describing phenomena, classifying it and examining how concepts interrelate (Dey, 1993).

The analysis was not sequential; rather the process involved a series of repetitive movements back and forth between the different aspects of analysis and the data (Miles and Huberman, 1983). This allowed retrospective analysis of the accounts to be carried out and a comprehensive description of the data was developed, this has been defined as 'thick description' or 'thorough descriptions' which led onto the support of categories within the data. The coding of the data was both an abductive and inductive process, in that particular phenomena were gathered into an emerging category. A process of abduction was used to find new, unknown categories based on anomalous events. In this way any 'theoretical preconceptions' could be revised or modified after immersion in the data (Seale, 1999; Silverman, 1997).

The coding followed a paradigm (Strauss and Corbin, 1987) after the first level coding was carried out which aimed at naming and classifying what was within the data. The next stage of coding aimed to "fracture" the data for the following;

- Conditions
- Interaction among the actors
- Strategies and tactics
- Consequences

The approach suggested by Miles and Huberman (1983) that an a priori theoretical framework should be used for coding and that the codes mould to the data was not adopted in this phase, as an open approach to analysis of the pilot data was considered more appropriate. The data was collected purposefully and referred back to a interview protocol. It was felt that the interviews followed a semi-structured approach, which yielded data that was considered valid.

As the analysis was undertaken the researcher kept a note of the issues that were emerging from the data, the records were in the form of memos and were in three forms, coding notes, theoretical notes and operational notes as suggested by Strauss (1988).

The findings from the data analysis of the first three interviews, yielded interesting patterns regarding estimating practice and the supply chain and it was felt that in order to consider whether these patterns are replicated within smaller organisations, an interview was organised with a smaller organisation of a turnover of less than £10m per annum. This was termed theoretical sampling (Strauss, 1987), as the initial proposition was that an organisation's size was likely to be a factor in estimating practice. A similar interview protocol was used and approach to the analysis and reporting of data was undertaken. The smaller organisation was found to rely heavily upon traditional practice of sending out enquiries to pre selected supply chain organisations and then analyse them using a comparison of unit rates. The estimator's view was that the process of estimating was unchanged however the organisation had little

experience of the newer trust based forms of procurement. The larger organisations had started to store information about the supply chain that could be used for estimating future resource costs. The interviews, data analysis and experience the researcher had in the field were used in the final questionnaire design.

A summary of the constructs, variable definitions and references used is shown in Table 5.2 below and the questionnaire design and rationale for the variable measurements are included in Appendix 2.

Construct	Questionnaire composition and measurement	Source of some literature references
Organisational demographics	18 variables, nominal and ordinal scales	(Akintoye and Fitzgerald, 2000, Abdel-Razek and McCaffer, 1987, DTI, 2004)
Procurement environment	9 variables, scale data	(Rowlinson et al., 2000, Masterman, 1992)
Risk management	46 variables, nominal and Likert scale	(Raftery, 1994, Robinson, 2000, Weyman and Kelly, 1999)
Supply environment	20 variables, scale, nominal and ordinal	(Gray and Flanagan, 1989, Greenwood, 2001, Hinze and Tracey, 1994, London and Kenley, 2001)
Informational environment	55 Variables, nominal and scale	(Jaggar et al., 2002, Bindslev, 1995b, Boissot, 1995)
Decision environment	46 Variables, nominal, Likert and scale	(Williamson and Masten, 1999, Winch, 2001)
Personal demographics	5 Variables, nominal	(Fortune, 1999)

Table 5.2 Questionnaire design of constructs

The four key components of a survey are: the identification of informants and persuasion of them to take part and provide data; the use of a standardised data collection instrument that is tested prior to sending out to the informants; systematic selection procedures justifying why the data collection instrument has been sent to the participants and finally; the use of appropriate statistical analysis in order to identify facts about the sample under investigation. Descriptive statistics can be used in order to identify facts about the sample and multi-variate statistical analysis can be used in analysing sets of variables whose values were varying simultaneously, the use of these tools is considered

later in this chapter. The key task of the survey in this study was to disentangle causal processes through the use of multivariate techniques, which were used to introduce statistical controls that eliminate complicating variables and allowed multiple scenarios, what if, questions to be answered

5.3 Questionnaire Design

The following key factors were identified as being important in the survey design;

- Design of the questionnaire and in particular the type and style of question, concentrating on the wording to ensure that appropriate terminology was used.
- The use of follow up procedures so as to convince the respondent that his/her response was needed.
- A cover letter, which indicates official sponsorship and by implication suggested the research, had credibility.
- The inclusion of a stamped addressed envelope.

De Vauss (1990) highlighted that in order to achieve a high response rate to a mailed survey that the questionnaire should be short and that the amount of work to be done by the respondent during its completion should be minimal. Oppenheim (1992) also identified design issues and indicated that the key factors in the successful use of self-administered postal questionnaires were the actual length and style of the questionnaire form itself. This aspect of the survey form was focused on particularly as the success of the research and was subject to sufficient responses to enable to carry out meaningful factor analysis and the pilot and subsequent design of the measuring instruments, rigorously tested layout, ordering and the design of questions.

In order to capture qualitative data on attitudes and behaviour, questions that could be fixed alternative, open ended or scaled in format were used. The fixed alternative questions were used to gather factual data on attributitional variables such as organisation type, procurement environment and individual attributes such as experience and age. The nominal categories for this data

were drawn from the literature review in chapters two and three and are illustrated in Appendix 2, the question wording was refined as a result of the pilot interviews. Panten (1971) indicated that piloting was important in providing guidance on the sampling frame, the length of time taken for the form to be completed, suitability on the method for gathering data and adequacy of the questionnaire, and the non-return rate expected. The piloting of the questionnaire design was initially carried out with postgraduate students studying at Liverpool John Moores University. The content and final structure of the piloting is reported below.

5.3.1 Pilot Survey

A pilot survey is a dummy run in which all the key aspects of the survey are tested including access to informants, the design of the research instrument and efficacy of the approach in gathering valid data. The pilot survey may be preceded by one or more pre tests in which particular aspects such as a particular set of questions can be assessed. Aldridge and Levine (2001) highlighted that the key aspects of a pilot survey were that quality was more important than quantity, a small scale but intensive pilot was suggested as being far better than large-scale crude piloting. That imaginative use of small-scale pre tests could be very productive. In order to make the best use of the piloting process the pilot survey was as similar as possible to the large-scale survey and a representative range of respondents for the piloting was selected.

A checklist drawn from Aldridge and Levine, (2001) was developed in order to answer the following questions:

1. Did the designated target population have the attributes for exploring the theoretical perspectives of interest?
2. Did the chosen survey design permit the logical comparison to be made when testing or exploring the hypotheses posed?
3. Could the theoretical concepts be adequately operationalised in order for questions to be asked that enable the derivation of variables?

The piloting of the questionnaire was carried out prior to the main send out. 17 non-random pilot questionnaires were sent out on 27 October 2003 indicating a return date of 14 November 2003. 12 pilots were returned and amendments were consequently made to scaling and question wording (the questionnaire that accompanied the pilot is included in the appendix to the thesis). The basis for the sampling for the pilot at this stage was by company name as no information on turnover, sector field of operation or procurement approach was available. The percentage of return of the pilot questionnaires of 71% was encouraging and responses to the open question indicated that the questions were appropriate. This indicated an interest by potential respondents in the study and boded well for the main survey.

5.3.2 Main Survey Design

The main survey was designed to be as attractive as possible; a columnar format was used with colours highlighting the questions. The header of the questionnaire included the logos of the CIOB and Liverpool John Moores University. Contact details of the researcher were also provided in case of confusion over the survey's aim. The questionnaire was designed to be as short as possible and to collect only information that related to the research questions. The questionnaire was four pages in length, with 21 questions. The proforma returned with the pilots identified that it took approximately twenty minutes to complete. The respondents were requested to tick boxes mainly and a considerable care was taken to make the design as attractive as possible. The survey was split into a number of sections requesting attribute data, behavioural data and attitudinal data. The more complex questions were presented within the middle and end of the questionnaire form and personal questions were kept to the end to gain the commitment of the informant. The piloting had trapped any ambiguous wording and areas of misinterpretation. The questions were collected together to ensure that the informant kept the research construct to mind when answering the questions and also to ensure the questionnaire was considered trustworthy, the sections were: -

Section One: Organisational information categorised into size measured by turnover, experience of the newer forms of procurement and market sector and tendering.

Section Two: Risk identification and Analysis and the supply chain approach.

Section Three: Supply chain price information and supply chain capability.

Section Four: The estimator's decision-making and information system support.

Section Five: Personal information.

Section Six: An open question on changing practice.

A statement thanking the informant was also included in the questionnaire; this was used in the second phase of the work that involved the collection of qualitative data and assisted with the theoretical sampling required by this second phase. The measuring instrument utilised a columns and landscape layout to give an ordered and interesting format to the questions. The questions were distinguished from the answer categories by highlighting them in blocks of text and increasing the font size. The final version of the questionnaire is included within Appendix 4.

The measuring instrument was designed to measure qualitative and quantitative variables. The nominal, ordinal and scale levels of measurement were utilised in the survey design and are illustrated below;

To measure qualitative data at nominal level, the establishment of categories was required; this establishment of these categories was developed in such a way that the informant can only answer the question in one category as illustrated in the question requesting the organisations field of operation.

Figure 5.1 indicates the level of measurement of an organisations field of operation. The nominal categories were drawn from those recognised within the annual construction industry statistics published by the DTI (2001). This measurement was used to identify the respondents employing organisation and allow cross industry comparisons to be measured. Good practice in survey design suggested that these categories must be exhaustive and mutually exclusive and were adopted

1 Which of the following best describes your organisations field of operation? (Please tick)	
General contracting: Building	
General contracting: Civil Engineering	
General contracting: Civil and Building Engineering	
Specialist Trade Contractor	
Other. Please indicate _____	

Figure 5.1 Format of question 1 of the measuring instrument

Table 1 in Appendix 2 indicates the variables measured at nominal level within the survey, the measuring instrument was carefully designed to increase the response rate as it has been found by Oppenheim (1992) who identified that if a questionnaire is perceived to be short the response rate will be higher than that perceived to be lengthy. To ensure that respondents were not put off by the amount of data requested, the numbering of the questions was carefully considered. Questions were numbered from 1- 21, however data was collected on 195 variables at nominal, ordinal and scale measurement.

To measure quantitative or qualitative variables at ordinal level, the establishment of ranked or ordered categories was required. As with the nominal level variable measurement, the categories should be exhaustive and mutually exclusive and the measures were drawn from the literature review.

Figure 5.2 illustrates how the questions were structured to gather data at a range of levels; measured at the nominal level i.e. does the organisation have a strategy to develop closer links yes/no, measured at ratio scale level i.e. how long has this strategy been in place and also ordinal level, where the informant was asked to rank the top five benefits.

12 Does your organisation have a strategy to develop closer links with selected specialist trade contractors/suppliers?

Yes ☐ No ☐ ***If no, please go to question 13***

How long has this strategy been implemented? ....Years

Please give your opinion on the assistance, if any, the strategy gives the estimator by ranking the top five of the following benefits:- **1=Highest, 5=lowest**

	Please Rank
Less of a requirement to send out enquiries e.g. Provision of standard unit rates that can be used for estimate development on a number of projects	
Guaranteed response to requests for quotations	
Improvement in sharing of knowledge about construction techniques	
Improvement in the communication of cost information and implications of alternative construction approaches	

Figure 5.2 The use of ordinal level scaling to gather data on partnering benefits

Likert scales were also used to gather attitudinal data at the ordinal level, this method of measurement allowed the informant to rank responses to questions that sought their opinion. There was no numerical difference between the categories identified and Figure 5.3 gives an example of the format used. A five point Likert scale was used which allowed the respondent to provide a mid range response, it has felt that this was a more appropriate means of measuring attitudes as it does not force the respondent to answer when they felt neutral about a construct.

11 Please indicate your opinion, for a typical project, on the significance of each risk that you usually have to identify/assess. (Please circle all that apply)

1 = Negligible 2 = Marginal 3 = Serious 4 = Critical 5 = Very Critical

Contractual Risks					
Inflation provisions	1	2	3	4	5
Dispute resolution	1	2	3	4	5
Contract complexity	1	2	3	4	5
Variation/claim expectation	1	2	3	4	5

Figure 5.3 Format of a section of question 11

The measuring instrument sought quantitative data of variables measured by a numerical scale. The numerical data sought on organisation size utilised an interval scale, illustrated by Figure 5.4 below. The indicator used to measure the size of the organisation was turnover and the categories are as shown. The

organisations size ranges from very small <£5m to large >£99m, a scale that has been used extensively by other construction researchers when developing nominal categories.

At the end of the questionnaire an open question was included to allow the respondents to indicate how they believed the estimating practice to be changing, if at all.

2 What was your organisations turnover in the last financial year? (Please tick)

<5m	☐
5-24m	☐
25-49m	☐
50-99m	☐
>99m	☐

Figure 5.4 Format of question 2 of the measuring instrument

5.4 Systematic Selection of Sample

Estimators, who were members of the CIOB, were the population that were chosen to be surveyed. The literature reviewed in chapter two suggested that these individuals are central to the process of organisational response to project risk at early stages. They were key decision makers considering subcontracting and that these individual were likely to be members of the main professional body in the UK. The CIOB categorise their membership by asking their members to identify the main functional group they work within. The survey aimed to develop a model of the structure of the estimate and the CIOB were seen as the professional body that construction estimators would be members of and consequently could be considered as a population that would represent good and prescient construction estimating practice. The CIOB were approached for the use of their database of estimating members and it was agreed that a mailed questionnaire could be sent. The CIOB also gave their permission for their logo to be incorporated into the questionnaire as this would add to the authority of the survey and potentially affect the return rate. The CIOB database comprised 751 individual's names and home addresses and the category of membership. There was no information on the type of

organisations, turnover or the procurement experience of the organisation. These were all factors that it was suggested by the literature as having a potential influence on the estimate. As the CIOB were unable to provide information on these factors and also as a secondary aim of the first phase of the investigation was to provide potential interviewees for the second phase of data collection, it was impossible to gather a randomised probability sample.

It was decided to undertake a full population survey of CIOB estimators within the CIOB's database of May 2003. Although by surveying the population, errors due to sampling may be minimised, errors due to the population itself may occur, in that the population may not be representative of UK construction, for example, it may be unlikely that estimators working for small subcontract organisations may have the opportunity to provide data. As the domain of the research was contracting, this was not considered to be a valid concern. The more valid concern was regarding gathering sufficient data from the nominal categories of organisational size and procurement experience. This aspect relating to the population would be considered at the data analysis stage. Additional problems that were not related to sampling were also considered at this stage and they related to the management of the data that was to be generated.

It was suggested by Fink (1995b) that an unsolicited mailed survey could attract a good response rate if attention was given to the cover letter to the survey, the reminder and any follow up procedures adopted. She has suggested that the use of incentives can also increase the response rate. The incentive that was offered for this study was a copy of the results of the analysis would be sent if requested. It was recognised that this was a modest incentive and potentially might have little effect on the return rate.

It was suggested by Robson (1993) that an unsolicited mailed survey could attract a good response rate if an initial letter inviting participation was sent. This suggestion was adopted, the efficacy of which is reported below.

5.4.1 Follow Up Procedures

The follow up procedures advocated by Oppenheim (1992) were adopted. It was necessary to be able to identify non-respondents in order to send a follow up letter. In order to do this, a reference number was placed on the back of each return envelope. It was felt that this would be non invasive and also would not discourage informants to return to questionnaire through fear of identification. As identified as good practice by Robson (1993), and in order to maximise potential returns, an initial letter inviting respondents to take part in the survey was mailed one week in advance of the main survey to 603 (80%) of the sample frame. It was decided that a number of individuals would not receive a preliminary letter, in order to investigate the effectiveness of this approach. The survey was sent by mail on 1 December 2003 with a return date of 14 December 2003. Care over the wording of the letter was taken, the support of the professional body was cited, and the importance of the research to the industry and the value of the informants' response were highlighted. The initial letter stated that the mailed survey would be sent within two weeks.

5.4.2 Main Survey

In total, 710 copies of the questionnaire were sent out to practising estimators in December 2003. The questionnaire package included a covering letter describing the purpose of the study, a four-page questionnaire and a pre paid envelope addressed to Liverpool John Moores University. The covering letter stated that the survey was confidential and that informants wouldn't be able to be identified from the analysed data. The survey was sent by mail on 1 December 2003, with a return date of 14 December 2003. It was acknowledged that the timing of the survey may have an impact on the returns, as it was just before the Christmas period, the construction industry was experiencing a period of intensive activity and estimators were central to completion of year end project budgets for clients. It was felt that despite these concerns, the survey should go ahead, as any later the questionnaire may get caught in with Christmas mail and that the follow up could occur early in the New Year at a potentially slack period.

55% of the 311 returns were received within two weeks of the initial mailing, this speed of response was similar to that reported by Fortune (Fortune and

Lees, 1996) and identified by Panten (1971) as usual. The overall response rate by the cited return date was 27%, which was considered as low. Moser and Kalton (1971) indicate that returns of less than 30% would lead to bias in the results which may be considered as unreliable, consequently follow up procedures were implemented. The individuals who had not responded to the initial survey were identified and in the week commencing 04 January 2004, a follow up letter was sent, four weeks after the initial mailing. The follow up letter included an additional copy of the questionnaire and reminder.

The final total response rate was 41.3% when measured in March 03, this can be considered as high compared to other recently reported survey response rates such as Akintoye (2000).

5.5 Data Coding and Analysis

Responses to the 21 questions were coded to give a total of 199 variables. The total sample size was 310, although there were a small number of missing responses to certain questions, which will be considered in the analysis of the data. The data were analysed with the aid of SPSS windows (Statistical Package for Social Science), which provides a range of data management and statistical techniques (Field, 2000). The statistical methods used, included chi squared, correlation, analysis of variance, factor analysis and multiple regression and the rationale for their use is given below.

The variable used to form the comparison group can be called the comparison group variable or independent variable, or is sometimes called the criterion variable. Both these terms were used in the data analysis that follows in chapter six.

The data collected by the survey fell into a number of related categories, independent or uncorrelated groups, or samples or related samples, or matched. For the estimating practice survey, where the data related to organisations practice and was compared with other organisations practice, the sample was considered as falling into the independent or uncorrelated group

category. When an analysis of the differing practices within an organisation was carried out, for example to investigate whether an organisation took a varying approaches with different procurement routes, the data was considered as being from a correlated or related group.

5.5.1 Stochastic Analysis

There remains an unresolved issue in data analysis, as to when parametric or non-parametric tests are used. The term parameter refers to a measure, which describes the distribution of the population such as the mean or the variance (Antonious, 2003). Parametric tests are more powerful than non parametric, a key assumption is that the sample is large enough to represent the population. Since parametric tests are based on the assumption that characteristics of the population from which the sample is drawn are known, they are called parametric tests. Non-parametric tests are so named because they don't depend on assumptions about the precise form of the distribution of the sampled population.

Fink (1995a) suggested that parametric tests should only be used when the data fulfils three conditions; that the level or scale of measurement is of equal interval or ration scaling, i.e. greater than ordinal, that the distribution of the population scores is normal and finally that the variance of both variables are equal or homogeneous. Tests have been carried out to assess the effect of divergence from these criteria, which have found that the results were not significantly affected so long as sample sizes are large. It has been also been argued that parametric tests can be applied to ordinal data so long as the first condition regarding level of measurement has been satisfied, as tests apply to numbers not what they signify (Tabachnick and Fidell, 1999). Regarding the second and third conditions, studies have shown that where samples have been set up artificially to violate these conditions that the results don't differ significantly (Allen and Skinner, 1991). In conclusion when parametric tests are utilised, it has been suggested by a number of authors (Nachmias and Nachmias, 1976; Sapsford and Jupp, 1996) that an equivalent non-parametric test is used for comparison. The following are the range of tests that were applied to the survey data during the analysis reported in chapter six.

5.5.2 Chi squared

The Pearson chi squared test is a non-parametric test and was used to investigate whether there is a significant variability of response within a set/group of responses. SPSS identifies the degrees of freedom, which refers to the number of components, which are free to vary. The method for the use of the chi square test on the data set was to establish contingency tables, the convention of identifying the independent or categorical variable as a column was used (De Vaus, 1990). The respondent's returns in certain nominal categories precluded the use of the chi square test in certain cases as one of the conditions for the use of chi squared is that the number of cases within a cell must exceed five (Allen and Skinner, 1991), whenever this was the case the non parametric binomial test was used.

$$x^2 = \sum \frac{(O-E)}{E} \qquad O = observed \qquad E = \text{exp}ected$$

5.5.3 Correlation and Variance

A correlation can be a linear relationship between variables. The variance of a single variable represents the average amount that the data varies from the mean. Correlation coefficients measuring the strength and direction between pairs of variables were used and were dependent on the level of measurement of the data. The two types of correlation coefficient, Pearson's r and Spearman's rho, were used for the data analysis were linear correlations and were used to establish the correlation between variables measured at interval level. The linear measure of correlation used was Pearson's product moment correlation, a parametric test, and was used with data that was interval or ratio, (Bryman and Cramer, 2001). The aid used to interpret the correlation statistic was the coefficient of determination that gave a more representative measure (Bryman and Cramer, 2001).

Variance

$$S^2 = \frac{\sum(x_i - \bar{x})^2}{N-1}$$

$N = sample\,size$

$x = \text{var}iable\,size$

$\chi = mean$

Co-variance

The averaged sum of the combined differences is known as the covariance

$$\text{cov}(x,y) = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{N-1}$$

$x = \text{var}iable$

$y = \text{var}iable$

$N = sample\,size$

A positive covariance indicated that as one variable deviates from the mean, the other variable deviates in the same direction. A negative covariance indicates the converse situation. To overcome the problem of dependence on the measurement scale, the covariance was standardised and is referred to as the correlation coefficient r shown below.

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{(N-1)s_x s_y}$$

5.5.4 Ordinal Data Correlation

A large proportion of the variables were measured at the ordinal level. In order to establish correlation between ordinal data and where the data were non-parametric, the rank correlation methods of Spearman's' rho or Kendall's tau was used, the latter is said to be more robust with smaller samples of n<30 and was used at the appropriate stage of the analysis. The consequent use of correlation for non-parametric ordinal data was used to identify linkages between ordinal data. The other proportional reduction effect (PRE) measures of association used when both variables were measured at ordinal level were Cramer's V and Gamma. The level of measurement and the size of the contingency table determined the appropriate non-parametric correlation measure; the following rules adapted from De Vauss (1990) were used for the descriptive data analysis.

1	*Nominal-Nominal. Contingency-table analysis in conjunction with chi-square as a test of statistical significance, to test for strength of association, Cramer's V or Phi was used.* $\phi = \sqrt{\frac{x^2}{n}}$ *n=number of cases in the data set. Cramer's V formula, this variation of Phi,* $v = \sqrt{\frac{x^2}{n(k-1)}}$ *where k is either the number of rows or columns in the table. Ordinal-Ordinal. Spearman's rho or Kendall's tau and their associated significance tests.*
2	*Interval-interval. Pearson's r and regression for estimates of the strength and character of the relationships*
3	*Dichotomous-Dichotomous- As 1 above and Phi was used*
4	*Interval-ordinal. Contingency table analysis was used as there were few categories in both ordinal and interval variables. Where the interval variables were unambiguously identified as the dependent variable and where the ordinal variable had few categories, an analysis of variance using F was used.*

Cohen and Holliday (1982) suggested the following rule of thumb for interpreting correlation, 0.19 and below is very low, 0.20-0.39 is low, 0.40 to 0.69 is modest, 0.70 to 0.89 is high and 0.9 to 1.0 is very high. There is little agreement on what should be used (Fink, 1995a; Bryman and Cramer, 2001). The above measures of correlation were used on the data set and were used with this limitation.

Table 5.3 adapted from Bryman and Cramer (2001) usefully summarises the tests that were carried out within, the tests used for this data analysis are shown in bold

Nature of criterion variable	Type of test	Type of data	Number of comparison groups	Name of test
Categorical: nominal or frequency	Non-parametric	Unrelated	1	Binomial
			2	**Chi square**
			2+	**Chi square**
Non-categorical	Non-parametric	Unrelated	1-2	**Kolmogorv-Smirnov**
			2	Mann-Whitney U
			2+	**Median**
			3+	**Kruskal-Wallis H**
	Parametric: means	Unrelated	1-2	T
			2+	**One way and two way ANOVA**
	Parametric: variances		2+	Levene's test

Table 5.3 Summary of data analysis techniques applied to survey data

The following rules taken from De Vauss (1990) were applied when using the appropriate non-parametric statistical measures of association for mixed levels of variable measurement.

When one of the variables was nominal and the other ordinal, for example when considering the risk significance of inflation (ordinal data) across a number of organisation's turnover (nominal data), one of two approaches was used to select the most appropriate correlation coefficient.

1. Dichotomous variables: If one variable has only two categories, ignore its level of measurement and let the other variable determine the choice of co-efficient. i.e. if subcontract strategy is cross tabulated with an ordinal variable, treat both as ordinal and select the appropriate statistic, i.e. Gamma.

2. Use a weaker statistic i.e. if one is nominal and the other ordinal, use the correlation coefficient that assumes both variables are nominal.

5.5.5 Analysis of Variance

Analysis of Variance (ANOVA) was used when the categorical variables had more than two levels of measurement, for example this was used to consider risk perception of estimators working for organisations that fell into five categories of turnover. ANOVA compares whether the average values or levels of one variable (the means of the dependent or criterion variable) differ significantly across categories of the independent variable. The F value was identified when the result was significant, the conventional approach of identifying the degrees of freedom and data set size are shown after the F value as well as the significant value e.g. $F(4,220)=2.748$, $p<0.05$. The post hoc Scheffe test was used to identify the significant differences between the groups and aid the discussion on the data analysis.

5.6 Factor Analysis

Factor analysis is a statistical method by which abstract concepts can be induced from the data set (Netemeter et al., 2003). It assumes that a set of variables combine to form an underlying dimension or factor, which is established by analysis of the correlations between the subjects responses on the variables under consideration. Basic descriptions of the stages of carrying out a factor analysis are given along with a rationale for the selection of an appropriate technique and procedure.

Factor analysis has been used extensively in other disciplines to uncover regularities that exist within data and has been used in construction by Akintoye (2000) to categorise factors that cause project estimate inaccuracy. It can be used when there are hypotheses about underlying structure, that researchers can use when they believe there exist a limited number of factors (Tabachnick and Fidell, 2001). One of its most useful functions is its data reduction property, where a large number of variables can be collapsed into factors describing general concepts. The technique was used to assess the task environment of the estimator, particularly the ability to assess supply chain data and the informational complexity of their environment.

There have been a number of criticisms concerning the use of factor analysis, these relate to the degree of subjectivity that exists in interpreting and labelling the underlying references (Field, 2000), and that insufficient attention is given to the selection of the variables that define the domain (Pedhazur and Schmelkin, 1991). In order to address these criticisms in the data analysis for this thesis, the literature review was reviewed again following the analysis in order to develop meaningful descriptions of the factors. The variables being studied had been developed through intensive piloting.

Specific limitations and assumptions are associated with each stage of carrying out a factor analysis. These relate to the data, the selection of an appropriate technique, the adequacy of the extracted factors, and the interpretation of the factors and the naming of the factors.

5.6.1 Data Considerations.

The data considerations relate to the level of measurement, the factorability of the correlation matrix, univariate and multi variate normality and linearity, the sample size and how to treat missing variables.

5.6.2 Level of Measurement

As identified earlier, when considering the level of measurement of a variable there are conflicting views regarding how to approach ordinal data. The view taken (Miller et al., 2002) is that the errors that arise from treating ordinal are minimal when considering the statistical possibilities that arise from its use. The first stage in factor analysis is to carry out a correlation matrix using Pearson's r as a measure of correlation. In this study for the purposes of factor analysis, the ordinal data have been considered as quasi interval and a correlation matrix using Pearson's r was developed. All correlation matrices and associated tables for the factor analyses are included within Appendix 7.

For a correlation matrix to be factor analysed, several moderate bivariate correlations should exist. An initial impression of the factorability of the matrix can be via the use of Bartlett's test of sphericity, Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the inspection of the anti image correlation matrix. The first test is particularly sensitive to sample size and can reject the null hypothesis even when correlation is low. The sample size in this study exceeds 310, consequently the recommendations of Tabachnick and Fidell (1996) are adopted which was to principally use the KMO test which represents the ratio of the squared correlation between the variables to the squared partial correlation between the variables. The measure varies between 0 and 1. If the value is close to one, this indicated that the patterns of correlations are compact and factor analysis can yield distinct and reliable factors. Kaiser (1974) reported in Field (2000) suggests that values of above 0.5 are acceptable however in this study a higher level was used which required the KMO value to be above 0.7 which would provide a more robust pattern in order to inform phase two.

5.6.3 Normality and Linearity

The underlying shape and linearity of relationship between the variables is not important to the application of factor analysis, however the solution is enhanced is they are normally distributed and display a linear relationship (Tabachnick and Fidell, 2001). The data in this study have been checked for normality and skewness, and although some skewness does exist, it was considered to be minor and transformation of the data was not carried out.

5.6.4 Sample Size

There exist a variety of views on what constitutes an appropriate sample size. Comrey and Lee (1992), reported in Tabachnick and Fidell (2001), identify that as a guide, that samples sizes of 50 are very poor, 100 as poor, 200 as fair, 300 as good, 500 as very good and 1000 as excellent. Tabachnick and Fidell suggest that as a rule of thumb that 300 cases are sufficient, 150 if solutions have a factor loading exceeding 0.8. This study adopts these recommendations.

5.6.5 Missing Values

The assumption is made that the missing values of variables are randomly distributed within the sample. There are three methods of treating missing values which are either to exclude the cases with missing values list wise, exclude the cases pairwise or to replace the missing values with the mean. The sample of data collected was 310 and just fell within the acceptability category above. It was decided to retain cases with missing variables as to exclude them would reduce the sample size and consequently weaken the analysis. The replacement of the missing values with the mean of the variables was consequently adopted.

5.6.6 Selection of an appropriate technique for factor extraction

There are two processes to determine the number and structure of the factors. These relate to extraction and rotation. The one used for this study is the most commonly used and is called principal component analysis (PCA).

When using PCA, there are two criteria for the selection of the number of factors to extract. The first is to determine the linear components within the data set by calculating an Eigenvalue. Eigenvalues indicate the importance of a particular vector. The Eigenvalues used in this study are those that exceed 1. The tables within the appendix for each factor analysis identify the Eigenvalues for the factors and are shown within the descriptive statistics where appropriate. The Eigenvalue after rotation is also shown to identify the percentage of variance accounted for by a particular factor. Another technique used in this study was to visually identify the Eigenvalue scree plots produced by the data set, and to consider the number of factors before the plot straightens out. The final assessment was to consider the components matrix, which identified the factor loadings of the variables on the factor. To ensure that trivial factors were excluded, a criterion of ensuring that the average communality was over 0.6 was taken when the sample size exceeded 250. The factors were rotated during the analysis.

There are two basic approaches to rotation of the factors, they can be orthogonal which assumes that the extracted factors share no association or they can be oblique which allows for the possibility that the factors share an association and may be related to each other. Orthogonal or varimax rotation was used in this study and the rotated transformation matrix was used to identify the variables. There are a number of conflicting views regarding the most appropriate method for rotation; Tabachnick and Fidell (2000) suggest that both approaches should be undertaken and Field suggests that varimax "*tries to load a smaller number of variables highly onto each factor resulting in more interpretable clusters of factors*". This latter approach was adopted for this study as this would closely limit the propositions for study during phase two of the study. This assumption of no association between the factors was carefully considered when naming the factors to ensure that there was no implied co-dependency.

5.6.7 Interpretation of the Factors

An assessment of the common features of the variables that loaded strongly on a factor was used to arrive at a label. The loadings less than 0.32 were suppressed within the tables included within the appendix, as the common practice is that loadings above this figure represent substantive values. Comrey and Lee (1992), reported in Tabachnick and Fidell (2001), suggest that the loadings in excess of 0.71 are excellent, 0.63 very good, 0.55 good, 0.45 fair and 0.32 poor. It was recognised that the naming is subjective, however the theoretical underpinnings, experience of the researcher and the interview data collected within the pilot and second phase of the research allowed the naming to be refined. Cronbach's Alpha was used to test the reliability of the dimensions, where high correlation between items was found this was considered to validate and suggest a reliable dimension (Cramer, 1994).

> *"One of the problems with PCA is that there is no criterion variable with which to test the solution. For other methods the observed and predicted DV's can be used to validate the analysis. A second problem with PCA is after extraction; there is an infinite number of rotations available. The final choice among alternatives depends on the researchers assessment of interpretability and scientific utility."* (Tabachnick and Fidell, 2001)*pg 583*

The factor scores were stored as variables to assess whether any further regression analysis and comparability of different groups was also carried out.

5.7 General Linear Model

The general linear model (GLM) was used to analyse whether there was a relationship between a number of independent variables such as procurement approach, trade and organisation size on dependent variables such as subcontract enquiries. It allowed for the control of co variance such as the percentage subcontracted and through the use of correction factors, such as Greenhose-Geisser or Huynh-Felt, which are dependent on the sphericity of the data, allowed for the assessment of interaction effects. The use of post hoc Bonferroni tests allowed for identification of where the differences lay and was used for further qualitative analysis in the second phase of the research.

5.7.1 Multi Variate Analysis

In order to examine the relationships between variables, it was necessary to calculate indices or factors rather than individual items scores to carry out multivariate analysis of the data, these are indicated in Table 5.4. Total scores were calculated for each individual and the differences between the groups on a given list were tested using one-way analysis of variance. A one-way analysis of variance test was carried out which yielded an F value, and identified significant differences for a given level of significance of 0.05. Table 5.4 below shows the derived variable, and how their scales were arrived at.

Areas measured in the questionnaire	Scale/Items used for further analysis	Description of scales and how factors were obtained from them
Demographic variables	Age	Five age bands
	Title	Five groups
	Employer size	Five groups
	Decision making role	Four groups
	Experience	Five groups
	Tenure	Five groups
Organisation variables	Subcontract strategy	Dichotomous
	Organisation size	Five groups
Risk perception	Contractual	Total score of the 4 item factor
	Project	Total score of the 6 item factor
	Supply chain	Total score of the 2 item factor
	Organisational	Total score of the 2 item factor
Supply chain	Performance	Total score of the 5 item factor
	Variability in price	Mean score of the 7 item scale
	Benefit	Total core of the items revealed from the PC analysis
	Technology price assessment	Total score of five item factor
	Technology performance assessment	Total score of five item factor
Decision making	Quotation assessment	Total core of the items revealed from the PC analysis
	Market price assessment	Total score of five item factor

Table 5.4 Derived variables from the measuring instrument

5.7.2 Validity and Reliability

Cronbach's alpha[1] measures how well a set of items (or variables) represent a single uni-dimensional latent construct. When data have a multidimensional structure, Cronbach's alpha will usually be low; a reliability coefficient of 0.80 is considered acceptable in most social science applications (Bryman and Cramer, 2001; Sapsford and Jupp, 1996) and was applied when considering scale reliability.

Equality of Variance

To take account of the assumption that variance in the populations being compared was the same, the Levene's test for equality of variance was used. This is based on the F statistic and sig., and states if sig is less than 0.05 ($p<0.05$) the Levene test indicates that the variances between the two populations are not equal. If sig is greater than 0.05, the Levene test indicates that equal variance can be assumed. This was particularly appropriate when carrying out analysis within the general linear model as a correction factor was applied when the test for sphericity was not met.

5.8 Summary

The constructs used were developed from the literature review and in depth analysis of the pilot interview. The measurement of these constructs was extensively pilot tested before the main survey was administered to ensure reliability. The descriptive statistics to be applied to the data are univariate and multivariate and have been discussed and justified. This chapter has identified the approach to the design, collection and analysis of survey data provided by construction estimators working in the UK. The next chapter reports on the analysis of the data and the discussion of the results.

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[1] Cronbach's alpha was used when a measure of internal consistency was required. $\alpha = \left(\frac{\kappa}{\kappa - 1}\right)\left(\frac{s_y^2 - \sum s_i^2}{s_y^2}\right)$ s_y^2 = the variance associated with each score

$\left(\sum s_i^2\right)$ = the sum of variances for each item

CHAPTER 6: PHASE ONE RESULTS

6.1 Introduction

The data analysis reported in this chapter is necessarily comprehensive as the number of variables measured was extensive and an exploration of their potential effect on the model was required. Whilst comprehensive, the analysis presented in this thesis is also a meaningful summary of that that was carried out during the study. The descriptive statistics that are used are described in the previous chapter and, where appropriate further tables are given within the appendices to support the analysis, all percentages are quoted as valid percentages and exclude missing responses. The results presented in this section are general descriptions of the data under the following headings (1) Personnel and organisational characteristics, (2) Risk management, (3) Supply chain and (4) Decision making. At the end of the chapter the model derived from the data and a statement of the supported hypotheses is given, this is used to inform the second phase of the study in chapter seven.

6.2 Personnel and Organisational Characteristics

Respondents were requested to provide personal information relating to their age group, their experience as an estimator, and the description of their current role, and how long they had worked for their current employer. The modal age of the 310 respondents was 41-50 (29%,) the age groups of the other respondents were as follows 31-40 (20%), 51-60 (27%), 13% exceeded 60 years old. The average number of years experience the respondents had as an estimator was 15-20 years, over 50% of respondents had over twenty years experience and less than 8 % had ten years or less experience.

Table 6.1 indicates that 99% of the respondents were male. Senior estimators constituted the largest group (53%), followed by estimating directors (28%), and estimators (12%) and others (7%). The ordinal group identified as the largest for tenure with current employer was 1-5 years (31%), followed by >15 years (25%), 5-10 years (20%), 10-15 years (14%) and less than one year (10%). A total of 163 of the respondents were members of the CIOB (53%),

100 were associates (32%), 27 were classified as incorporated (9%) and 7% had the classification of membership of Fellow. The largest group of employer was building contractor, 208 (72%), followed by contractors who carried out both building and civil engineering projects 26 (9%), specialist trade contractors 16 (6%), civil engineering contractors 11 (4%) and 27 (9%) respondents indicated that they were employed by organisations that fell outside these classifications.

Demographics	Categories	N=310	Valid %
Age	20-30	7	3
	31-40	55	20
	41-50	82	29
	51-60	104	27
	>60	34	13
	Missing	28	
Job category	Estimator	34	12
	Senior Estimator	148	53.
	Est. Director	78	28
	Other	19	7
	Missing	31	
CIOB classification	Associate	100	32
	Fellow	20	6
	Incorporated	27	9
	Member	163	53
Experience	<5	2	1
	5-10	23	8
	10-15	43	16
	15-20	56	21
	>20	145	54
Tenure with employer	<1yr	28	10
	1-5yrs	85	31
	5-10yrs	56	20
	10-15yrs	40	14
	>15 yrs	68	25
	Missing	33	
Employer	Building contracting	206	72
	Civil Engineering contracting	11	4
	General contracting: Both	26	9
	Specialist Trade contracting	16	7
	Other	27	9
	Missing	22	

Table 6.1 Demographic characteristics of respondents.

6.2.1 Employment Tenure

Respondents were given five ordinal categories to identify how long they had been employed with their current employer. This scale was included in order to ascertain the respondent's familiarity with their employing organisations practices. The demographic data on organisation turnover, age range and tenure with current employer is displayed in Table 6.2.

The results displayed in Table 6.2 indicate the tenure of employment for the differing age ranges of estimators. A higher than expected percentage of estimators in the 51-60 category indicated that they had been employed by their current employer for 1-5 years (28%). Respondents in the >60 age group tended to be employed by organisations for over 15 years (42%). The recent high levels of activity in the construction industry and the reported shortage of estimators may be underlying factors that have lead to the rates of job churn indicated.

Tenure with current employer * Age range Crosstabulation

% within Age range

		Age range(years)					
		20-30	31-40	41-50	51-60	>60	Total
Tenure with current employer	<1yr	14%	15%	12%	9%		10%
	1-5yrs	57%	27%	37%	28%	19%	30%
	5-10yrs	29%	25%	19%	21%	13%	20%
	10-15yrs		20%	16%	8%	26%	14%
	>15 yrs		13%	16%	34%	42%	25%
Total		100%	100%	100%	100%	100%	100%

Table 6.2 Tenure with current employer

The data in Figure 6.1 indicated that smaller organisations tended to employ older estimators (m= 15-20 years, n=61), who were employed by them for the longest period of time (m=10-15 years) when compared to organisations of differing turnovers. The largest organisations employed comparatively younger staff, who also have a generally shorter period of tenure with the organisation. Respondents who were employed by organisations with a turnover of £50-99m were employed for a median period of 1-5 years and tended to be in the 41-50

years age group. Tenure with employer was the highest for civil engineering organisations; however, the sample size (n=11) was too small to allow any significance inferences to be made.

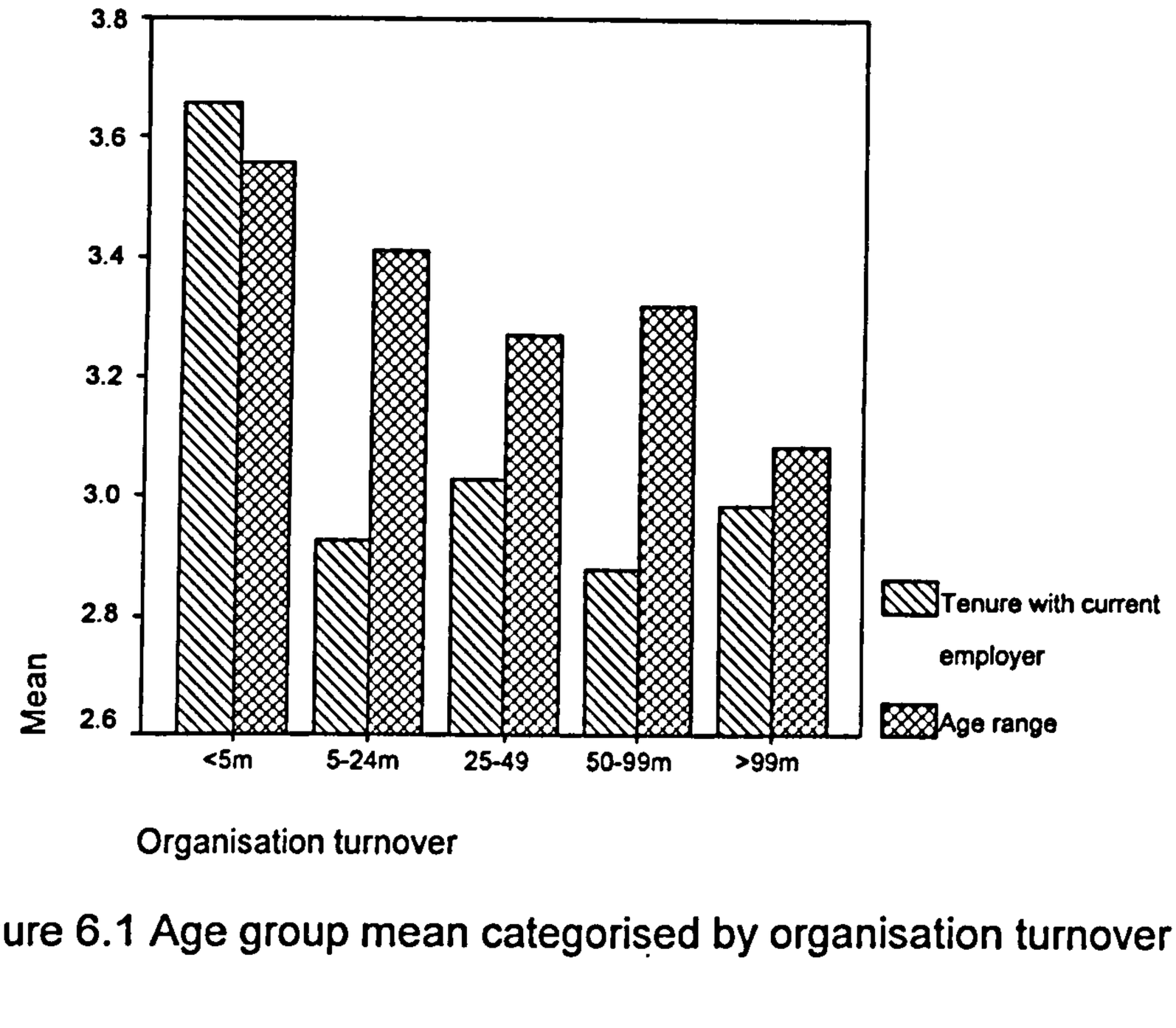

Figure 6.1 Age group mean categorised by organisation turnover and tenure

The respondent's demographic data indicated that the informants were experienced and had worked for their organisations for a period of time that indicated that they had reliable knowledge of current organisational practice regarding estimating and project organisation.

6.2.2 Organisational Characteristics

Each respondent was asked to categorise his or her organisation. The respondents were given five nominal categories including a category of "other ", this allowed the respondent to classify, without bias, their area of operation. The responses to this question would enable analysis of trends and practices associated with sectors, types and organisation sizes within the construction industry. The results displayed in Table 5.30 indicate that the largest category of employing organisation was Building contractor (73%) followed, General contracting, 9%, Other (8 %), specialist trade contracting (5%) by208 organisations and civil engineering (5%). The most popular types of organisation that were classified as other were consultant estimators, freelance

construction managers and specialised manufacturers. Respondents were asked to identify their respective organisations financial turnover in the last financial year. The turnover categories have been used extensively in surveys of this kind (Akintoye and Fitzgerald, 2000; El-Ghandour and Al-Hussein, 2004), and allow subsequent categorisation for data analysis. Table 6.3 indicates that the categories of organisational turnover, the largest was £5-24m (30%), >£99m (25%) and <£5m (24%). The numbers of responses in these categories were 86, 71 and 67 respectively, which was sufficient to identify these responses as large (Levin and Rubin, 1991). The low response rate (8.1%, n=25) for respondents employed by organisations with a £50-99m turnover was noted and taken into account in the data analysis.

Organisation type * Organisation turnover Crosstabulation

% within Organisation turnover

		Organisation turnover (£)					
		<5m	5-24m	25-49	50-99m	>99m	Total
Organisation type	Building contracting	82%	77%	65%	76%	62%	73%
	Civil Engineering contracting	3%	1%	6%		8%	4%
	General contracting: Both		6%	12%	4%	23%	9%
	Specialist trade contracting	6%	7%	6%	12%	1%	6%
	Other	9%	9%	12%	8%	6%	8%
Total		100%	100%	100%	100%	100%	100%

Table 6.3 Organisational Characteristics

A cross tabulation shown in Table 6.3 after conflating general contracting with building contracting gave sample sizes exceeding 30 in all categories of organisation when categorised by turnover with the exception of organisations with a turnover of between £50-99m (n=20).

6.3 Procurement Environment

Respondents were asked to identify the appropriate percentage, measured by value, of the procurement approach to tender enquiries that their employing organisation had priced over the last twelve months.

The results are indicated in Table 6.4 and display that the most popular procurement approach taken by respondent's employer's clients was drawings and specification (48%), followed by design and build (34%), traditional bills of quantities (25%), cost reimbursement (23%) and then prime contracting (17% and management contracting (13%). The construction management (8%) and the measured civils approach (12%) accounted for low levels of respondents employing organisations estimating workload. An ANOVA was performed to test for differences between the organisation sizes and procurement approaches, used by their clients at p=0.05. A post hoc scheffe test indicated that there was variance between the organisation sizes for the following approaches, Drawings and specification (F (4,223)=17.979, p<0.01) <£5m and £25-49m, £50-99m, >£99m and Design and Build F(4,205)=6.316, p<0. 01)<£5m and >£99m, £5-24m and >£99m, a test for linearity indicated that a linear relationship existed. This analysis supported the assertion that smaller organisations priced significantly more tenders on the drawings and specification procurement approach than larger organisations, and larger organisations priced significantly more projects based on the design and build approach. There were no differences between organisations of different sizes for the other six procurement arrangements; there was no evidence of a non-linear relationship.

	N	Minimum	Maximum	Mean	Std. Deviation
Traditional Bills of quantity	230	1	90	25.4	19.6
Drawings and specification	245	2	100	47.9	29.3
Design and Build	207	1	100	34.3	25.8
Prime Contracting	18	2	50	16.8	15.1
Cost reimbursement	25	5	100	23.1	24.0
Management Contracting	26	2	80	13.3	15.2
Construction Management	13	1	20	8.3	4.9
Measurement Civils	15	2	30	11.7	7.2

Table 6.4 Respondent's clients' procurement arrangements

Procurement route was considered as an independent external environmental variable. Differing organisations categorised by size secured projects that used different routes. This supported the proposition that organisational turnover could be used as a proxy for project complexity.

6.3.1 Organisations Business Sector

The question utilised the categorised identified by the DTI for business sectors. The ten categories were housing, industrial, warehousing, schools and colleges, universities, healthcare, offices, leisure, retail and infrastructure. Data was gathered at ordinal level and respondents were requested to identify the percentage of annual turnover for each category of business sector. The aim of this question was to identify within the sample, the levels of specialisation that occurred which would allow for consequent examination of trends. The data were assessed for distribution to establish whether a parametric or non-parametric statistic was appropriate. A descriptive statistic was used to determine whether there was an association between the categorical variable of organisation size and the criterion contribution to turnover made for each business sector.

Housing

151 respondents indicated that their organisations carried out work in the housing sector. The data were assessed for distribution, a z score of skewness =4.43 indicated that the data were positively skewed and a Kolmogorv-Smirnov (KS) test =0.261, $p<0.01$ indicated that the data were not normally distributed. 64% of respondents indicated that projects carried out in the housing business sector accounted for less than 30% of their organisations turnover. A non-parametric KW test was performed and it was found that there was no significant association between organisation size (x^2 (4,151)=4.67 p=0.323) and the sector percentage contribution to annual turnover.

Industrial

145 respondents indicated that their organisations carried out work in the Industrial sector. The data were assessed for distribution, a z=8.66 indicated that the data were positively skewed and a KS test =0.261, $p<0.01$ indicated

that the data were not normally distributed. 86%of respondents indicated that projects carried out in the industrial sector accounted for less than 30% of their organisations annual turnover. . A non-parametric KW test was performed and it was found that there was no significant association between organisation size (x^2 (4,145)=2.23 p=0.694) and the sector percentage contribution to annual turnover.

Warehousing

94 respondents indicated that their organisations carried out work in the warehousing sector. The data were assessed for distribution, a z=3.76 indicated that the data were positively skewed and a KS test =0.298, p<0.01 indicated that the data were not normally distributed. 86%of respondents indicated that projects carried out in the warehousing sector accounted for less than 30% of their organisations annual turnover. A non-parametric KW test was performed and it was found that there was no significant association between organisation size (x^2 (4,94)=3.01 p=0.566) and the sector percentage contribution to annual turnover.

Schools and Colleges

181 respondents indicated that their organisations carried out work in the schools and college sector. The data were assessed for distribution, a z=5.12 indicated that the data were positively skewed and a KS test =0.241, p<0.01 indicated that the data were not normally distributed. 65%of respondents indicated that projects carried out in the schools and colleges sector accounted for less than 30% of their organisations annual turnover. A non-parametric KW test was performed and it was found that there was no significant association between organisation size (x^2 (4,181)=7.17p=0.127) and the sector percentage contribution to annual turnover.

Universities

88 respondents indicated that their organisations carried out work in the university sector. The data were assessed for distribution, a z=5.66 indicated that the data were positively skewed and a KS test =0.261, p<0.01 indicated that the data were not normally distributed. 65%of respondents indicated that projects carried out in the universities sector accounted for less than 30% of

their organisations annual turnover. A non-parametric KW test was performed and it was found that there was no significant association between organisation size (x^2 (4,88)=4.56,p=0.335) and the sector percentage contribution to annual turnover.

Healthcare

149 respondents indicated that their organisations carried out work in the healthcare sector. The data were assessed for distribution, a z=5.69 indicated that the data were positively skewed and a KS test =0.245, p<0.01 indicated that the data were not normally distributed. 77%of respondents indicated that projects carried out in the healthcare sector accounted for less than 30% of their organisations annual turnover. A non-parametric KW test was performed and it was found that there was no significant association between organisation size (x^2 (4,149)=2.25,p=0.691) and the sector percentage contribution to annual turnover.

Offices

144 respondents indicated that their organisations carried out work in the offices sector. The data were assessed for distribution, a z=10.09 indicated that the data were positively skewed and a KS test =0.288, p<0.01 indicated that the data were not normally distributed. 77%of respondents indicated that projects carried out in the offices sector accounted for less than 30% of their organisations annual turnover. A non-parametric KW test was performed and it was found that there was no significant association between organisation size (x^2 (4,144)=1.307 p=0.860) and the sector percentage contribution to annual turnover.

Leisure

102 respondents indicated that their organisations carried out work in the leisure sector. The data were assessed for distribution, a z=7.85 indicated that the data were positively skewed and a KS test =0.346, p<0.01 indicated that the data were not normally distributed. 90%of respondents indicated that projects carried out in the leisure sector accounted for less than 30% of their organisations annual turnover. A non-parametric KW test was performed and it was found that there was no significant association between organisation size

(x^2 (4,102)=1.02 p=0.906) and the sector percentage contribution to annual turnover.

Retail

115 respondents indicated that their organisations carried out work in the retail sector. The data were assessed for distribution, a z=8.31 indicated that the data were positively skewed and a KS test =0.306, p<0.01 indicated that the data were not normally distributed. 86%of respondents indicated that projects carried out in the retail sector accounted for less than 30% of their organisations annual turnover. A non-parametric KW test was performed and it was found that there was no significant association between organisation size (x^2 (4,115)=4.00 p=0.406) and the sector percentage contribution to annual turnover.

Infrastructure

65 respondents indicated that their organisations carried out work in the infrastructure sector. The data were assessed for distribution, *z*=2.22 indicated that the data were positively skewed and a KS test =0.306, p<0.01 indicated that the data were not normally distributed. 59%of respondents indicated that projects carried out in the infrastructure sector accounted for less than 30% of their organisations annual turnover. A non-parametric KW test was performed and it was found that there was no significant association between organisation size (x^2 (4,65)=5.58,p=0.212) and the sector percentage contribution to annual turnover.

6.4 Summary of Organisational Demographics

The results indicate that the respondents carry out work in a range of business sectors and for both public and private sector clients. Business sectors of schools, housing and healthcare make up largest proportions of workload rather than universities, warehousing. The data analysis did not suggest that organisations were specialising in any specific business sector. The results of this analysis are in concordance with the secondary data analysis from the DTI's data on industry output. This would confirm that the sample could be considered as representative of the UK construction industry.

6.5 Tendering Procedures

The survey sought data on the percentage of work secured by the organisations for four categorical tendering procedures. These were competition, competition with partnering arrangement, negotiation and negotiation with partnering agreement. The results are indicated in Table 6.5 and display that the most popular approach to tendering taken by respondent's employer's clients was competition (66%), followed by negotiated partnered (27%), negotiation (26%) and then competitive tender, partnered (22%). The partnering approaches of competitive partnering and negotiated partnering (n=105 and 78 respectively) were used less than competition and partnering. The data were assessed for distribution, competitive tendering z=-4.067 indicated that the data were negatively skewed and a KS test =2.025, $p<0.01$ indicated that the data were not normally distributed. Negotiated partnering, z=5.374 indicated that the data were positively skewed and KS=1.969,$p<0.01$ indicated that the data were not normally distributed, negotiation z=9.96 indicated the data were positively skewed and KS=2.735,$p<0.001$ indicated that the data were not normally distributed. Competitive tendered partnered z=7.60 indicated that the data were positively skewed and KS=1.706,p=0.06 indicated that the data were normally distributed. A non-parametric KW test was carried out to determine whether there was a significant difference between organisation size and client's use of tendering procedure. Competitive tendering x^2 (4)=33.818,$p<0.01$ indicated that differences existed. An ANOVA was performed to identify where the differences were and a post hoc scheffe test indicated that there was variance between the organisation sizes <£5m and £5-24m, ($F(4,223)=7.767$), $p<0.01$) and organisations in the following categories £25-49m, £50-99m, >£99m, a test for linearity indicated that a significant linear relationship existed. The data analysis consequently supported the assertion that smaller organisations priced significantly more competitive tenders, <£5m $\overline{x}_{(61)}$ =78, £5-24 $\overline{x}_{(84)}$ =69 and >£99 $\overline{x}_{(63)}$ =57 than larger organisations.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Competitive tender	264	5	100	66.3	24.9
Competitive tender Partnered	105	0	100	22.4	18.0
Negotiation	208	0	100	25.5	20.2
Negotiated Partnered	78	1	100	26.8	23.8

Table 6.5 Tendering procedures used by respondent's client organisations.

The data displayed in Table 6.6 indicates that there were no significant differences found between organisation sizes and the other three tendering procedures. Lower numbers of the sample secure work by partnering, 105 respondents indicated that their organisations secured an average of 22% of their turnover through competitive partnering, 79 respondents identified that an average of 34% was secured by negotiated partnering.

Organisation turnover		Competitive tender	Competitive tender Partnered	Negotiation	Negotiated Partnered
<5m	**Mean**	78.4	30.0	26.6	47.6
	N	61.0	8.0	44.0	5.0
5-24m	**Mean**	68.9	20.3	20.9	27.3
	N	84.0	28.0	70.0	23.0
25-49	**Mean**	60.2	21.4	29.8	28.3
	N	31.0	15.0	22.0	14.0
50-99m	**Mean**	57.4	17.6	26.2	25.0
	N	25.0	13.0	21.0	10.0
>99m	**Mean**	57.5	24.3	27.3	22.3
	N	63.0	41.0	51.0	26.0
Total	**Mean**	66.3	22.4	25.1	26.8
	N	264.0	105.0	208.0	78.0

Table 6.6 Cross tabulation of the tendering arrangements and organisational size

The data indicated that larger organisations clients were less likely to use competitive tendering, and were adopting more relational approaches to construction procurement. All categories of organisation secured turnover by negotiation and partnering, however respondents employed by the larger organisations indicated more involvement than respondents who were employed by small organisations. Competitive tendering was used by smaller respondents employers clients, which may reflect the size and type of project that these organisations undertake. As identified in the data analysis of business sector, no specialisation was identified, consequently smaller projects may adopt differing procurement approaches than projects undertaken by larger organisations however the measuring instrument did not seek data to support this contention.

6.6 Risk Management

Respondents were asked to provide data on how their organisation managed the risks associated with projects. The questionnaire sought to gather data on who was principally responsible for the identification and analysis of risks, the systems used for risk identification, the techniques used for risk assessment and an indication of the respondent's perception of the risk for a typical project. The risks were categorised under headings of contractual, project, supply chain and procurement and organisational risk. The categories were drawn from the literature as suggested by Bowen and Edwards (1998) and Raftery (1994), the perception scales were based upon those used for the PRAM risk management tool developed by Simister (1994), an example is given in figure 6.2.

11 Please indicate your opinion, for a typical project, on the significance of each risk that you usually have to identify/assess. (Please circle all that apply) 1 = Negligible 2 = Marginal 3 = Serious 4 = Critical 5 = Very Critical					
Contractual Risks					
Inflation provisions	1	2	3	4	5
Dispute resolution	1	2	3	4	5
Contract complexity	1	2	3	4	5
Variation/claim expectation	1	2	3	4	5

Figure 6.2 Measuring Instrument design of informants risk perception.

6.6.1 Responsibility for Risk Identification and Analysis

The respondents were asked to identify their approach to the identification of risks at tender stage. The normative good practice guides suggested the use of prompt lists that are based on risk registers from previous projects.

The use of experience alone to assess risk or no systems, tended to be used more for smaller organisations than the larger organisations that had a more systematic approach to risk identification identified in Table 6.7 below. Larger organisations (>£99m) used meetings with the supply chain more often than smaller organisation suggesting a more relational approach to estimate development.

% of Total N

Organisation turnover	Experience	Prompt lists	Past projects	Subcontract meeting	No system used
<5m	23%	14%	19%	12%	29%
5-24m	32%	23%	30%	24%	21%
25-49	13%	17%	19%	22%	13%
50-99m	8%	10%	11%	10%	
>99m	24%	36%	21%	33%	38%
Total	100%	100%	100%	100%	100%

Table 6.7 Risk identification systems

6.6.2 Risk Perception and Assessment

The respondents were requested to provide data on who was responsible for the identification of risks, the analysis tools they used and their perception of the importance of the risks. The responses are considered below, however risks are considered as being interdependent (Raftery, 1994; Smith, 1999) and consequently the categories are a simplification and purely used to give an indication of the construct. The respondents were asked to identify the assessment technique used to assess the risks identified in section 2 of the questionnaire. The assessment techniques were categorised into judgement (i.e. no technique), risk registers (a technique that requires the user to identify

the scale of the risk and calculate the severity of the risk occurring by estimating the outcome), statistical analysis (a numerical analysis of past projects performance to give a parametric assessment of the risk), sensitivity analysis (a stochastic Monte Carlo analysis which identifies the areas which have the highest impact on the outturn), decision trees (these identify a sequence of events with associated probabilities) and other categories. The respondents perception of risk was measured using a 5 level Likert scale, 1=negligible, 2=marginal, 3=serious, 4=critical and 5=very critical. The level of perception was analysed descriptively for each of the sections the secondary analysis comparing groupings is then reported.

The risks were categorised as;

1. Contractual, which included inflation, dispute resolution, contract complexity and variation/claim expectation,
2. Project which included programme, site characteristics, resource productivity, design complexity, design completeness and health and safety.
3. Supply chain procurement risks included subcontract quotation selection and supplier quotation assessment
4. Organisational risk included design team, project management team and client organisation.

6.6.3 Contractual Risks

Respondents identified that contract complexity ($\bar{x}_{(275)}$ =3.2)was the risk that was perceived as being the most significant, followed by variation/claim expectance ($\bar{x}_{(272)}$ =2.33), inflation ($m_{(278)}$ =2.21) and dispute resolution $\bar{x}_{(269)}$ = 1.88.

6.6.3.1 Inflation

69% of respondents indicated that the estimator was principally involved with the identification and analysis of inflation risk, 9% indicated that the responsibility lay with the director, and 7% indicated that a team approach was taken.

The use of judgement was used to assess inflation was identified by 59% of the respondents, statistical analysis was identified by 29.1% as the means of assessment, risk registers were used by 5.2% of respondents. A cross tabulation was used to identify any standardised residual values, these are the residuals divided by an estimate of their standard deviation. It has been identified by De Vaus (1990) that standardised residuals with a value that falls outside the range of –2.5 to 2.5 indicate that a significant variance from the norm was occurring. The standardised residual values in the cross tabulation in Table 6.8 indicate that larger organisations make significantly less use of judgement and tend to use risk registers as a technique for inflation risk assessment more than other organisations.

Inflation * Organisation turnover Crosstabulation

Std. Residual

		Organisation turnover (£)				
		<5m	5-24m	25-49	50-99m	>99m
Inflation	Judgement	2.2	1.1	-.9	.1	-2.8
	Risk registers	-1.9	-1.8	.0	-1.2	4.5
	Statistical Analysis	-2.0	-.5	1.3	.1	1.5
	Sensitivity Analysis	-.5	-.6	-.4	-.3	1.5
	Decision Tree	-.5	1.3	-.4	-.3	-.5
	Other	1.1	-.8	.1	-.8	.2
	More than one techniqu	-1.4	-.3	.0	1.6	.7

Table 6.8 Risk analysis for inflation risk assessment – standardised residuals shown

Organisations with a turnover of less than £5m made significantly more use of judgement, and also indicated that they made less use of the more analytical methods available to identify and analyse risks. This was generally displayed until organisations turnover was >£99m whereby risk registers, a technique that disaggregates risks into component parts was used, and is a means of responding to project complexity. Quantitative analysis of inflation risk was not used significantly which was considered as an unexplained result as the technique of use of indices to forecast future cost rises is well established within the client sector.

6.6.3.2 Dispute Resolution

26% of respondents indicated that the director was principally concerned with dispute resolution risks, 22% indicated that a team approach was taken to this risk and 26% indicated that the estimator was responsible for dispute resolution risk identification and analysis. A number of respondents indicated that the quantity surveyor was involved at this stage. 72.5% of respondents identified that judgement was used as a techniques for the assessment of dispute risks as shown in Table 6.9, 9.2% of respondents identified that they used risk registers and 4.2% identified that they used statistical analysis. Risk registers were used by the larger organisations.

Disputes * Organisation turnover Crosstabulation

Std. Residual

		Organisation turnover (£)				
		<5m	5-24m	25-49	50-99m	>99m
Disputes	Judgement	1.3	1.6	-.2	-.4	-2.6
	Risk registers	-1.5	-1.9	-1.7	-.8	5.2
	Statistical Analysis	-1.6	-.7	3.1	.0	.1
	Sensitivity Analysis	.6	-.4	-.1	1.3	-.9
	Decision Tree	.3	.6	-.9	.5	-.6
	Other	-1.3	-2.1	.1	.6	3.2
	More than one techniqu	-1.2	-.6	1.5	.6	.4

Table 6.9 Risk analysis for dispute risk assessment

The standardised residual results indicated in Table 6.9 indicated that judgement was used extensively for risk analysis, organisations with a turnover >£99m made significantly more use of risk registers and a corresponding lower use of judgement. Groups assessed this risk. Consequently Delphi techniques may be used more effectively, however there was no evidence for this. Organisations with a turnover of £25-49m indicated that significant use of statistical analysis was made for dispute assessment, this may be a function of the programming software which allows for clashes to be checked and consequently may be due to respondents misinterpretation.

6.6.3.3 Contract Complexity

32% of respondents indicated that the estimator was the individual who was responsible for the identification and assessment of the complexity of the contract. 40% indicated a team approach was adopted and 16% indicated that the director took responsibility for risks that fell within this category. A cross tabulation indicated that the approach differed between organisations of differing sizes. The director was more involved with the identification and analysis of contractual risks for organisations that had a turnover of less than £5 m and £5-24m than organisations that had a higher turnover, where a team approach was more often adopted. This pattern drawn from the data validates the qualitative data gathered during the pilot stage, which indicated that the director was more involved with the tendering process in smaller organisations due to the size of the team, the more hierarchical approach within these organisations and the level of director involvement. Table 6.10 displays that 72% of respondents identified that they used judgement to assess contract complexity risks, 17% used risk registers and the numerical based analyses of statistical and sensitivity analysis were used by only 3% of the respondents.

Contract comp * Organisation turnover Crosstabulation

Std. Residual

		Organisation turnover (£)				
		<5m	5-24m	25-49	50-99m	>99m
Contract comp	Judgement	1.9	2.1	-.5	-.8	-3.4
	Risk registers	-2.7	-3.5	1.3	-.6	5.9
	Statistical Analysis	-.2	-1.2	.5	.8	.7
	Sensitivity Analysis	.4	-1.0	-.6	1.4	.3
	Decision Tree	-.2	1.2	-.8	.8	-1.1
	Other	-1.5	-1.6	.8	1.4	1.8
	More than one technique	-1.3	.6	-.9	.5	.9

Table 6.10 Risk analysis for contract complexity risk assessment

Contract complexity risks were associated with the client contractual arrangements. A similar trend was evidenced as with the other contractual risks. The largest organisations disaggregated their risks using risk registers.

Judgement and the reliance of advice of third parties (identified within the open questions) were most used for this category of risk.

6.6.3.4 Variation Assessment

44% of respondents indicated that the estimator was principally responsible for the identification and analysis of potential variations, 29% indicated that a team approach was adopted, 5% indicated that the contracts manager, 19% indicated that the estimator was responsible. The director was identified as being responsible by 19% of respondents. A contingency table of organisational size and individual indicated that for small organisation the estimator, director and contracts manager were more involved that for larger organisations who made more use of the function of planning engineer 76% of the respondents to this question identified that judgement was used, the data is displayed in Table 6.11 identified that risk registers were used by the larger organisation.

Variation assessment * Organisation turnover Crosstabulation

Std. Residual

		Organisation turnover (£)				
		<5m	5-24m	25-49	50-99m	>99m
Variation assessment	Judgement	1.3	1.5	-.6	.4	-2.7
	Risk registers	-1.7	-2.9	.3	-1.6	5.5
	Statistical Analysis	.0	-1.0	1.1	-.2	.4
	Sensetivity Analysis	-.2	-.4	1.7	-.7	-.2
	Decision Tree	-.5	-.5	-.4	3.0	-.5
	Other	-1.5	.0	-.2	.1	1.6
	>1 Technique	-1.4	-.3	.0	.3	1.4

Table 6.11 Risk analysis for variation risk assessment

In order to assess whether the organisational size has an influence on contractual risk perception, a non-parametric bivariate analysis was carried out. Spearman's rho is reported in Table 6.12 for each of the categories of risk above, identifying levels of significance when $p < 0.05$.

Risk	Spearman's Rho	p	n
Contractual			
Inflation*	0.320	0.001	n=274
Disputes	0.037	0.545	n=266
Contract complexity*	0.125	0.039	n=271
Variation risk assessment	-0.028	0.651	n=268

Inflation and contract complexity are significant at p=0.05

Table 6.12 Bi variate analysis of contractual risk perception and organisational size

The significant differences for inflation risk perception and contract complexity were from respondents employed by organisations of <£5m and >£99m and £5-24m and >£99m. The larger organisations tend to use more systematic processes such as risk registers for contractual risks and perceive inflation and contract complexity higher than smaller organisations.

Figure 6.3 indicates a summary of the contractual risk perceptions of the group and identifies that the category that the estimator is most responsible for is inflation and with contract complexity was perceived as being a serious risk.

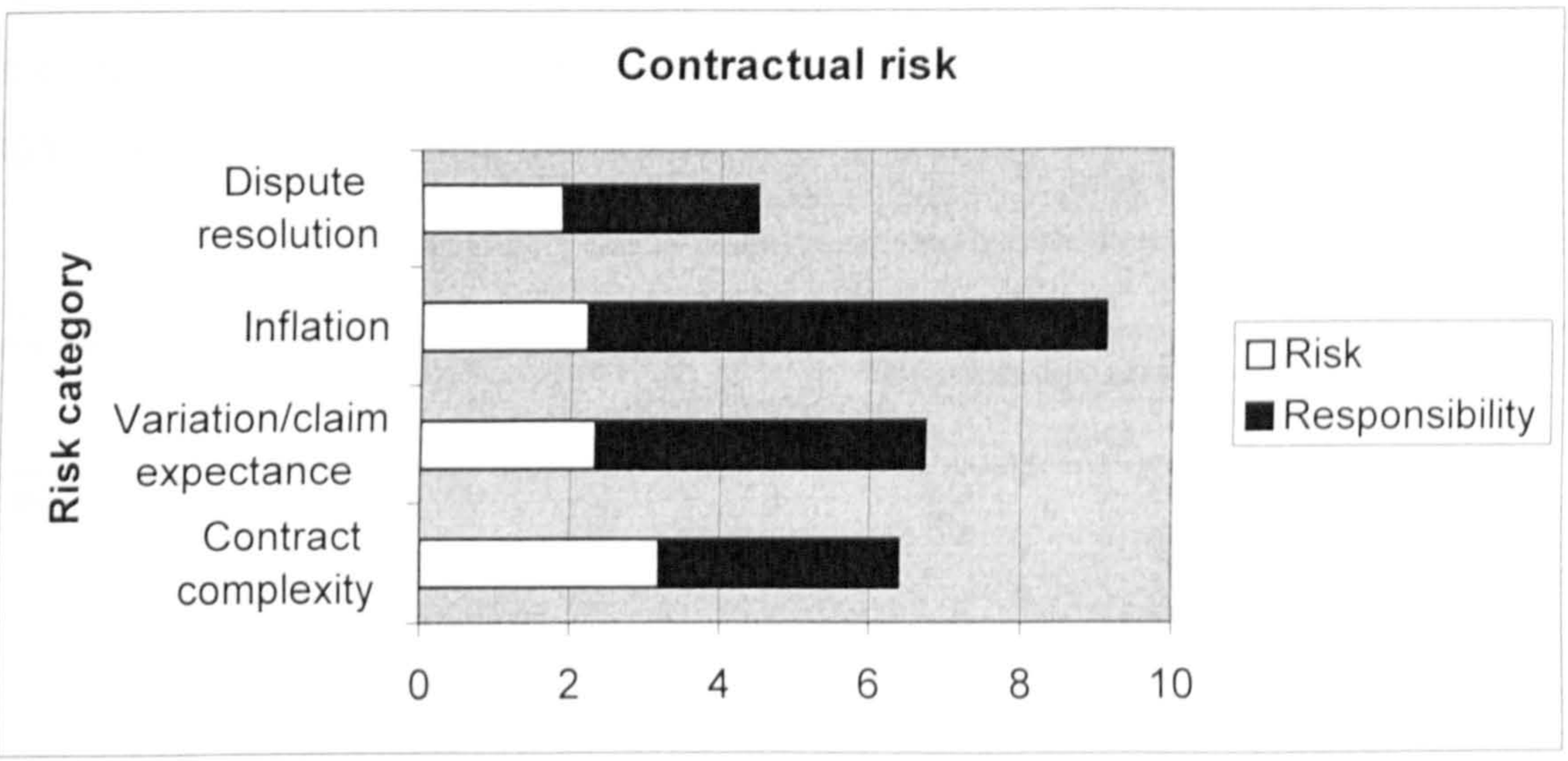

Figure 6.3 Contractual risk perception and responsibility for identification and analysis

6.6.4 Project Risks

Respondents were asked to provide information on who was responsible for the identification and analysis of project risks in the following categories, programme, site characteristics, resource productivity, design complexity, design completeness, health and safety. Respondents identified that programme ($\bar{x}_{(277)}$ =3.57)was the risk that was perceived as being the most significant, followed by design completeness ($\bar{x}_{(273)}$ =3.43), design complexity ($\bar{x}_{(277)}$ =3.41) , health and safety ($\bar{x}_{(279)}$ =3.36) , site characteristics ($\bar{x}_{(280)}$ =3.34) and resource productivity ($\bar{x}_{(275)}$ =2.93)

6.6.4.1 Programme

23% of respondents indicated that the planning engineer was principally responsible for the programme, 20% indicated that the contracts manager, 19% indicated that the estimator was responsible and 23% indicated that a team approach was adopted. The director was identified as being responsible by 8% or respondents. A contingency table of organisational size and individual indicated in Table 6.13, that for small organisation the estimator, director and contracts manager were more involved that for larger organisations who made more use of the function of planning engineer. This validates the qualitative data gathered which suggested smaller pre tender teams for smaller organisations and corresponding less specialisation.

Programme * Organisation turnover Crosstabulation

Std. Residual

		Organisation turnover (£)				
		<5m	5-24m	25-49	50-99m	>99m
Programme	Judgement	2.3	1.0	-.3	.4	-3.2
	Risk registers	-2.6	-2.7	-.7	.1	5.9
	Statistical Analysis	-1.0	.3	1.4	-1.0	.2
	Sensitivity Analysis	.1	.7	.7	-.6	-1.0
	Decision Tree	-1.1	.4	-.8	-.6	1.5
	Other	-.8	1.1	-.6	-.5	.3
	>1 technique	-1.5	-.6	.7	.2	1.5

Table 6.13 Risk analysis for programme risk assessment

Risk registers were used by the larger organisations for the assessment of this risk; there was a very low usage of statistical analysis or sensitivity analysis. This may be due to respondents' unfamiliarity with planning techniques.

6.6.4.2 Site Characteristics

117 (42%) of respondents indicated that the estimator was responsible for identification and analysis of site characteristics. 20% indicated that a team approach was adopted, the contracts manager (13%) and planning engineer (10%). The standardised residual Table 6.14, identified that Judgement was the primary form of assessment with 63% of respondents indicating that they relied solely on this technique, risk registers were adopted by 17% of respondents who mostly worked for organisations with a turnover >£99m. More stochastic or quantitative forms of analysis were used rarely, statistical analysis 6% by organisations of any size.

Site Char * Organisation turnover Crosstabulation

Std. Residual

	Organisation turnover (£)				
	<5m	5-24m	25-49	50-99m	>99m
Judgement	1.7	1.3	.1	.1	-3.2
Risk registers	-2.3	-2.7	-.8	-.7	6.2
Statistical Analysis	.3	-.2	-.8	1.2	-.3
Sensitivity Analysis	-.7	-.8	3.6	-.4	-.7
Decision Tree	-.5	1.3	-.3	-.3	-.5
Other	-.8	1.1	-.6	-.5	.3
> one technique	-1.6	-.2	1.5	.0	.7

Table 6.14 Risk analysis for site characteristic risk assessment – standardised residuals shown

6.6.4.3 Resource Productivity

129 (48%) of respondents indicated that the estimator was principally responsible for resource productivity risks, 12% indicated that the contracts manager was responsible and 10% indicated that it was the planning engineer. 21% indicated a team approach was used. The trend of a reliance of experience and judgement was seen for this risk 67% of respondents indicating that they relied solely on judgement, risk registers were used by 8.1% of

respondents, the standardised residual table 6.15 displayed below, identified that they worked primarily for organisation with turnover <£99m. Quantitative forms such as statistical analysis, 13.2% and sensitivity analysis were used very rarely. This risk was surprisingly identified by the majority of respondents as perceived of lower significance that the other project risks and was expected to have a high level of quantitative analysis supporting judgement.

Res productivity * Organisation turnover Crosstabulation

Std. Residual

	Organisation turnover				
	<5m	5-24m	25-49	50-99m	>99m
Judgement	1.6	1.3	-.7	.2	-2.6
Risk registers	-2.0	-2.4	.0	-.1	4.7
Statistical Analysis	-.8	-1.1	1.4	.2	.8
Sensitivity Analysis	.4	-1.0	1.1	-.5	.3
Decision Tree	-.7	1.7	-.5	-.4	-.7
Other	-1.2	.8	.3	-.7	.4
> one technique	-1.1	-.4	-.4	-.1	1.7

Table 6.15 Risk analysis for resource productivity risk assessment

6.6.4.4 Design Complexity

132 respondents (48%) indicated that the estimator was principally involved with the identification and analysis of design complexity risks. A team approach was adopted by 34% of the respondents employing organisations and 21 respondents indicated that the contract manager was the individual principally responsible. Judgement was used as the sole means of analysis by 60.3% of respondents; risk registers were used by 16.5% who mostly worked for larger organisation as indicated by the standardised residual table 6.16, statistical analysis was used rarely by 5% of respondents

Design complexity * Organisation turnover Crosstabulation

Std. Residual

		Organisation turnover (£)				
		<5m	5-24m	25-49	50-99m	>99m
Design complexity	Judgement	2.6	1.5	-.3	.3	-4.1
	Risk registers	-2.9	-3.2	-.3	.1	6.5
	Statistical Analysis	-.8	1.1	1.0	-.3	-.9
	Sensitivity Analysis	-.8	-1.0	1.2	-.5	1.4
	Decision Tree	-.8	1.1	-.6	-.5	.3
	Other	-1.3	-.8	1.4	.4	.9
	>1 one technique	-1.5	.1	-1.0	-.9	2.5

Table 6.16 Risk analysis for design complexity risk assessment

6.6.4.5 Design Completeness

123 (44%) respondents indicated that the estimator was principally concerned with the identification and assessment of design completeness risks. 98 (35%) identified that their organisations adopted a team approach and 9% indicated that the contracts manager was principally involved. The use of judgement to assess design completeness was used by 68% of respondents; risk registers were used by 19% who worked for larger organisations, this possible reflects that level of design and build projects these organisations are estimating for, statistical analysis was used by 3.3% of respondents and was not a strong feature of practice as indicated in Table 6.17.

Design completeness * Organisation turnover Crosstabulation

Std. Residual

		Organisation turnover (£)				
		<5m	5-24m	25-49	50-99m	>99m
Design completeness	Judgement	2.5	1.6	-.6	.5	-4.2
	Risk registers	-3.2	-3.3	1.0	.1	6.0
	Statistical Analysis	-1.4	1.3	1.1	-.9	-.2
	Sensitivity Analysis	1.4	-1.4	-.8	-.7	1.2
	Decision Tree	-1.2	.8	-.8	-.7	1.2
	Other	-1.3	-.8	1.4	.4	.9
	> one technique	-1.4	.3	-.9	-.9	2.1

Table 6.17 Risk analysis for design completeness risk assessment

6.6.4.6 Health and Safety Risks

74 (26%) of respondents indicated that estimators were principally responsible for the identification and assessment of the health and safety risks on projects. 72 (25%) of the respondents indicated in Table 6.18, that the contracts manager was principally responsible, 88 (31%) indicated that a team was involved and 30 (11%) indicated that the director was responsible. More formal systems of risk assessment than the use of judgement, identified as sole form of assessment by 46.5%, were expected to be used however the respondents indicated that a team approach or other were principally responsible for assessment. Formal systems that would allow for audit may be revealed however the data collected didn't support such further analysis however risk registers were used by 25.5% of respondents who mostly worked for larger organisations. Statistical analysis was used rarely by 8.4% of respondents.

Health and Safety * Organisation turnover Crosstabulation

Std. Residual

		Organisation turnover (£)				
		<5m	5-24m	25-49	50-99m	>99m
Health and Safety	Judgement	2.8	.8	-.8	.5	-3.3
	Risk registers	-2.1	-1.0	.2	-.7	3.4
	Statistical Analysis	-.9	-.3	1.1	1.1	-.2
	Sensitivity Analysis	.0	-.2	-.7	-.6	1.0
	Decision Tree	-.7	.5	-.5	-.4	.7
	Other	-.9	.0	-.2	-.9	1.6
	> one technique	-1.7	.2	1.3	-.1	.6

Table 6.18 Risk analysis for health and safety risk assessment

As indicated in the Figure 6.4, the estimator is responsible for risks relating to resource productivity, site characteristics and design. The estimators perceive the risks for resource productivity the lowest and programme the highest; of the risks that he is principally responsible for design completeness and complexity are the highest.

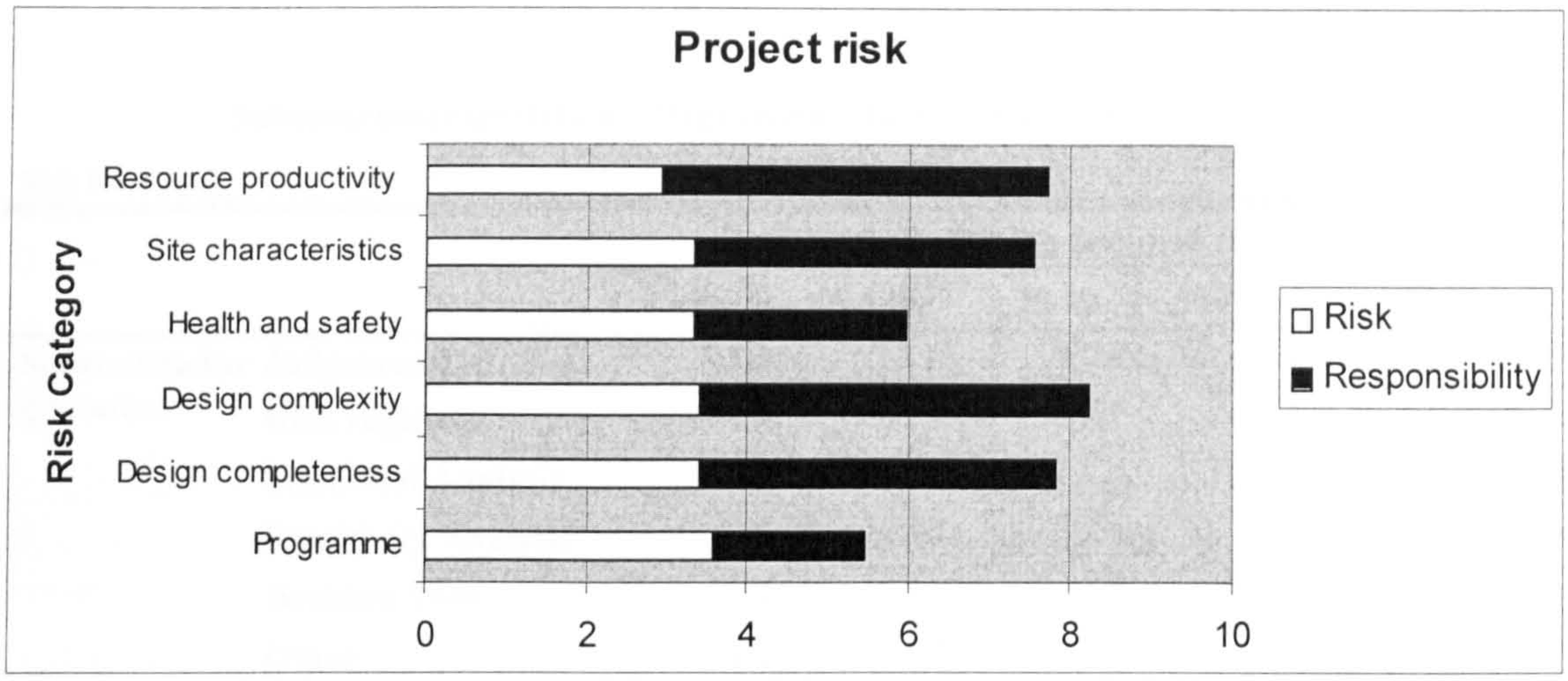

Figure 6.4 Project risk perception and identification

In order to assess whether the organisational size has an influence on project risk perception, a non-parametric bivariate analysis was carried out. Spearman's rho is reported for each of the categories of risk above, identifying levels of significance when $p < 0.05$ and is displayed in Table 6.19.

Risk	Spearman's Rho	p	N
Project			
Programme*	0.200	0.001	n=274
Site characteristics	-0.012	0.839	n=276
Resource productivity	0.107	0.079	n=273
Design complexity*	0.177	0.003	n=273
Design completeness*	0.213	0.001	n=269
Health and safety	0.123	0.051	n=275

*Programme, design complexity and design completeness are significant at $p<0.05$

Table 6.19 Bi variate analysis of project risk perception and organisation size

The between groups post hoc Scheffe test identified that the following significant differences were found between groups of differing turnovers, programme risk perception <£5m and >£99m and design completeness and design complexity risk perception <£5m and £50-99m and <£5m and >£99m. The data identified that estimators are principally responsible for the project risk identification and analysis for the following areas; contractual, site characteristics, resource productivity, design complexity and design completeness. This responsibility didn't significantly change for differing organisation sizes. A team approach was taken to the area of contract

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Subcontractor quotation * Organisation turnover Crosstabulation

Std. Residual

		Organisation turnover (£)				
		<5m	5-24m	25-49	50-99m	>99m
Subcontractor quotation	Judgement	1.3	1.0	-.6	.3	-2.1
	Risk registers	-1.5	-2.2	2.1	-.4	2.7
	Statistical Analysis	-1.0	.1	.0	-.5	1.2
	Sensitivity Analysis	-.5	-.5	-.3	3.0	-.5
	Decision Tree	.3	.1	-.6	-.5	.3
	Other	1.2	-.4	-1.0	.2	-.2
	> one technique	-1.4	-.7	.9	-.3	1.6

Table 6.20 Risk analysis for subcontract quotation risk assessment

6.6.5.2 Supplier Quotation

194 (69%) indicated that the estimator was principally responsible for the risk assessment of the suppliers quotation, 43 (15%) identified that their organisations adopted a team approach and 29 (10%) respondents indicated that the buyer carried out this function. The director was identified by 11(4%) of respondents as being involved in this area. There was a higher level of statistical analysis for risks associated with supplier's quotation, although judgement was the sole use of assessment identified by 60% of respondents, statistical analysis was used by 24%. The format of the question did not allow for further exploration of this area. The standardised residual Table 6.21 identified that risk registers were again used by the larger organisation.

Supplier quotation * Organisation turnover Crosstabulation

Std. Residual

		Organisation turnover (£)				
		<5m	5-24m	25-49	50-99m	>99m
Supplier quotation	Judgement	1.4	.8	-.5	.0	-1.9
	Risk registers	-1.8	-2.5	1.0	.8	3.3
	Statistical Analysis	-.9	.4	.1	-.4	.6
	Sensitivity Analysis	-.7	-.8	-.5	1.9	.7
	Decision Tree	.3	.1	-.6	-.5	.3
	Other	.8	-.2	-1.0	.3	.0
	> one technique	-1.1	-.3	1.3	-1.0	1.1

Table 6.21 Risk analysis for supplier quotation risk assessment

In order to assess whether the variable organisational size has an influence on supply chain risk perception, bivariate analysis was carried out. Spearman's rho is reported for each of the categories of risk above, identifying levels of significance when p <0.05 and is displayed in table 6.22.

Risk	Spearman's Rho	P	n
Supply chain procurement			
Subcontract quotation selection	0.111	0.065	n=275
Supplier quotation	0.090	0.134	n=276

No significant differences for organisational size however a correlation for level of subcontracting Spearman's rho 0.154, p<0.05 n=272 was evident for subcontractor and 0.152,P<0.05 n=278 for supplier.

Table 6.22 Bi variate analysis of supply chain risk perception and organisation size

There was no significant difference for organisational size however there was a correlation between the level of subcontracting and risk perception. Organisations that sublet higher percentages of work perceived these risks as more critical than organisations that subcontracted lower percentages. Contingency tables were used to assess the patterns that existed for these two categories of risk. Respondents employed by organisation with a turnover exceeding £90m identified that the following functional groups were not involved in the identification and assessment of risks regarding subcontract and supplier, director, planning engineers and contracts managers. Respondents who were employed by smaller organisations identified that the estimator was principally responsible however in a low number of cases a director was involved. The data indicated a low level of involvement of the contract manager, a function that may have knowledge of the post contract performance of the supply chain organisations being incorporated into the tender. Data was gathered regarding the feedback systems that exist to assist the estimator in making judgements about the prices quoted by the supply chain and the results of the analysis are reported in section 6.90.

6.6.6 Organisational Risk

Respondents were asked to identify who was principally responsible for the identification and analysis of organisation risks in the areas of design team, project management team and client organisation. Respondents identified that risks associated with the design team ($\bar{x}_{(269)}$ =3.12) was the risk that was perceived as being the more significant, followed by project management team ($\bar{x}_{(268)}$ =3.10).

6.6.6.1 Design Team

75 (28%) respondents indicated that the estimator was principally involved with the assessment of the risks associated with the design team. 109 (41%) indicated that a team approach was used and 59 (22%) indicated that the director was responsible. A high level of respondents indicated that they solely used judgement 70.7% for the assessment of the design team, 8.4% indicated that they used statistical analysis and 6.5% indicated that they used sensitivity analysis. The standardised residual results displayed in Table 6.23 indicate that they are mainly employed by organisations with a turnover exceeding 99m.

Design team * Organisation turnover Crosstabulation

Std. Residual

		Organisation turnover (£)				
		<5m	5-24m	25-49	50-99m	>99m
Design team	Judgement	2.0	.7	-1.0	-.1	-1.9
	Risk registers	-1.9	-1.8	.4	-.6	3.9
	Statistical Analysis	-.8	.0	.6	.1	.4
	Sensitivity Analysis	-.7	-.8	-.5	-.4	2.1
	Decision Tree	-1.3	1.3	-.9	1.6	-.6
	Other	-.7	-.3	1.4	.9	-.4
	> one technique	-1.5	.0	1.9	-1.0	.9

Table 6.23 Risk analysis for design team risk assessment

6.6.6.2 Project Management

110 (41%) respondents indicated that a team approach was taken to the identification and assessment of risks associated with the project management team. 57 (21%) respondents indicated that the estimator was responsible, 71 (27%) identified the director as taking responsibility and 24 (9%) identified the contract manager as responsible. Judgement was used as the sole method of assessment by 66.4% of respondents; risk registers were used by 11.7% of respondents who were identified by the standardised residual Table 6.24 as being employed by larger organisations.

Project Management team * Organisation turnover Crosstabulation

Std. Residual

		Organisation turnover (£)				
		<5m	5-24m	25-49	50-99m	>99m
Project Mgmt. team	Judgement	1.9	.7	-1.4	.0	-1.7
	Risk registers	-1.9	-2.2	.5	-1.4	4.7
	Statistical Analysis	-1.0	-.1	1.7	.3	-.2
	Sensitivity Analysis	-.7	-.8	-.5	-.4	2.0
	Decision Tree	-1.3	1.3	-.9	1.7	-.6
	Other	-.7	-.3	1.4	.9	-.4
	> one technique	-1.5	.0	1.9	-1.0	.9

Table 6.24 Risk analysis for project management risk assessment

6.6.6.3 Client Organisation

79 (30%) indicated that the director was involved in the identification and assessment of risks associated with the client organisation. 107(40%) indicated a team approach was taken and 73(24%) identified that the estimator was involved.

Cross tabulations of organisational size and risks associated with organisational risks categorised as design team, project management team and client organisation indicated a similar pattern to those of other risks. Smaller organisations had a lower number of functional groups involved. The senior functional grouping of director was involved in the assessment of the client whilst a team approach was used to assess risk relating to design team.

In order to assess whether the organisational size has an influence on supply chain risk perception, a non-parametric bivariate analysis was carried out. Spearman's rho is reported for each of the categories of risk above, identifying levels of significance when p <0.05 and is displayed in Table 6.25.

Risk	Spearman's Rho	p	n
Organisational			
Design team*	0.122	0.046	n=266
Project Management team	0.051	0.407	n=265

* Design team risk is significant at 0.05

Table 6.25 Bi variate analysis of organisational risk perception and organisation size

The bivariate analysis indicated that a significant difference in risk perception of the design team existed for differing organisation turnovers, larger organisations perceived this risk as significantly higher than smaller turnover organisations. The data identified that a team approach was adopted for organisation risk analysis for the following areas; design team and project management. This responsibility didn't significantly change for differing organisation sizes. The director tended to have more of an involvement in this strategic area of risk management than in the other three areas. The director tended to have a higher level of involvement in this area for smaller organisations <£24m than larger organisations possibly reflecting the significance of tendering decisions to small organisations, the composition of the tender team and the pre tender resources that larger organisations can deploy.

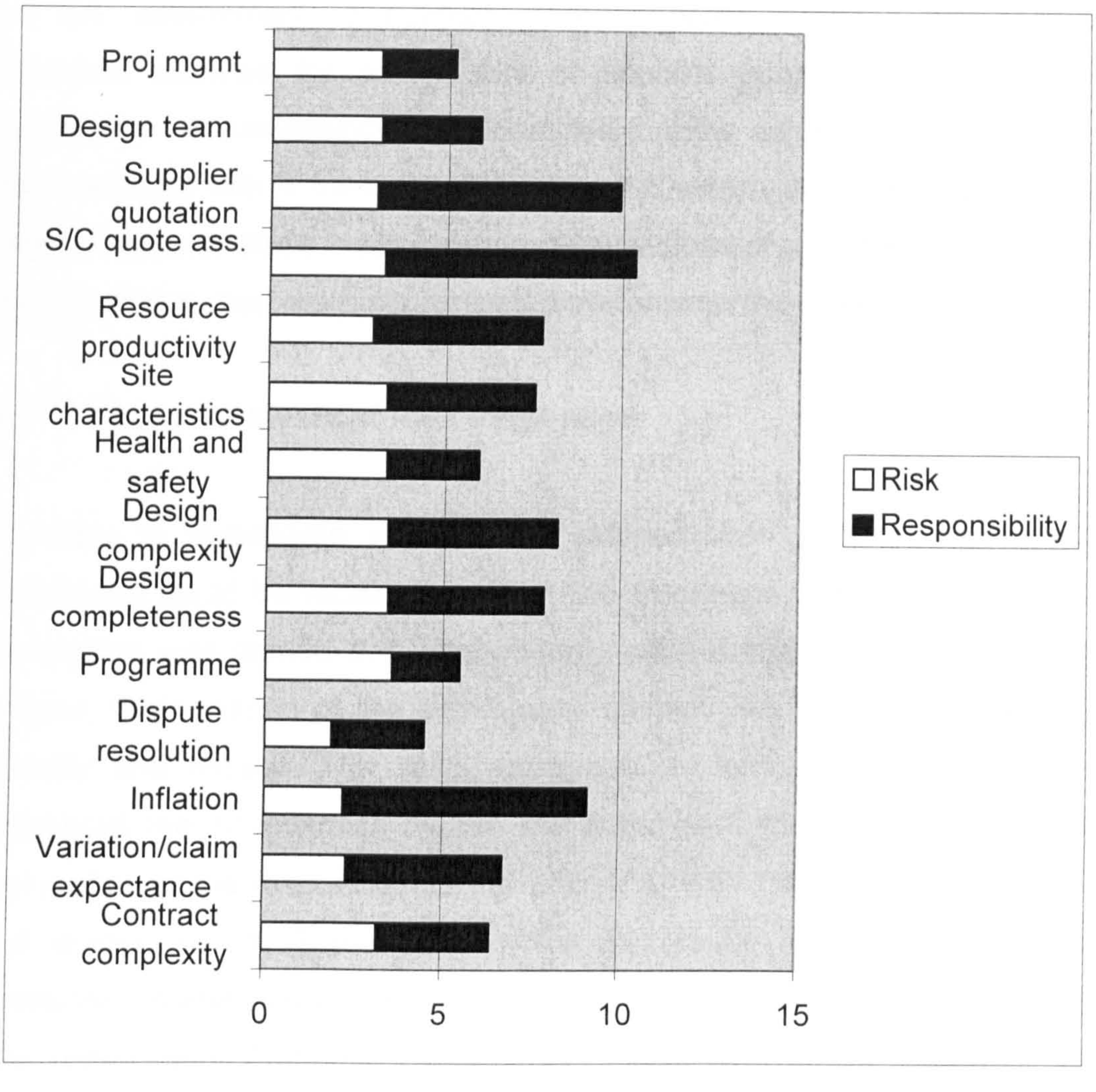


Figure 6.5 Summary of risk perception and responsibility for the sample

The Figure 6.5 indicated that there was evidence of the change in the estimator's role when identifying and analysing risks. They were principally responsible for supply chain quotation assessment, which when combined with their perception of the risk of design completeness and complexity as being high, would indicate that they require a good ability to assess the technical complexity of the supply chain's input into projects. As indicated in the literature review, the design and build procurement route was used by a significant proportion of the industry's clients, which when used in competition, requires the contractor to give a lump sum price usually before the design was complete. The estimator perceived inflation risk and design risk as serious and this is further developed in the thesis when considering the informational environment of the estimator. There was little evidence of sophisticated analysis of risks across the range identified; the use of judgement was identified by a significantly high number of respondents as their primary method

for risk assessment, a number of respondents identified that they used statistical analysis for assessment of supplier quotations and subcontract quotations. A contingency table identified that the adjusted residual values for organisations with a turnover >99m was 1.6, which indicated a proportionally higher usage of these methods than organisations of a smaller size. The larger organisations used more sophisticated systems for the analysis of risks.

6.7 Factor Analysis of Risk Perception

In order to investigate whether the categorisation used in the measuring instrument could be recast, based on the responses, a factor analysis of risk perception was carried out. Respondents were asked to identify, for a typical project, their opinion of the significance of each risk that they usually had to identify and assess. The scale used was a Likert scale and was used to represent the seriousness of the, the outcome if the risk occurred and the perception of the respondent to the amount of effort taken to manage it during the tender period. The attitude scale was factor analysed using principal components analysis with varimax rotation. Missing values were replaced with the mean and Cronbach's alpha was used to test the reliability of the dimensions. The number of factors to be extracted was obtained by inspecting the scree plot.

The analysis illustrated in Table 6.26 revealed five orthogonal factors, which were labelled 1. Project complexity, 2. Supply chain price veracity, 3. Management, 4. Project governance and 5. Legislative, which are indicated in table 6.03 below.

The project governance factor had a Cronbach's alpha of lower than 0.7, indicating that the items were not highly correlated however even though the alpha values were low the scale did factor out in a meaningful way.

Risk components	Factor loading	% Very critical	% Serious	% Negligible
Project Complexity				
Programme	.706	50	38	11
Resource productivity	.701	25	44	31
Design complexity	.718	46	40	14
Design completeness	.701	44	35	21
Cronbach's alpha=.79				
Supply chain price veracity				
Subcontract quotation	.889	39	40	21
Supplier quotation	.794	28		
Cronbach's alpha=.86				
Management				
Design team	.888	35	42	23
Project team	.822	34	38	27
Cronbach's alpha=.91				
Project governance				
Dispute	.901	3	18	79
Variation assessment	.724	8	34	58
Inflation	.536	9	25	66
Cronbach's alpha=..45				
Legislative				
Health safety	.831	41	38	20

Table 6.26 Factor analysis of risk perception

The factor analysis usefully recast the risk perceptions into categories that supported the development of the model based upon those risks that the estimator was principally responsible for and that were perceived as serious. The project complexity factor has a high loading for design completeness and the supply chain price veracity factor has a high loading for the variable subcontract quotation. The risk factors identified, as management was not generally found to be the responsibility of the estimator and can be considered to be delimited by survey. This concurs with the open interviews during the pilot of the study, the project management teams and design teams were considered to be critical for project success however the assessment of the

price risks associated with these teams were considered to be the responsibility of the adjudication team.

Organisations were not specialising in any one particular market which corresponds with the findings of Hilebrandt (Hillebrandt et al., 1995), they tended to have a wide and diverse portfolio of clients and consequently required systems that can adapt to a wide range of procurement approaches and client requirements. There was no evidence of any specialisation within any one particular sector.

The environmental circumstances that surrounded construction in the period between 1980 and 2000 are reported as relating to changes in competitive structures, increasing complexity of projects, a move away from traditional contracting, rapidly fluctuating workloads, lack of skilled labour, reduction in overseas opportunities, pressure for performance improvements from Latham and Egan reports and an increasing move towards relational contracting (Langford and Male, 2001). It was suggested that contractors are caught in a dilemma; they are required to compete in a range of diverse markets that have specific technologies (which include procurement arrangements and construction technologies) and consequently in order to survive they offset a lot of risk to other organisations and tend to subcontract a large proportion of their work (Lansley, 1987). It has been argued that this places the contractor in a strong position over subcontractors and suppliers, and allows them to manage workloads and maximise their market position. The findings of the survey support this assertion. However, the power differential between subcontractor and main contractor was found to be more complex than suggested above. The next section of the results considers the main contractor's use of subcontractors.

6.8 Supply Chain

In order to assess the relevance of transaction cost economic theory to organisational behaviour during the estimating stage, a detailed analysis of the relationships that organisations develop with their supply chain was carried out. The questionnaire development was discussed in chapter five of the thesis,

which indicated how the various constructs were measured. This section reports on the data analysis of questions 8,10, 12 and 13.

The summary aims of this section of the survey were to inter-alia:

- Establish the current approach organisations take to the procurement of specialist trade contract estimates, which could be considered as a proxy measure of the asset specificity of subcontract organisations;
- Evaluate the benefits offered by an approach that increases the asset specificity of subcontractors from supply chain partnering;
- Establish the extent and format of ex-ante communication of price information between supply chain organisations and the link with the technology employed by the supply chain;
- Determine the market price variability and the influence, if any, that asset specificity of specialist trade contractors may have .

6.8.1 Supply Chain and Contractors

The respondents were asked to provide information about the percentage of work their organisation subcontracted. A five point Likert scale was used to gather the data. 36% of the respondents indicated that they subcontracted over 80% of their work, 22% indicated that they subcontracted 60-80%, 16% indicated that they subcontracted 40-60%, 15% indicated that 20-50% was subcontracted and 12% identified that their organisation subcontracted less than 20%. A Chi square test 79.078, $p<0.001$ indicated that there was an association with organisation size and level of subcontracting; Kendal Tau 0.380 indicated that the association was moderately strong.

Respondents were asked to identify whether their employing organisation had a strategy to develop closer links with selected specialist trade contractors and suppliers and the length of time the strategy had been implemented. 172 respondents stated that their employing organisation had a supply chain strategy, 33% of respondents identified that the strategy had been in place for up to 2 years, 59% for up to 4 years, 81% for up to 6 years, 6% of respondents identified that they had a strategy for over 10 years. The data was then used to

place organisations into five categories, none n=56, emergent (<2 years) n=42, developing (3-5years) n=60, mature (6-9 years) n=7 and stable (>10 years) n=15 and then a comparison of the approaches taken by each of these against organisations that did not have a strategy was carried out to assess whether and what effect a strategy had.

6.8.2 Contractor's Supply Chain Procurement Practice: GLM

Respondents were asked to identify the typical number of enquiries sent out to specialist trade contractors during the development of the estimate. A matrix style question displayed in Figure 6.6 was used identifying six trades and three procurement routes. The criterion data collected was at interval level for the three nominal procurement route categories for six nominal categories of trade contractor. The trade nominal categories were based upon the categorisation by Gray and Flanagan (1989). The mechanical and electrical work package was selected for the design, manufacture, supply and fit category, the steel work and roofing and cladding workpackages were selected for the design, supply and fix, supply and fix included finishes and fix only included brickwork and groundwork. The former usually labour only and the latter usually labour and plant.

8 Please indicate the number of subcontractors usually invited to submit bids for the three procurement approaches indicated.			
Work Package	Design and Build	Drawing and specification	Firm BQ
Groundworks and Drainage			
Steel Frame			
Mechanical and Electrical			
Roofing and Cladding			
Brickwork			
Finishes			

Figure 6.6 Project specificity of supply chain organisations and procurement route

The data had been gathered from a number of individuals and was considered as "between subjects" data. Data such as organisational size, subcontract strategy, and estimator experience are all categorical variables that are subject specific and used for between subject analysis. The data gathered on the number of send outs for the three different procurement routes was considered

primarily as "within subject" data but was analysed between subjects and within subjects. The following set of analyses use between subjects, repeated measures, as respondents provide data on their send out behaviour for three different procurement routes, which can be considered as an independent variable and six differing trades of subcontractor (trade was also considered as an independent variable).

6.8.2.1 Procurement-Between Subject Effects

The general linear model for repeated measures was used. To consider whether respondents varied in their send out behaviour for the three different procurement routes, procurement was identified as a factor with three different levels, traditional, design and build and drawings and specification. The dependent variable was the derived criterion variable of average number of sends outs for each procurement arrangement. The % level of subcontracting was identified as a covariate. The contrasts between the means were selected as repeated. The Bonferroni correction was selected, as

> "the Bonferroni method is generally the most robust of the univariate techniques available" (Field, 2000) pp330.

Mauchly's test of sphericity was violated (41.05, $p<0.001$) consequently a correction factor was applied to the F ratio, the Greenhouse-Geisser estimate is applied when 1/k-1 is close to 1. The value in the repeated measure case was 1/(3-1) or 0.5, the calculated $\tilde{e}$ was 0.839, which is closer to the upper limit of 1.0 and consequently the variances of difference were considered as more homogenous. There is a lack of consensus about the relevant value and the impact that the correction factor has upon sphericity. However wherever the value exceeds 0.75 Girden reported in (Tabachnick and Fidell, 2001) suggests that the Huynh-Felt correction should be applied.

An value of $F(1.69,193)=74.35$ at $p<0.001$ indicated that a significant difference existed between the mean number of send outs for three procurement routes. The transformation matrix identified that a significant difference was found between design and build and traditional procurement F

(1,139)=86.415, p<0.001 and drawings and specification and traditional F (1,193)=106.38, p<0.001 however a non significant result was found between drawings and specification and design and build F (1,193)=1.275, p=0.260. A review of the pair wise comparisons indicated that the largest difference in-group means was between the design and build and the traditional procurement route.

6.8.2.2 Procurement and Trade-Between Subject Effects

To assess whether this model was found for the different trades for the three procurement routes, the repeated measured GLM was extended to take into account the trades. This can be considered a 3x6 repeated measures factorial GLM (Bryman and Cramer, 2001).

The order of variables in a repeated measure is important, the bill of quantities was found to have the highest number of send outs and this was considered as a comparator and consequently entered last in the repeated measure analysis.

As before, the Mauchly's test of sphericity was violated for both procurement and subcontract trade, 0.810,0.608 and0.682. The interaction test was lower than 0.75, consequently the Greenhose-Geisser corrected values were taken. There was a significant main effect of procurement F(1.619,221.86)=69.61, p<0.001, a significant main effect of subcontract trade F(2.97,406.18)=25.41, p<0.001 and a significant interaction effect between these two variables F(6.82,934.18)=2.96, p<0.05. The tests of within subjects comparisons indicated, that for trades, a significant difference was found between groundworks and drainage and finishes F (1,137)=29.55, p<0.001, mechanical and electrical and finishes F (1,137)=7.06, p<0.05 and brickwork and finishes F (1,137)=58.97, p<0.001.

When the interaction effects of procurement and subcontract trade were taken into account, the significant differences were found as follows, Design and build/Traditional procurement-groundwork and finishes F (1,131,12)=4.00, p<0.05 and mechanical and electrical and finishes F(1,183.45)=4.87, p<0.05 and Drawings and specification groundworks and finishes F(1,180.4)=5.30,

$p<0.05$. An analysis of the contrasts indicated that mechanical and electrical and groundworks were significantly lower than finishes for each procurement approach when tested against traditional. The approach above gave a general analysis of the interaction effects of trade and procurement and identified that there were differing levels of asset specificity for differing trades and procurement routes however the important intervening variable of project complexity was required to be taken into account. Project complexity was considered a difficult variable to measure consequently organisation turnover was considered as a proxy.

In order to carry out an analysis of the effect of organisational turnover on the trends identified above, a mixed design GLM was carried out, the within subject variables of procurement and subcontract trade were as before and a between subject factor of organisational turnover was used. A post hoc Bonferroni test was utilised to identify if any significant differences between the groups was found. As before the Mauchly's test of sphericity was violated for both procurement and subcontract trade, 0.831,0.613 and0.681. The interaction test was lower than 0.75 consequently the Greenhose-Geisser corrected values were taken. The independent variable, turnover had a significant main effect, $F(1,132)=6.64$, $p<0.001$, the interaction between turnover and procurement (Design and Build, traditional and Drawings and specification) was significant, $F(6.65,219.35)=2.42$, $p<0.05$. This indicated that different organisation sizes took a significantly different approach to the three procurement arrangements tested. The plots in Figure 6.16 indicate the differing approaches taken by organisations for the three procurement approaches.

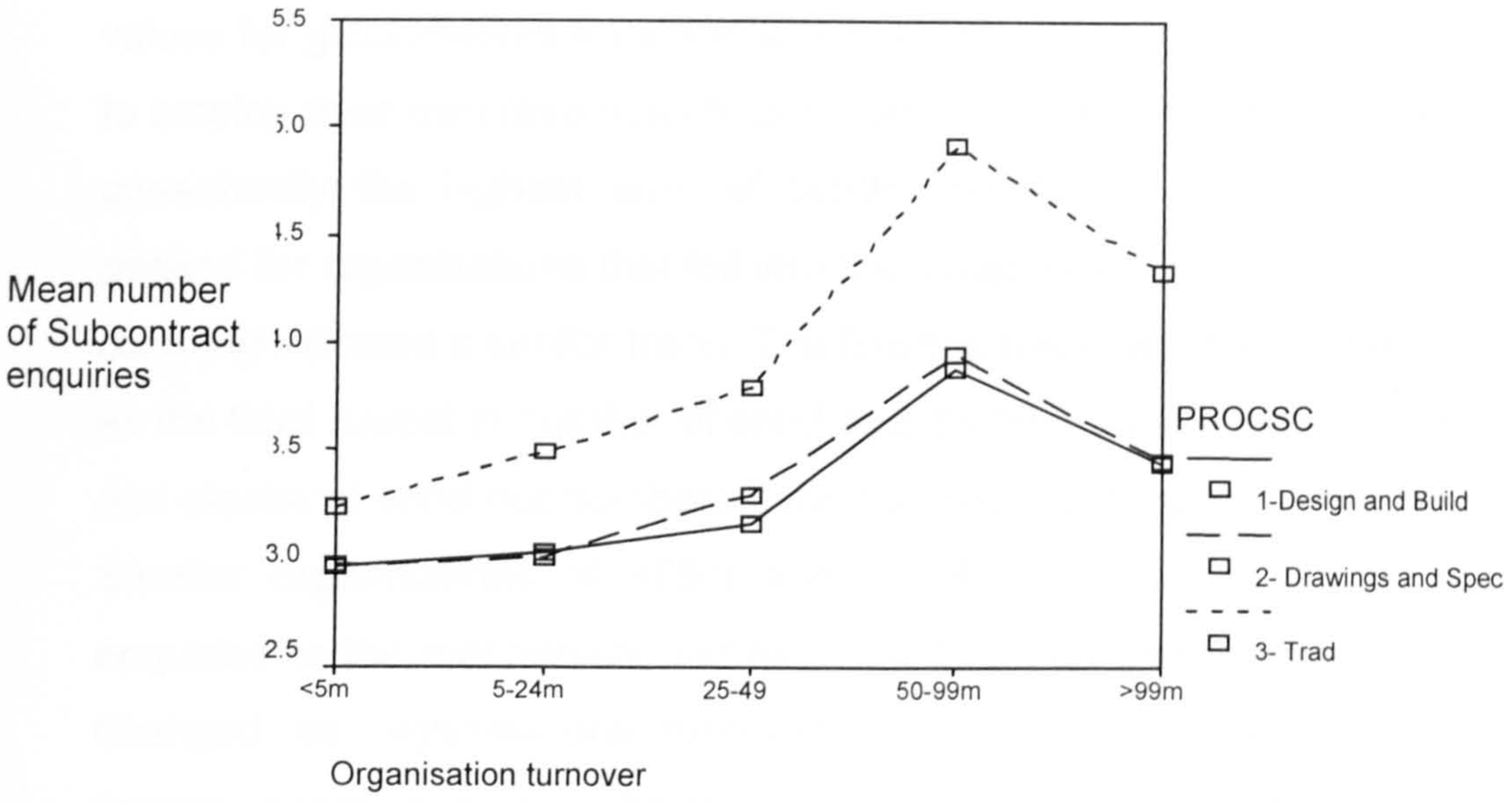


Figure 6.7 Mean number of subcontract enquiries for three procurement approaches

The effect of trade also violated the sphericity conditions; consequently the corrected value for F was reported. There was a significant interaction between the turnover of the organisation and the trade F(12.266,404.79)=2.08, p<0.005. This indicated that organisations took a significantly different approach to the different trades as indicated in Figure 6.8.

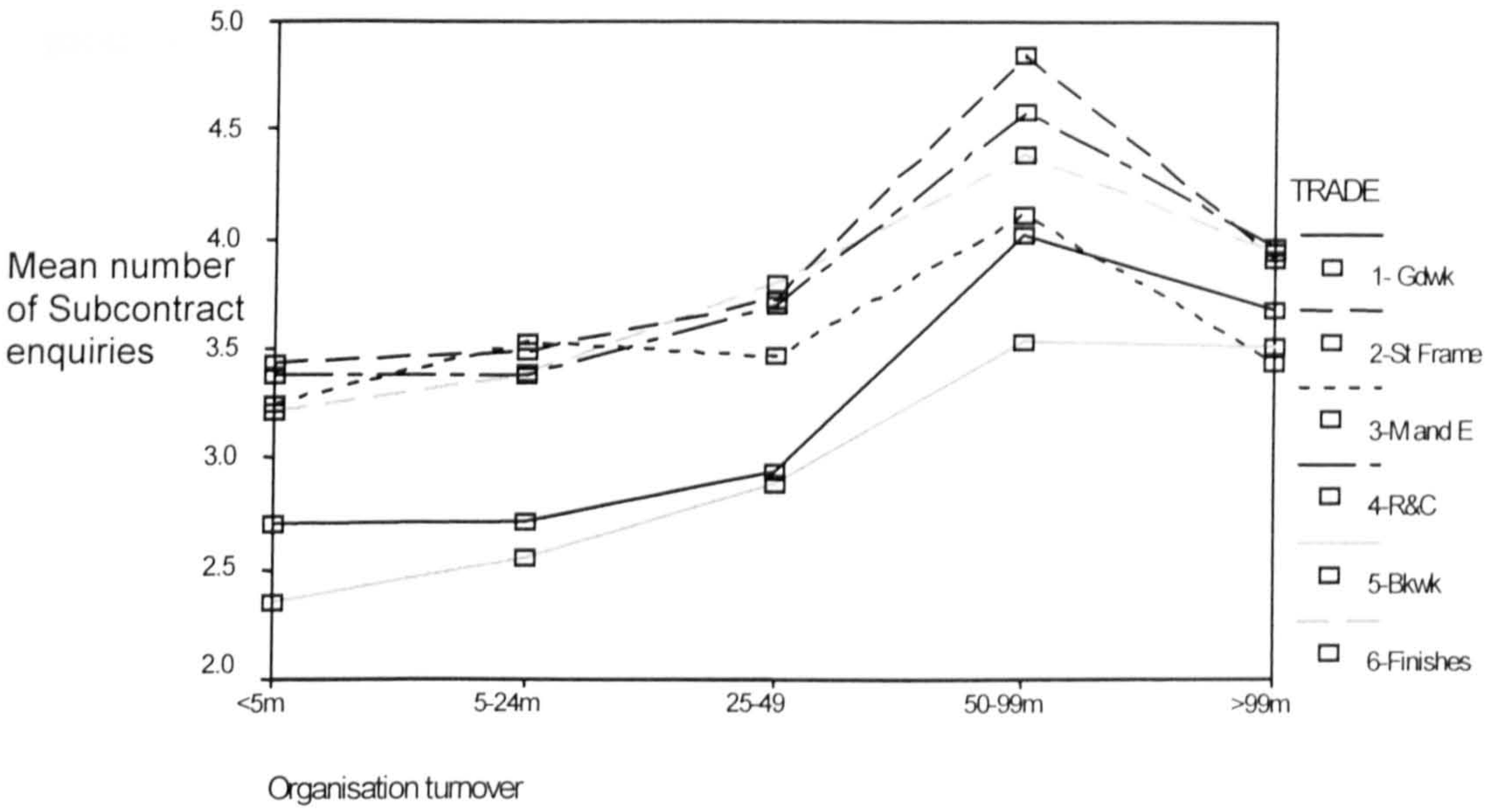


Figure 6.8 Interaction effects of organisational turnover and trade

The trades of groundwork and brickwork were indicated as having the lowest number of send outs for all organisational groups. The number of missing values for groundworks for lower sized organisations indicated that they tended to employ their own resources to carry out this work. The steel frame trade was consistently the highest level of sends outs for all organisation sizes, this peaked for organisations that fell into the category of £50-99m, and roofing and cladding followed a similar trend. The finishes trade was the consistently placed as the third lowest in number of send outs by all organisations. The mechanical and electrical send out numbers varied across the range of organisation sizes. Smaller organisations of <£5m and £5-24m sent out a similar number of enquiries to the mechanical and electrical trade as other trades, this approach changed as organisations turnover exceeded £25m, which indicated that organisational size was having a significant effect. Organisations with a turnover <£99m sent out less to the mechanical and electrical trade than any other trade or any other organisation category.

6.8.2.3 Interaction Between Turnover, Procurement and Trade

As the sphericity conditions were violated and were below 0.60 the Greenhose-Geisser correction factor was applied, $F(29.73,981.16)=1.47$, $p<0.05$ which indicated that there was a significant interaction between turnover, procurement and trade. Figures 6.18, 6.19 and 6.20 identify the differences for the three procurement arrangements.

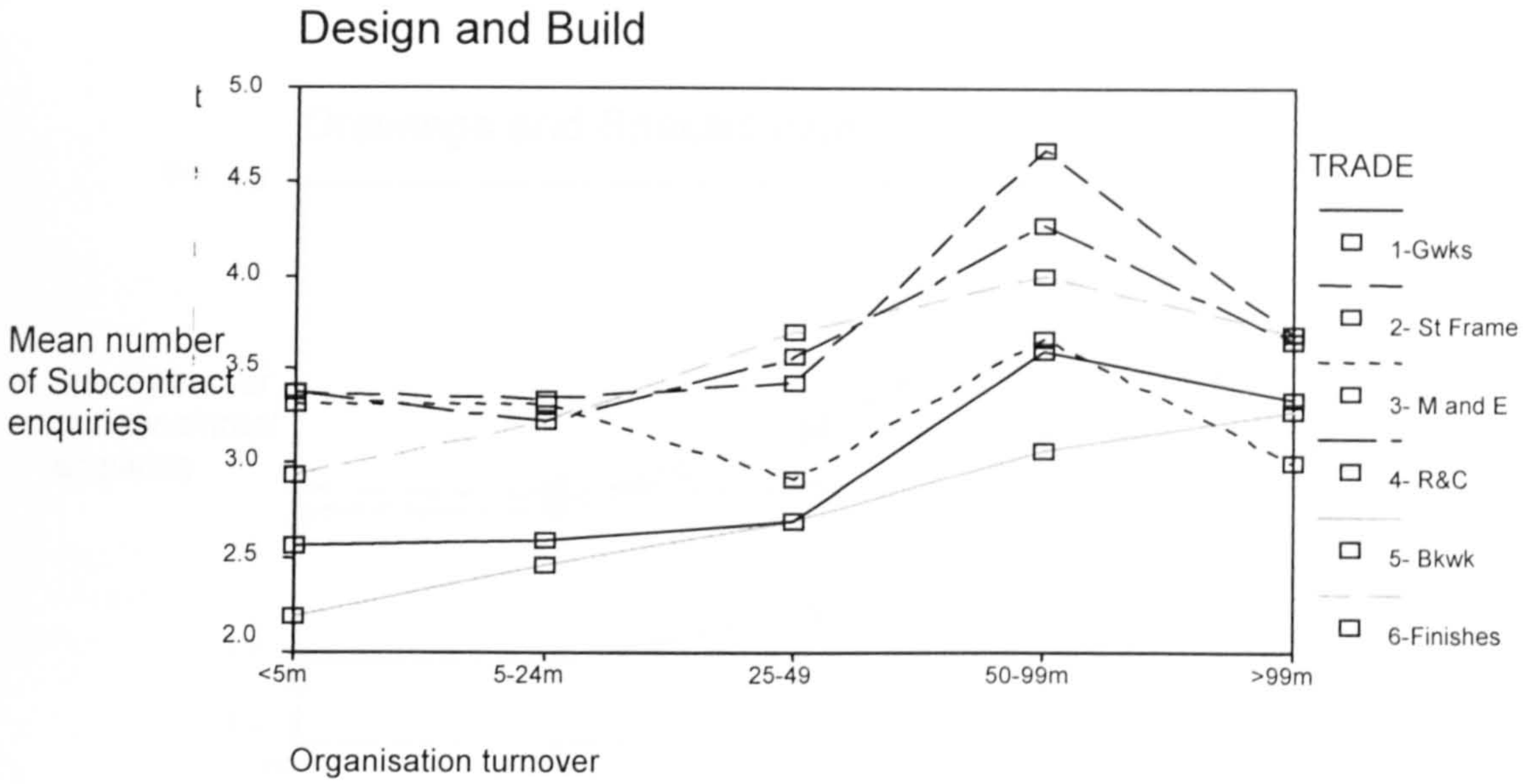


Figure 6.9 Subcontract enquires sent out by trade and organisational turnover for the design and build procurement approach.

The general trend for steel frame, roofing and cladding and finishes were similar to the general results however a significant reduction in enquiries sent was evidenced by organisations with a turnover >£99m. The low levels of enquiries sent to groundwork, brickwork was as the general trend identified earlier. The mechanical and electrical trade was emerging from the analysis as an subcontract trade that had a high level of specificity than other trades particularly for the design and build procurement route for organisations with a turnover >£99m.

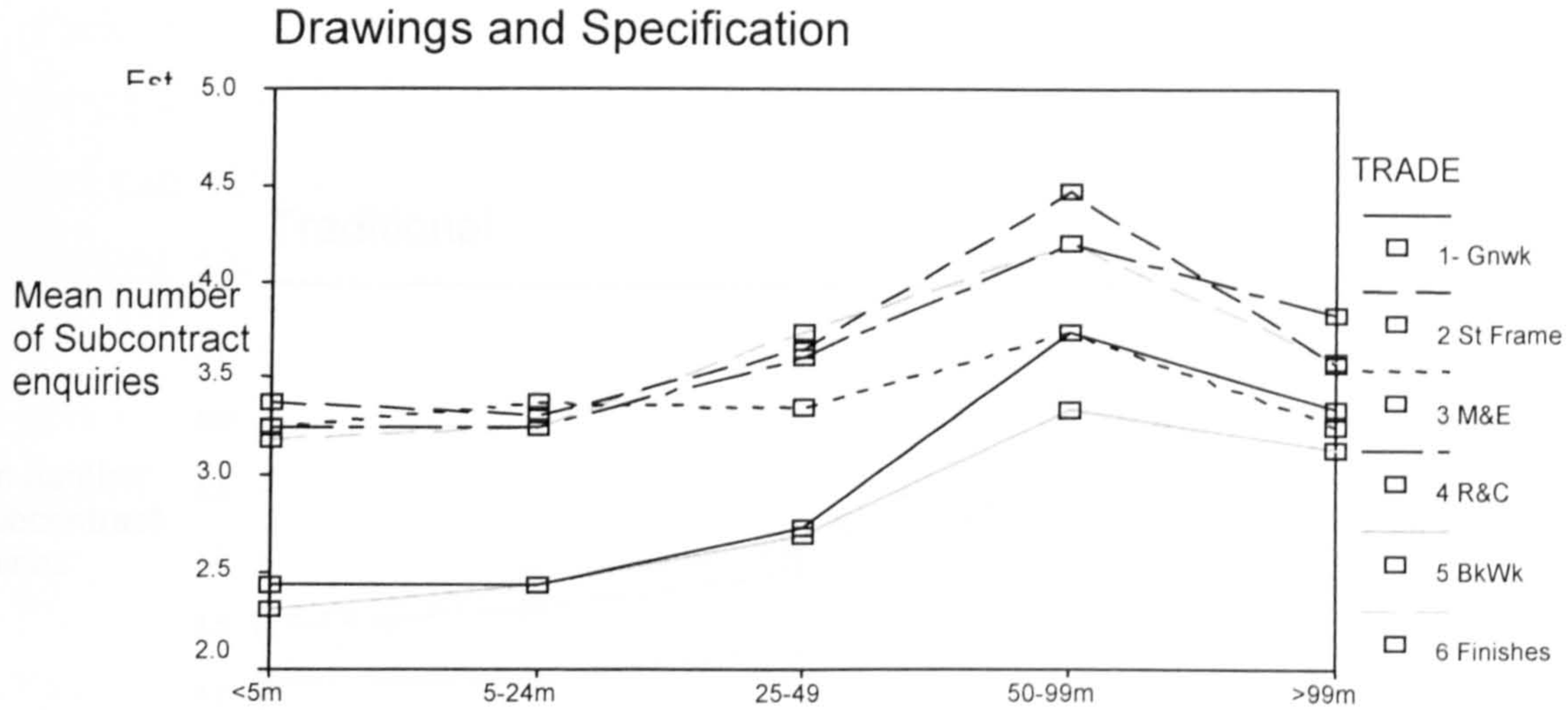


Figure 6.10 Subcontract enquires sent out by trade and organisational turnover for the drawings and specification procurement approach

The trends for the number and order of enquiries sent out for the drawing and specification route was, that the differing trades was similar to the design and build approach with the exception of the significantly reduced extent of mechanical and electrical. The high levels of enquiries sent to the steel frame trade was surprising as this trade has an element of design and was considered to have a similar asset specificity to the mechanical and electrical trade.

When the work was quantified within the traditional procurement route, all organisations sent out significantly more enquires than when the work was procured using design and build and drawings and specification. Similar distinctions were seen between the numbers sent out to the different trades, however as organisations of turnover >99m tended to follow a similar approach for all trades, the asset specificity of the trade could be considered as being lower than comparable procurement approaches that require design development.

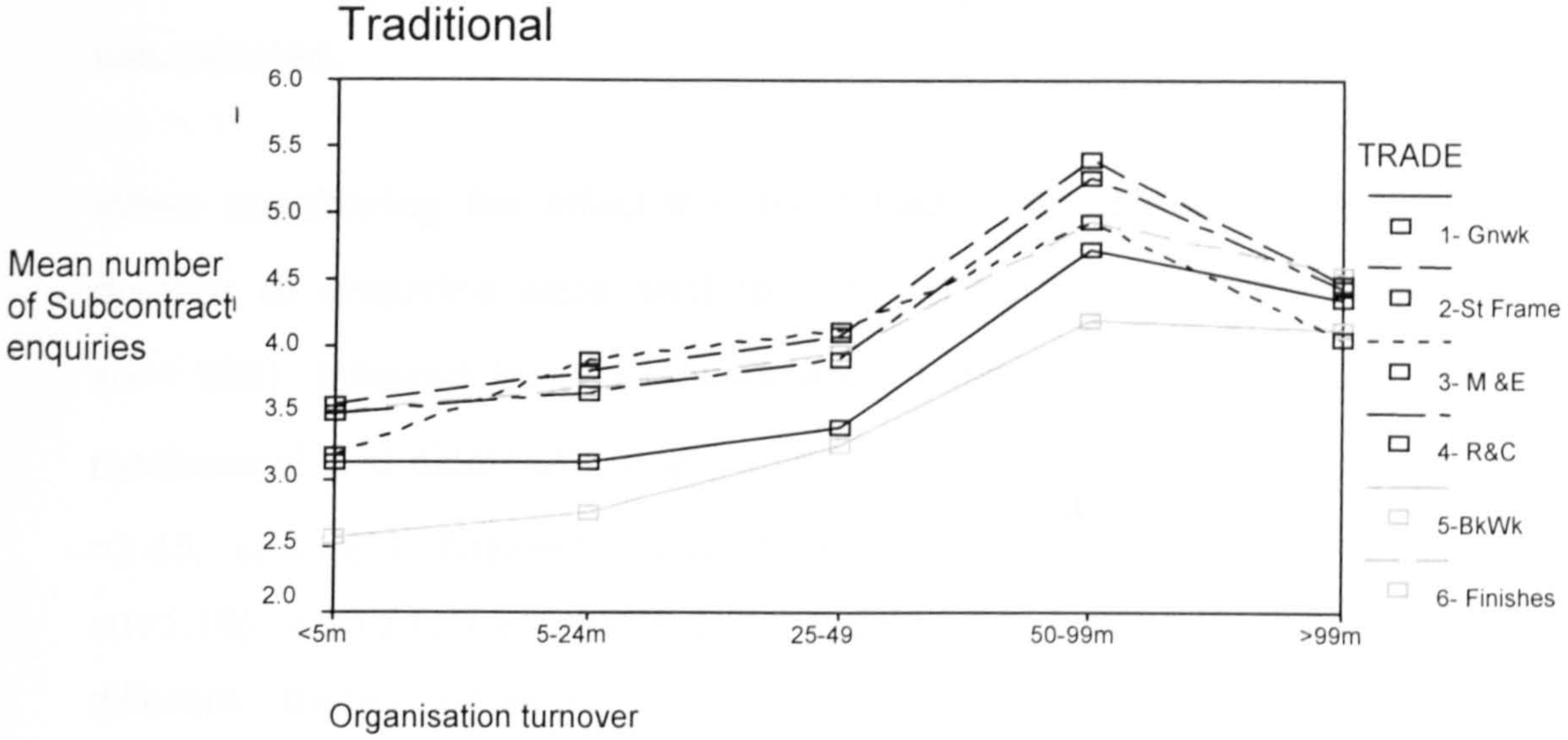


Figure 6.11 Subcontract enquires sent out by trade and organisational turnover for the traditional procurement approach

6.8.2.4 Summary of GLM

The contrasts within the repeated measures GLM indicated that the mechanical and electrical subcontractor was significantly interacted upon by procurement and turnover for the design and build/traditional procurement route $F(4,132)=5.49$, $p<0.05$ and for the drawings and specification route/traditional $F(4,132)=2.58$, $p<0.05$.

6.8.3 Non-Parametric Validation of GLM

In order to ensure a robustness of this finding, a non parametric validation of the general linear model was carried out, although the corrections for non sphericity of data were applied within the GLM above which correct for non homogeneity of data (Tabachnick and Fidell, 2001), where there is doubt about whether some of the assumptions of the parametric have been met it has been suggested that a equivalent non parametric assessment should also be carried

out (Bryman and Cramer, 2001; Field, 2000). The full series of tests is included within Appendix 6 and a summary of the analysis is included here, a Kruskal Wallis test established that the chi square value for the Design and build procurement route was x^2=19.495, df, 4, p<0.001, Drawings and specification x^2= 46.498, df 4, p<0.001 and the traditional route x^2=62.668, df,4, p<0.001. It was established that the differences were significant and the null hypothesis was rejected.

When considering the effect that trade had a KW test indicated that lowest number of enquiries were sent to brickwork subcontractors ($\bar{x}_{(224)}$ =2.86, sd=1.358), followed by groundwork and drainage ($\bar{x}_{(233)}$ =2.933, sd=1.29), mechanical and electrical ($\bar{x}_{(257)}$ =3.51, sd=1.14), roofing and cladding ($\bar{x}_{(251)}$ =3.45, sd=1.21), finishes ($\bar{x}_{(243)}$ =3.45, sd=1.17, steel frame ($\bar{x}_{(250)}$ =3.49, sd=1.16). A KW test established that a difference existed for the means of the different trades between organisations of differing sizes. groundworks x^2=44.017, df,4, p<0.001, mechanical and electrical x^2=26.367, df,4, p<0.001roofing and cladding x^2=50.902, df,4, p<0.001 finishes x^2=57.510, df,4, p<0.001steel frame x^2=50.531, df,4, p<0.001brickwork x^2=42.790, df,4, p<0.001.

When considering the effects of Organisational size and procurement approach, it was established for the following trades and procurement routes that there was a significant difference between organisations of different size, shown in table 6.27 below.

Trade	Design and build		Traditional		Drawings and spec.	
	x^2	p	x^2	p	x^2	P
Groundworks and drainage	19.27	p<0.001	52.15	p<0.001	28.485	P<0.001
Steel frame	22.467	p<0.001	42.003	p<0.001	35.060	P<0.001
Mechanical and electrical	13.708	p=0.05	24.936	p=0.001	15.802	P=0.001
Roofing and cladding	18.716	p<0.001	45.358	p<0.001	42.246	P<0.001
Brickwork,	11.497	P<0.05	42.819	p=0.001	25.682	P=0.0012
Finishes	22.885	p<0.001	56.846	p<0.001	38.864	P<0.001

Table 6.27 KW test for differences for trade for three procurement approaches

The null hypothesis was consequently rejected, and Ha was accepted that there were significant differences found of the means for the trade subcontract send outs for the design and build, traditional and drawings and specification client procurement routes between organisations with different annual turnovers. This supported the findings within the general linear model identified above. A non-parametric intra organisation analysis was also required, as a method of non-parametric analysis of between subject and within subject independent variables was not found. A Friedman test was used to investigate the difference in send outs for the different trades for organisations of differing turnover as indicated in Table 6.28.

Trade	<5	5-24	25-49	50-99	>99
Groundworks	3.29	2.61	2.70	3.00	3.48
Steel frame	4.03	4.01	4.09	4.50	3.88
Mechanical and Electrical	4.0	4.20	3.23	3.00	2.63
Roofing and cladding	3.84	3.77	4.04	4.05	3.96
Brickwork	2.51	2.71	2.88	2.50	3.13
Finishes	3.33	3.70	4.07	3.95	3.92
x^2 (df 5)	31.35	70.48	28.41	27.133	42.71
n	38	64	28	20	63

P<0.001

Table 6.28 Friedman test for six trades and five turnover groups.

The data analysis results in table 6.28 indicated that organisations whose turnover exceeded >£99m only differentiated for mechanical and electrical and brickwork by sending out fewer enquiries to these two groups. Organisations with a turnover between £50-99m sent out more enquiries to steel frame subcontractors and roofing and cladding, significantly lower numbers were sent to brickwork subcontractors. Organisations with a turnover of £25-49 m grouped groundworks and brickwork together, they sent significantly lower numbers of enquiries to these contractors than steel frame, roofing and cladding and finishes. Organisations with a turnover £5-24m indicated that steel frame and mechanical and electrical were grouped as the highest, roofing and cladding and finishes grouped as the median and the lowest number sent to brickwork and groundworks. For organisations with a turnover of less than <5m

the lowest number of enquiries were to brickwork and finishes, the highest number to steel frame and Mechanical and Electrical.

6.8.3.1 Summary of Factors influencing project specificity of subcontractor

As identified by the non-parametric data analysis, organisational size was an intervening factor when considering the specificity of the subcontract organisation. The largest organisations whose turnover exceeded £99m sent out fewer enquiries generally than those organisations of smaller turnovers. This would indicate that the project specificity of subcontractors does vary with organisational size and suggested that project complexity was a significant factor. This was further supported, when the detailed analysis identified that the highest project specificity was indicated as being the mechanical and electrical subcontractors for organisations whose turnover exceeded £99m. This would suggest that this subcontract category are influencing organisation behaviour significantly more than those other trades which include a design element such as steelwork and roofing and cladding. The survey did not uncover the reasons underlying this however this formed an aspect that required validation in phase two. The specificity of the groundwork and drainage and brickwork categories of trade contractor were difficult to assess from the send out dataset, organisations sent out less to these trades, there was extensive missing data for the smaller types of organisation suggesting that they had integrated these activities into their firms. This aspect of the model was also explored in phase two. In order to assess whether an espoused supply chain strategy had an effect on specificity a further analysis was carried out and is reported in the next section.

6.8.4 Supply chain Strategy Effect

The derived nominal category of supply chain strategy was developed to represent the stability of the respondents employing organisations and their supply chains. The five nominal categories were none n=56, emergent (1-2 years) n=42, developing (3-5years) n=60, mature (6-9 years) n=7, and stable (>10 years) n=15.

The results indicated that although a strategy existed, it did not have an effect on the pattern established previously for the send out to the different trades. This was tested in two ways, firstly a non-parametric KW test was carried out, the results of which are reported in Table 6.29, and to test whether organisation turnover was an intervening variable a factorial ANOVA was carried out.

Ho: The means of given subcontract trades (*u*) send outs for a given client procurement route do not vary between organisations with differing supply chain strategies

Trade	Procurement					
	Tradition		Design and Build		Drawings and Specification	
	x^2	p	x^2	p	x^2	p
Groundworks	21.845	<0.001	5.57	.234	11.853,	0.018
Steel Frame	4.836	0.305	0.415	.981	10.425	0.034
Mechanical and Electrical	2.448	0.654	13.708	.372	4.837	0.304
Roofing and cladding	12.805	.012	18.716	.168	20.608	<0.001
Brickwork	19.038	<0.001	11.497	.362	15.233	<0.005
Finishes	23.366	<0.001	22.885	.012	14.658	0.0126

Traditional-Significant differences found for groundworks, brickwork and finishes
Design and build-No significant differences found for the design and build procurement route
Drawings and specification-Significant differences found for groundworks and drainage, steel frame, roofing and cladding, brickwork.

Table 6.29 KW tests comparison of means of sends outs for three categories of procurement route for organisations with subcontract strategies.

A Kruskal Wallis test was used to compare the means for the five categories above for each of the three procurement routes, Table 6.29 displays the results. The null hypothesis was not rejected for all trades, however it appeared that an intervening variable was having an effect. In order to test for the effect of an intervening variable, a factorial ANOVA for an unrelated factorial design was carried out. The two independent variables were organisational turnover (5 categories) and subcontract strategy (5 categories); the derived criterion variable was the average subcontracts send outs for three procurement routes. The Levene's test was carried out to test for homogeneity of variance for each

of the three runs, in each, the result was non-significant indicating that the assumption had been met.

The results were;

Traditional; there was a significant main effect of supply chain strategy on the average number of subcontract enquiries sent out for the traditional approach. The post hoc scheffe test indicated that this was significant for none-emergent and emergent-stable $F(4,220)=2.748$, $p<0.05$. It was found that there was no significant interaction effect between organisation turnover and the subcontract strategy maturity on the average number of subcontracts sent out for the traditional procurement approach $F(4,201)=1.240$, $p=0.245$.

Design and build; there was a non-significant main effect of supply chain strategy on the average number of subcontractors sent out for the design and build procurement approach $F(4,214)=0.610$, $p=0.656$.

Drawings and specification; There was a non-significant main effect of supply chain strategy on the average number of subcontractors sent out for the drawings and specification procurement approach $F(4,220)=2.165$, $p=0.074$.

The overall effect of having a supply chain strategy to develop closer links was minimal when considering extent of use of the market. The main influencing factor was the clients procurement route, the highest subcontract project specificity found was the design and build procurement route regardless of espoused subcontract partnering strategy. The lowest project specificity was indicated to occur for the traditional procurement route. The underlying reasons for this difference were not considered in phase two of the research.

6.8.4.2 Client Partnering Effect

Partnering experience was a derived nominal variable, the data collected at ratio scale was the % that partnered projects contributed to annual turnover. There were only two nominal categories, less than 50%, n=283 and over 50%, n=27.

The quantity of data was low and the quality was also low as the data was derived, although no significant difference between the two groups, a comparison of the means indicated a slightly lower number of subcontractors sent out to by organisations who were involved in client partnering.

In order to assess whether variability in price returned from the subcontract trade was a reason for the differentiation in behaviour to the differing trades, a further analysis was carried out. The analysis was carried out in two ways, firstly a within analysis was carried out to determine whether organisations varied in their behaviour to the different trades and considered turnover and supply chain strategy. The second group of analysis was between organisations to investigate whether trade was a differentiating variable for different organisation sizes and whether supply chain strategy had an effect.

In order to assess whether one of the drivers for the differences in the extent of the use of the market was the variability of returned prices, an analysis of the price variability was undertaken and is shown in Table 6.30 below, a Friedman test was carried out for a within subject design on the means of the range of prices returned from the supply chain.

Trade	<5(n=38)	5-24(n=64)	25-49(n=28)	50-99(n=20)	>99 (n=63)
Groundworks	3.96	3.69	4.12	3.77	4.31
Steel frame	3.20	3.31	2.74	3.27	2.64
Mechanical and Electrical	4.35	5.24	4.94	4.00	4.50
Roofing Cladding	3.17	3.11	2.85	3.41	3.05
Brickwork	3.11	2.60	3.12	3.64	3.29
Finishes	3.22	3.04	3.24	2.91	3.21
x^2 (df 5)	12.28*	51.94**	21.39**	2.97	48.21**

* p<0.05 **p<0.01

Table 6.30 Friedman tests on average variability of prices returned from the supply chain

The highest variability in prices was seen for the mechanical and electrical trade, which paradoxically had the lowest number of enquiries, sent. The steel

frame trade had the lowest variability for the largest organisations yet had one of the highest levels of enquiries.

6.8.4.3 Supply Chain Price Variability- between subjects

Respondents were requested to provide data on the variability of prices received from the supply chain under competition. The trades were groundworks and drainage, steel frame, mechanical and electrical, roofing and cladding, brickwork and cladding and finishes. A descriptive analysis of the data indicated that the work package showing the greatest variability was mechanical and electrical $\bar{x}$ (21.32)=21.32, sd=14.677 followed in descending order by were groundworks $\bar{x}$ (149)=16.37 sd =9.23, steel frame $\bar{x}$ (162)=13.76 sd=11.63, finishes $\bar{x}$ (154)=13.74, sd=10.20, roofing and cladding $\bar{x}$ (159)=13.42, sd=13.42 and, brickwork $\bar{x}$ (142)=13.26, sd=9.04. The data were assessed for distribution and skewness using the KS test at $p<0.05$ and the following z scores of skewness were found; Groundworks z=1.91 ks= 0.224, steel frame z= 3.48 ks= 0.269, M and E z= 1.72 ks= 0.194, roofing and cladding z= 3.26 ks=0.294, brickwork z= 1.90 ks=0.253, finishes z=2.44 ks=0.234 indicated that the data were positively skewed were not normally distributed.

To establish whether there was a difference between the variability of prices received from the supply chain and the different organisation sizes, a non parametric KW test was performed which indicated that there was no significant difference for the workpackages groundworks (x^2 (4)=. 898 p=0.925) steel frame (x^2 (4)=9.25 p=0.055), mechanical and electrical (x^2 (4)=6.05 p=0.195), roofing and cladding (x^2 (4)=4.48 p=0.345), brickwork (x^2 (4)=0.687 p=0.953) and finishes (x^2 (4)=0.075 p=0.999). The only workpackage that approached a significant difference was the steel frame a post hoc scheffe indicated that the difference was between organisations of turnover <£5m and >£99m. In order to establish whether a correlation existed between the average number of workpackage enquiries sent out and the variability of prices received a non-parametric bivariate analysis was carried out for each trade. In each case Spearmans rho is reported, and the measured level of significance .The results

were groundworks r=-0.007, p=0.932, steel frame r=-0.045 p=0.572 mechanical and electrical r=0.108 p=0.085 roofing and cladding r=-0.105 p=0.095 brickwork r=0.046 p=0.297 finishes r= -0.005 p=0.476. These indicated that there was negligible correlation for any trade between the range of prices and the average number of enquiries sent out for each trade and where p>.2 it can be assumed that the correlation difference from zero is due to sampling error.

In order to establish whether the existence and maturity of a strategy for closer links with the supply chain had an effect on the range of prices for each workpackage a further bivariate correlation was carried out. The derived subcontract strategy variables were none n=56, emergent (<2 years) n=42, developing (3-5years) n=60, mature (6-9 years) n=7 and stable (>10 years) n=15. The criterion variable was the variability of subcontract prices. The results were as follows groundworks r=0.11 p=0.896, steel frame -0.166, p<0.05, mechanical and electrical -0.166, p=0.138, roofing and cladding -0.020 p=0.806 brickwork r=0.095 p=0.262, finishes r=0.066,p=0.419. A significant negative correlation existed between subcontract strategy and steel frame price ranges. This indicated that as an organisations subcontract strategy developed that the range of prices for this workpackage fell significantly however the strength of the correlation was low.

A bivariate analysis was carried out for each of the groups to investigate whether the average number of sends outs across all procurement routes and variability in prices received as correlated. Both variables are measured on the interval scale and Pearson's product moment correlation was used to investigate correlation. There was no correlation between variability of price and the number of enquires sent to each trade. The organisations did not seek to gather more data from those trades that had greater variability in price as was expected consequently it was suggested that intervening factors were present that effect their use of the market place, these intervening factors were explored in phase two of the research

6.8.6 Supply Chain Communication

The respondents were requested to provide data on their opinion of the performance of their supply chain partners. A five point Likert scale was used ranging from 1= excellent, 2= very good, 3=neither good nor poor, 4=poor, 5=very poor. The scale was consistently applied within the measuring instrument and consequently had internal validity however after analysing the data, a scale that increased with performance would have aided interpretation. This was considered as a measure that would be altered if the survey was carried out in future. The data were tested for normality of distribution and were found to be not normally distributed; consequently non-parametric descriptive statistics were applied.

The questions related to three broad areas that the supply chain are involved in at the estimating stage;

1 Design cost management

Provision of reliable early budget cost information

Input into the value management process

2. Construction information

Involvement in risk management

Provision of advice on alternative methods

3. Communication of resource costs

Provision of accurate resource cost information.

The supply chain capability in the areas of risk management ($\bar{x}_{(274)}$ =3.17), value management ($\bar{x}_{(274)}$ =2.99) and provision of resource cost information ($x_{(275)}$ = 3.03) were identified as poorer than early design advice $x_{(276)}$ =2.63 and advice on alternative specification information $\bar{x}_{(277)}$ =2.37.

6.8.6.1 Design Cost Management

42% of respondents indicated that the supply chain were very good in their provision of early budget cost information at the early design stage, 41%

indicated that it was neither good nor bad and 13% indicated that it was poor or very poor. A very small percentage, 4% indicated that this aspect was excellent. Respondents who worked for larger organisation rated their supply chain capability slightly higher than those who worked for smaller organisations. The Figure 6.12 below indicates a general improvement for organisations that had a subcontract strategy with the exception of the larger organisations that identified little improvement in capability.

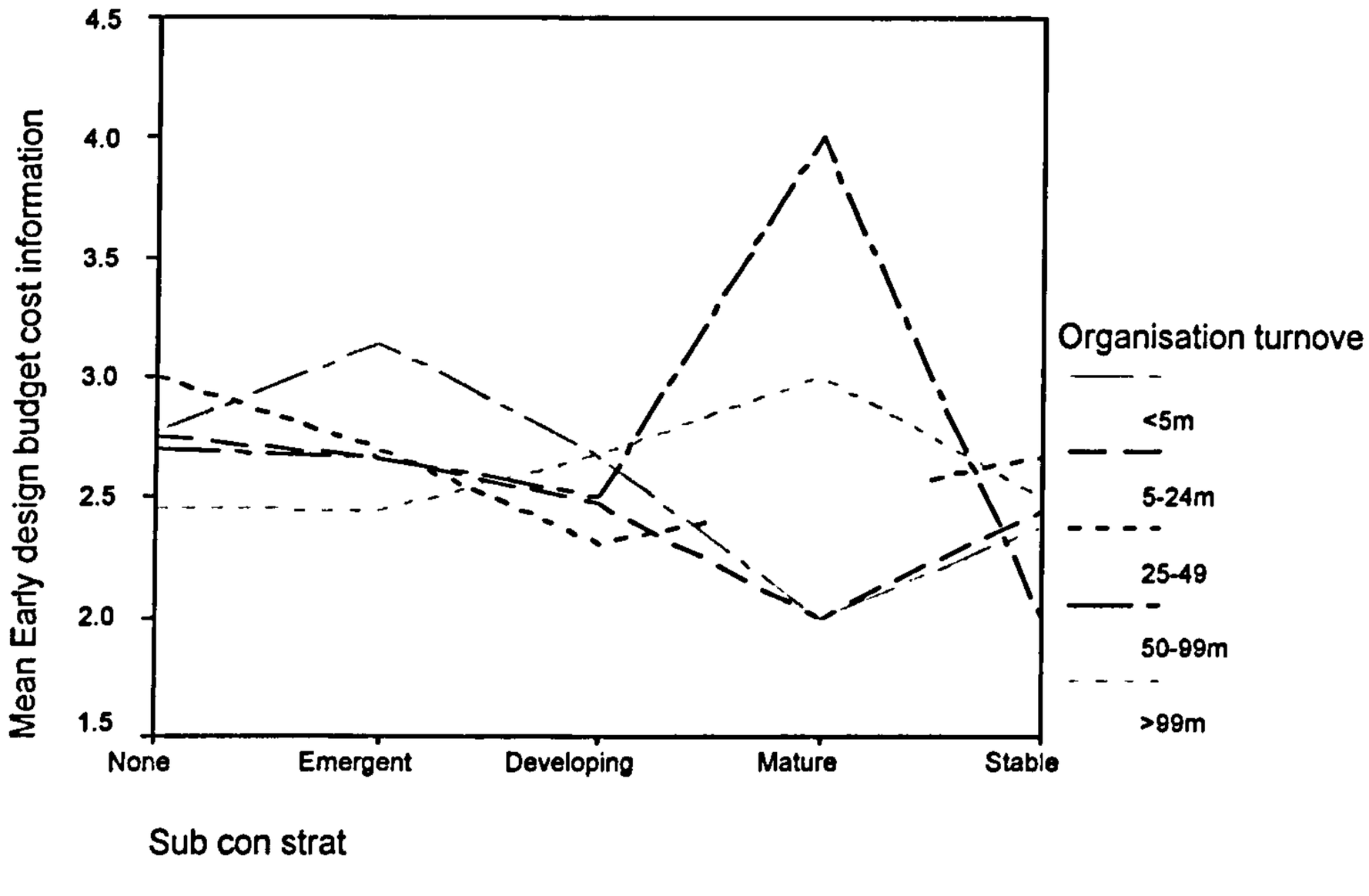


Figure 6.12 Subcontract communication – early design budget and organisational size and subcontract strategy

The input into the value management process required more communication with the subcontractor than the traditional approach and is shown in Figure 6.13. 29 % of respondents indicated that their organisations supply chain were very good or excellent in their involvement in the value management process. 46% indicated that they were neither good nor bad and 26% indicated that the supply chain was poor or very poor.

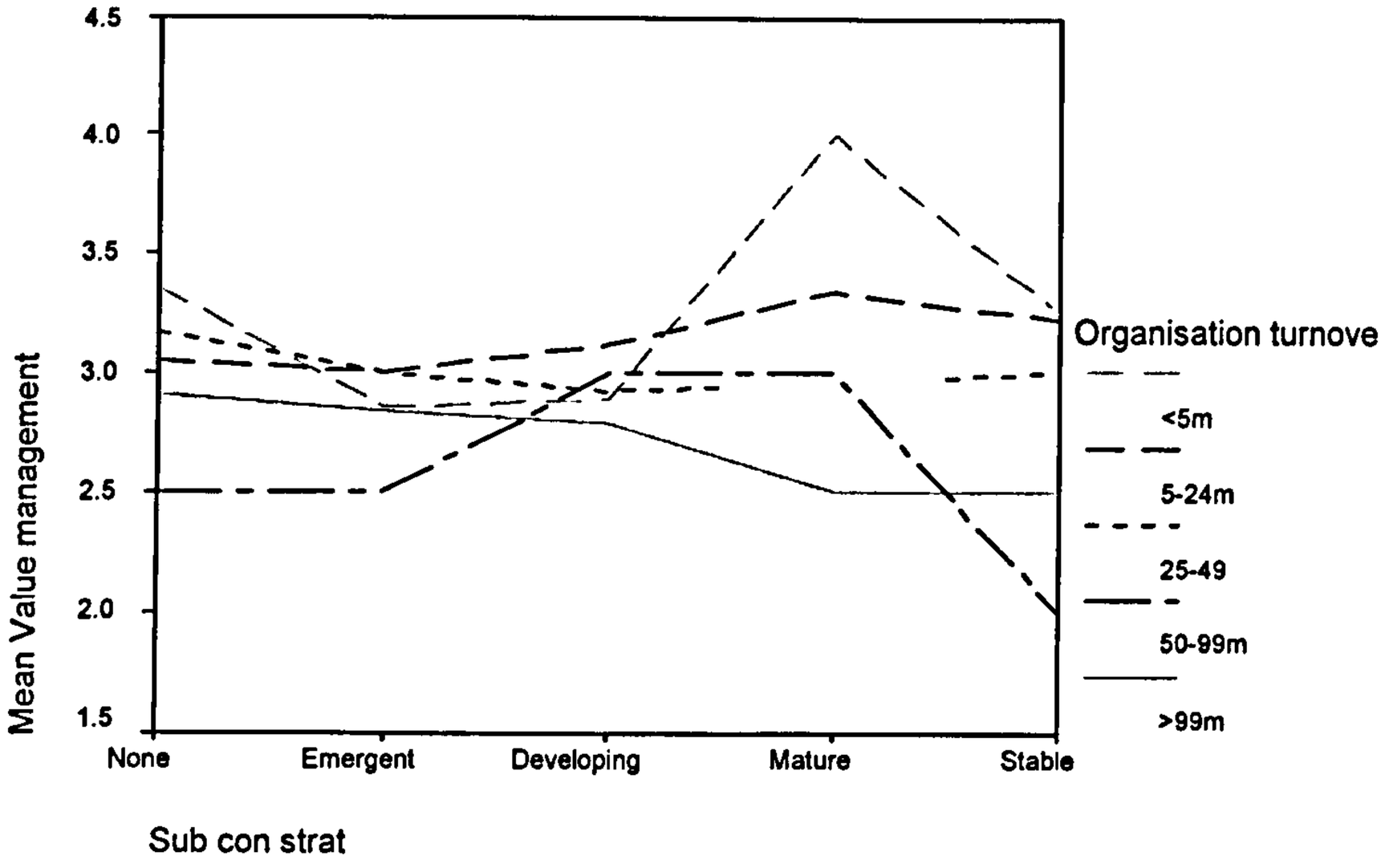


Figure 6.13 Subcontract communication – value management and organisational size and subcontract strategy

Respondents who worked for the largest organisations indicated that their supply chain performed better when compared with the performance of smaller organisations. This may be due to the communication requirement of complex projects and the need for discussion on the relative merits of different designs.

21% of the respondents indicated that their supply chain was very good to excellent in their involvement in the risk management process. 46% indicated that the supply chain was neither good nor bad and 33% indicated that it was poor or very poor. There was little variability in the respondent's assessment of this aspect of the supply chain between organisational sizes or the existence of a subcontract strategy.

58% of respondents indicated that their supply chain was very good or excellent at providing advice on alternatives, 37% indicated that it was neither good nor bad and 5% indicated that it was poor or very poor. The results of a comparison of the different groups are shown in Figure 6.14. This high level of assessment may be used to support the assertion that the supply chain regularly suggests alternatives of specification that have associated savings.

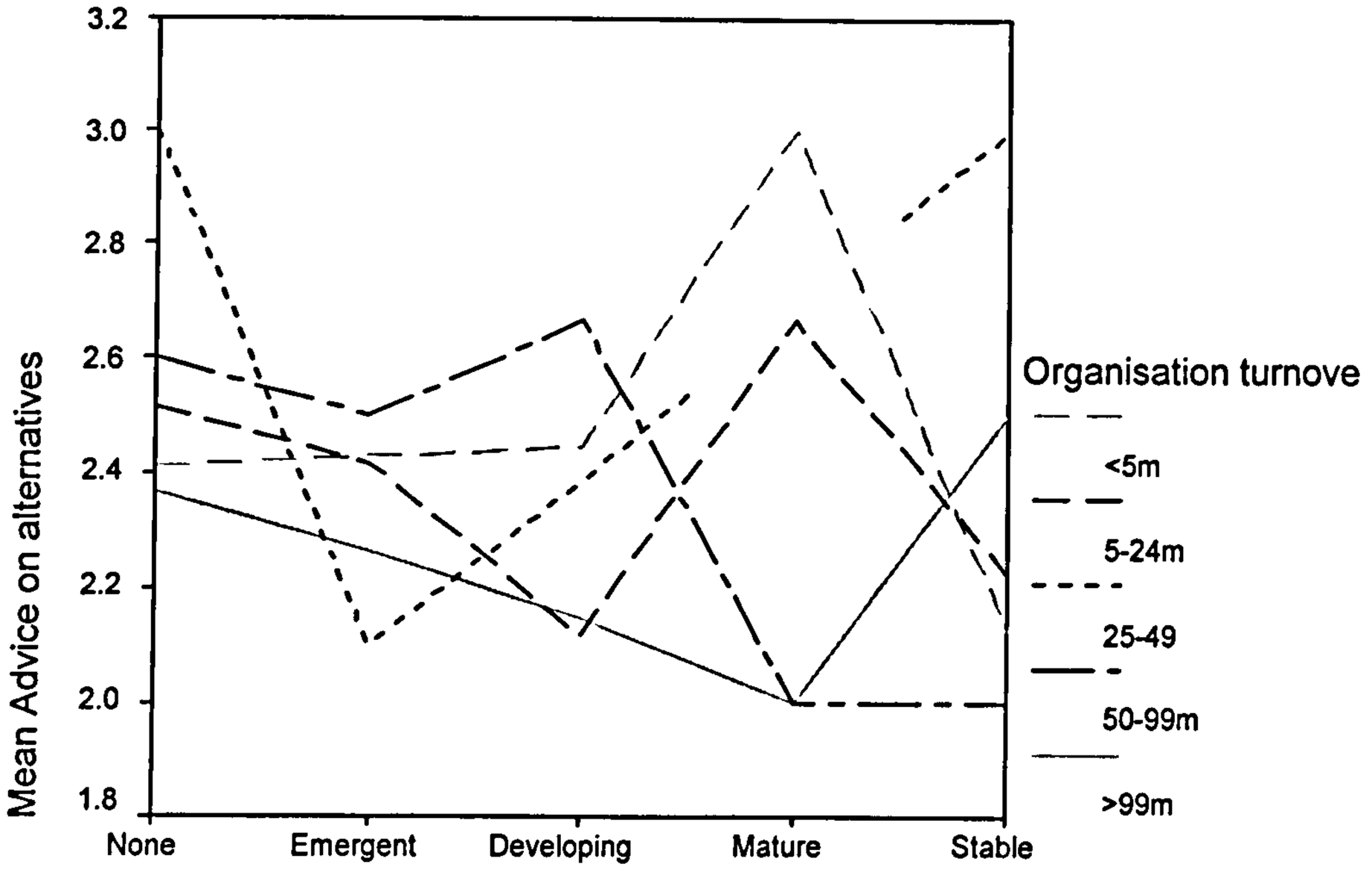


Figure 6.14 Subcontract communication – advice on alternatives and organisational size and subcontract strategy

The Figure 6.14 above indicates that the respondents who had a strategy for closer linkages with their supply chain assess the capability for providing sound advice on alternatives as higher in almost all cases than respondents whose employing organisation didn't have a strategy.

25% of respondents indicated that their supply chain provides very good or excellent information about their resource costs. 43% indicated that it was neither good nor bad and 26% indicated that it was poor or very poor. This was a surprising result considering the overall means of responses to the categories of resource cost information provision.

In order to establish whether the existence and maturity of a strategy for closer links with the supply chain had an effect on the capability of the supply chain, a bivariate correlation was carried out. Spearman's rho correlation coefficient was reported for each of the tender functions early design budget cost advice $r=-0.126$, $p<0.05$, risk management $r=0.014$, $p=0.813$, value management $r=0.061$, $p=0.316$, resource cost information $r=-0.123$, $p<0.05$, sound advice on alternatives $r=0.114$, $p=0.058$.

A significant correlation was found for early budget cost advice and resource cost information. Both correlations were weak and no causal significance could be established.

In order to establish whether organisational turnover had an effect on the estimator's assessment of the capability of the supply chain, a bivariate correlation was carried out. Spearmans rho correlation coefficient is reported for each of the tender functions; Early design budget cost advice r=-0.048, p=0.432, risk management r=0.014 p=0.813, value management r=0.194 p<0.001, resource cost information r=-0.029 p=0.632, sound advice on alternatives r=0.033 p=0.588. A significant correlation was shown for value management and organisational size.

In order to establish whether there was an interaction effect between the two independent variables, a factorial ANOVA for early budget cost advice and resource cost information and value management were carried out. The results were early budget cost advice F (11)=0.453, p=0.069 which indicated that turnover was not having an interaction effect and that the benefits derived were due to the existence of the maturing strategy, Value management F (11)=0.436 p=0.938, which indicated that subcontract strategy was not having a significant effect on the subcontract capability.

6.8.6.2 Summary of supply chain strategy effect

It was established that the supply chain strategy was having an effect on the quality of advice given by the subcontractor during the estimating stage. This would suggest that main contracting organisations have a network of subcontractors that they use, their role as market maker would appear to give them an element of power to require compliance with their requirements for input however they don't appear to reciprocate in reducing the extent of competition they use to gather prices. The survey data didn't identify the extent of trade capability in early project development, which on reflection would have been useful, however it was explored in phase two of the research. The assertion that there is a great deal more to transactions by Granovetter (1985), who suggested, that an element of social embeddedness is present would appear to be supported. The dependency of subcontractors for advice

regarding alternative specifications in order to make the main contractors bid more competitive was a good example of this, whether this increased the specificity of the subcontracting organisation was considered in phase two. More contextual information was required when considering the benefits derived from a subcontract strategy.

6.8.6.3 Benefits Derived from Supply Chain Strategy

Respondents were asked to rank the top five benefits from 1 =highest to 5=lowest that the close links with the subcontractor afforded the estimator. The categories for ordinal response were:

Price data: Provision of standard rates for a number of projects, commitment to provide price data
Cost data: Sharing of resource costs, communication of cost of alternative construction methods
Design cost management: Communication of cost of alternative designs, communication of cost of alternative specifications
Construction information: Provision of information regarding construction techniques, communication of risk information

The underlying distribution of the data was assessed and was not normal; the rankings were given by different individuals and can be considered, as being from an independents sample and the intervening variable of organisational size wasn't controlled. The appropriate method of comparison was to identify the overall average ranking, coefficient of variation and the percentage of respondents who gave a score to the benefit. The rankings, when compared as an overall group were similar as seen in Table 6.31 below.

A high consensus was obtained from the respondents that a guaranteed response was the highest scored benefit. This reflects the difficulties expressed in the open question answers and the pilot interviews. The lack of a market rate was identified as one of the areas of high risk and perceived as a failure of the estimating process by the tender team. The respondents gave the three benefits, relating to communication a similar score. Alternative construction

cost information was scored marginally higher than the others with lower coefficients of variation and higher percentage response. The improved communication of alternative design cost information was identified as the benefit that was scored by 51% of respondents. This benefit may relate to the development of design and build projects, however the data set couldn't be interrogated to firmly support this assertion, however a KW test on the data set when considering organisation size and benefits from closer links identified a significant difference $x^2(4)=10.29$ $P<0.05$. The KW ranking for organisations with a turnover over £99m was ranked as significantly higher than organisations of smaller turnover. This supports the assertion that organisations that undertake design and build projects rank the communication benefits associated with closer links with the supply chain higher than organisation that carry out fewer projects that require design development. The management of risks, inter organisational knowledge sharing and price data were scored overall respectively lower than the communication benefits. The closer links don't afford the benefit of the improved sharing of resource cost data, which was ranked as the lowest benefit by the lowest percentage of respondent. There was no evidence to support the assertion that increased transparency was occurring through the sharing of private information by the supply chain.

Benefit	Average score (rank) Variance. (Percentage responded)
Guaranteed response	2.25(1) 1.97(53)
Improved communication of cost alt const	2.61(2) 1.25(52)
Improved communication of alt design cost info	2.62(3) 1.41(51)
Improved communication of alt spec cost info	2.64(4) 1.42(48)
Management of risk.	2.72(5) 1.33(45)
Intra organisational knowledge sharing	2.79(6) 1.55(49)
Price data benefit	2.92(7) 2.08(49)
Improved sharing of resource cost info.	3.07(8) 1.39(43)

Table 6.31 Benefits from increasing asset specificity of supply chain

A comparison of the respondent's scores for the differing levels of maturity of linkage was carried out and is shown in Table 6.32 below. It should be noted that although the KW test results are shown in the table, they shouldn't be considered as transitive between the benefits. The figures give an indication for the relative ranking of the benefits however they are also affected by sample

size, as statistically significant results cannot be obtained when the sample size is too small. The groupings that had small sample sizes were mature (n=22) and stable (n=7). The benefits that were scored significantly differently at $p<0.05$ by the groups were guaranteed response and management of risk. Guaranteed response was ranked within the top three of benefits by all categories and the difference may be considered as sample size effect for the stable organisations. The driver for establishing linkages for these organisations may have been to manage the risk of submission of bids with rates that are based on historical records rather than market rates. Respondents employed by organisations that had supply chain linkage over ten years identified the management of risk as being a key benefit, which would support this relative ranking of, guaranteed response. The sample size may have been having an effect on this scoring, a KW test considering the effect of organisation size on the ranking of benefit for management of risk did not give a significant result.

Benefit	Emergent	Developing	Mature	Stable
Guaranteed response*	2.72(3) 2.13(61) 98	2.11(1) 1.81(69) 78	2.63(2) 1.98(33) 97	1.62(1) 1.34(76) 58
Improved communication of cost alt. const	2.75(4) 1.35(62)	2.43(2) 1.22(69)	3.11(3) 1.36(33)	2.74(6) 1.02(76)
Improved communication of cost alt. design	2.63(1) 1.18(62) 74	2.55(4) 1.44(69) 75	3.33(4) 2.25(33) 103	2.54(4) 1.56(76) 78
Improved communication of cost alt. spec.	2.70(2) 2.08(62) 86	2.62(5) 1.15(69) 74	3.44(5) 1.28(33) 102	2.24(2) 69(76) 87
Management of risk *	2.86(5) 1.49(62) 74	2.66(6) 1.17(69) 67	3.86(8) 1.48(33) 104	2.33(3) 1.03(76) 56
Intra organisational knowledge sharing	3.04(6) 1.78(62) 85	2.51(3) 1.25(69) 67	3.57(7) 3.29(33) 96	2.88(7) 1.99(76) 79
Price data benefit	3.1(7) 2.30 (62) 82	2.96(8) 2.18(69) 78	2.50(1) 3.10(33) 63	2.63(5) 1.64(76) 67
Improved sharing of resource cost info.	3.22(8) 1.34(62) 74	2.90(7) 1.35(69) 63	3.50(6) 1.10(33) 82	3.04(8) 1.02(76) 68

Average score (rank)
Variance. (Percentage responded) KW test
* significant at $p<0.05$

Table 6.32 KW test for benefits derived through length of time of strategy to increase asset specificity

Organisations with an emergent strategy identified the improved communication of design information and alternative specification cost information between contractor and subcontractor as the highest ranked benefits, the next ranked benefit for organisations in this category was guaranteed response. Organisation with strategies that had been in existence for between 2 and 5 years identified that guaranteed response was ranked highest with the alternative construction cost communication benefits and inter organisational knowledge sharing ranked as third highest benefit. The communication of the costs of alternative design and specifications were ranked highly with a high level of consensus amongst the respondents. This suggested that the benefits derived through close links might develop from exchange of price data to increased technological interdependence, which matured into organisational knowledge exchange. This trend was not evidence when considering organisations with a mature strategy as inter organisational knowledge exchange was identified as a benefit but a lower ranked benefit than others. Respondents employed by this group identified the provision of standard price data that could be adapted for projects as the highest ranked benefit however there was a large variance in respondents ranking. The improved communication in the costs of alternative construction methods, alternative designs and specification were ranked in decreasing order as the next three benefits. There was a consensus that sharing of organisational resource cost information was the lowest ranked benefit. The data indicated that there was little transfer of "sensitive" private information between the parties.

6.8.7 Communication of Price Information

Respondents were asked to identify the format of price information usually returned from the specialist trade contractors to their organisations during the development of the estimate. The options for format of price information ranged from all in unit rates, mainly lump sums, method related charges, to resource costs. These can be considered as ranging from transparent (i.e. resource costs which result in low information asymmetry) to opaque, which results in high levels of information asymmetry.

Communication	Finishes	Brickwork	Groundwork	Roofing & cladding	Steel Frame	Mechanical and Electrical
All in rates	86	85	80	51	25	13
Lump sums	13	12	17	49	74	86
MRCS		2	1	0	1	1
Resource costs	1	1	2	0	0	0

Table 6.33 Communication of price information from the supply chain

Table 6.33 indicates that there is a range of price information format, as the level of technology increases through the supply chain the quality and quantity of information available to assess the price and also available for ex post governance decreases. A cross tabulation of communication format with existence of a subcontract strategy and carrying out a Pearson's chi square test identified there was no significant difference between the communication format for subcontract price information.

6.9 Summary of Supply Chain Communication

The data collected in the survey indicated that main contracting organisations are developing closer relationships with their supply chain. The majority of respondents indicated that their organisation was still in the early stages of developing closer relationships. The data analysis suggested that the main factor influencing contractors subcontract price procurement behaviour was the procurement arrangement adopted by clients. It was also suggested that as the relational approaches to procurement by client organisations allied with the use of the design and build approach, and as the subcontract strategies start to mature, more technological interdependency will occur and richer data will pass between the parties. A consequent opportunity will exist in the future for the partial un-entanglement of price and cost data. Contractors make less use of the market place when gathering subcontract price information for the design and build, and drawings and specification procurement approach than when the main contract was quantified, a procurement approach that only contributed an average of 25% of respondents organisations turnover. The asset specificity of the subcontractor for these approaches can therefore be considered as being consequently higher and may relate to the higher levels of dependency of the contractor on the subcontractors ex-ante involvement in the development of the

tender, this contention was supported by the benefits identified by the estimators which related to improved communication. The benefits derived by the estimator from the closer relationships could also be considered as relating to the dependence on the subcontractor to provide information that enhances the competitive position of the contractor. The identified benefits were associated with the development of alternative designs and specification, benefits that would only be realised where the product was incompletely specified and capable of development. The results considered above however don't provide any evidence of the sharing of resource cost data. This may be considered as a transaction asset that may be used ex post to provide an economic power differential between the parties or may be appropriated by the contractor for use in other relationships, which will influence ex ante communication. Design information and attendant cost information could be considered as a transaction asset that will only be released when more formal ex post governance structures are in place to compensate for the investment made by the subcontractor, the information provided at the estimate stage can also be considered as being influenced by the subsequent use of the information during the negotiation stage in entering into a contract and also the ex post governance of the subcontract. The communicative behaviour at the early stage relies upon the trust established between the parties; the data collected in the survey would suggest that even where organisations have mature relationships with the supply chain parties, there is a limit to the provision of information that could be considered as private to the selling organisation.

6.10 Decision-making: the Estimators Task Environment

This section of the data analysis reports upon the estimators approach to decision making and the supply chain, the questionnaire asked respondents to give an indication of their organisations information systems supporting their decision making and their role as a decision maker. The survey also sought to uncover some of the limits to their rationality and the factors that influence the inclusion of a subcontract prices within a estimate. The summary aims of this section of the survey were to;

- Determine the factors that influence subcontractor price selection for inclusion within tenders.
- Assess the estimators self reported ability to analyse supply chain price information
- Appraise the organisational systems in place to support decision making

6.10.1 Factors that Influence the use of a Subcontract Price within a Tender

The seven factors that related to the use of a subcontract quotation within an estimate were estimators market knowledge, the variability in the prices received, the extent of qualifications to the price estimators knowledge of a particular subcontractor, the quality of information available to manage post contract claims and variations and the consequence of workload. A four point Likert scale was utilised to identify the factors and their relative importance on the selection of a subcontract price for inclusion within the estimate and are indicated in Table 6.34 below.

Rank	Market Knowledge	Subcontract Knowledge	Price variability	Contract compliance	Ex post var. Gov	Ex post claim Gov	S/C performance
	N=281	280	280	279	272	272	279
Essential	51	28	32	57	20	13	38
Important	39	43	44	26	40	33	49
Of some importance	10	16	13	7	35	47	12
Not important	0	3	1	0	5	7	1

Table 6.34 Factors influencing the selection of a subcontract price

Respondents indicated that the estimators market knowledge ($\bar{x}_{(278)} = 1.61$) as being the most significant factor when considering the inclusion of a subcontract price within a tender, followed by contract compliance ($m_{(279)} = 1.44$) and price variability ($\bar{x}_{(280)} = 1.82$) . Subcontract performance was a factor ($\bar{x}_{(279)} = 1.77$) with less importance, whilst the ex post factors of variance

assessment ($\bar{x}_{(272)}$ = 2.25) and claims governance ($\bar{x}_{(272)}$ = 2.48) had the least importance. A Pearson's chi squared test indicated that organisation size or seniority of estimator had no significant effect on the responses given.

6.10.2 Factors that Influence the assessment of price information.

Respondents were asked to identify the factors that caused them difficulty when assessing subcontract price information and rank them in order of decreasing difficulty, i.e. the lower the mean for each factor the greater the identified difficulty that the factor causes the estimator in the assessment of the price. The ranks were from 1 most difficult to 6 least difficult. The factors related to information, personal knowledge and communication.

The results in order of difficulty were as follows; Comparative price information ($\bar{x}$=2.34), quality of information provided with quotation ($\bar{x}$=2.84), price variation ($\bar{x}$=2.90), personal knowledge of the technology ($\bar{x}$=2.99), lack of communication with the subcontractor ($\bar{x}$=3.60), lack of in house expertise ($\bar{x}$=3.82) and time since reviewing a similar quotation ($\bar{x}$=4.09). An independent t test considering the difference between experience of the two main groups of estimators was carried out which indicated that the null hypothesis was not rejected and the means were similar, consequently the results were taken as representative of the whole group.

A factor analysis was carried out on the attitude scales using PCA with varimax rotation. The number of factors to be extracted was obtained by inspecting the scree plot. The KMO and Bartlett's test of sphericity conditions were met. The results are displayed in Table 6.35 below.

Quotation assessment	Factor loading	% High difficulty[1]	% Moderate difficulty[2]	% No difficulty[2]
Technical knowledge				
Lack of company in house expertise	.782	33	20	56
Lack of communication with Subcontractor	.746	27	31	42
Time since reviewing a similar quotation	.681	13	28	59
Cronbach's alpha=.67				
Information Impactedness				
Comparative price information	.834	41	34	25
Quality of information with quotation	.792	44	29	17
Price variation	.812	61	31	8
Cronbach's alpha=.65				

[1] includes responses for values 1 &2
[2] includes responses for values 3
[3] includes responses for value 4,5 &6

Table 6.35 Factor analysis of components that constrain estimator's assessment of supply chain prices.

The analysis revealed two orthogonal factors, which were labelled 1.Technical knowledge and, 2.Information Impactedness

6.10.3 Estimator's ability to assess Subcontract Information

Respondents were asked to give their opinion on a number of statements that related to the differing workpackages. The statements were related to assessment of market price, assessment of alternative specification costs, assessment of the performance of alternative specification and the risks associated with the work package. The scale used was a Likert scale and was used to represent the level of agreement.

6.10.3.1 Market Price

In section of the questionnaire, respondents were asked to give their level of agreement regarding their ability to assess the accuracy of market prices on a 5-point scale (strongly agree, agree, neither agree nor disagree, disagree and strongly disagree) with regard to four aspects of subcontract quotations, price,

price of alternatives, acceptability of alternatives and risks associated with the work package.

In order to establish the extent or strength of any confounding variables Spearman's rho tests were carried out for organisational size as indicated by annual turnover and estimators experience. It was found that organisational size was not a confounding variable on the ability of the estimator to assess the market price of the specialist work package. It was also found that the experience as an estimator when recoded into three variables of less that 10 years, ten to twenty years and over twenty years also had no statistical significant effect upon the respondents self reported ability.

A factor analysis was carried out on the attitude scales using principal components analysis with varimax replaced with the mean and Cronbach's alpha was used to test the reliability of the dimensions. The results are reported in Table 6.36. The number of factors to be extracted was obtained by inspecting the scree plot. The KMO and Bartlett's test of sphericity conditions were met.

Price assessment	Factor loading	% Strong agreement[1]	% Neither	% Strong disagreement[2]
Non-quantifiable Price veracity				
Steel frame Market price assessment	.720	64	27	9
Roofing and cladding Market price assessment	.801	61	31	8
Mechanical and Electrical Market price assessment	.794	24	40	36
Cronbach's alpha=.72				
Quantifiable price veracity				
Groundworks Market price assessment	.712	88	10	2
Flooring Market price assessment	.672	77	19	4
Bkwk Market price assessment	.879	91	8	1
Finishes Market price assessment	.807	84	15	1
Cronbach's alpha=.80				

[1] includes responses for strongly agree and agree
[2] includes responses for disagree and strongly disagree

Table 6.36 Factor analysis of estimators self reported ability to assess market prices

The analysis revealed two orthogonal factors, which were labelled 1.Non-quantifiable price veracity and 2.Quantifiable price veracity

6.10.3.2 Alternative Specification Price Assessment

The assessment of specialist trade subcontracts also requires estimators to assess alternative specifications suggested by the subcontractor. The design and build contract that have an element being designed by a specialist are used in part to take advantage of the knowledge available on differing specifications of materials or alternative designs. The estimator, when selecting a specialist trade contractor, has to assess the costs of alternative specifications in order to make a rational comparison between alternatives. The acceptability to the client of such an alternative is also considered at the estimate stage. The results are reported by trade in Table 6.37 and 6.38, the variables of organisational size and estimator experience did not have an intervening effect.

Alternative spec price assessment	Factor loading	% Strong agreement[1]	% Neither	% Strong disagreement[2]
Non comparable/Opaque				
Steel frame alternative price assessment	.712	45	36	19
Roofing and cladding alternative price assessment	.754	50	36	14
Mechanical and Electrical alternative price assessment	.875	20	37	43
Cronbach's alpha=.75				
Comparable/transparent				
Groundworks alternative price assessment	.740	72	24	4
Flooring alternative price assessment	.580	65	29	6
Bkwk alternative price assessment	.911	80	16	4
Finishes alternative price assessment	.833	73	23	4
Cronbach's alpha=.82				

[1] includes responses for strongly agree and agree
[2] includes responses for disagree and strongly disagree

Table 6.37 Factor analysis of estimators self reported ability to assess prices of alternative technologies

The analysis revealed two orthogonal factors relating to alternative specification price assessment, which were labelled 1.Non comparable/ Opaque and 2.Comparable/transparent

6.10.3.3 Alternative Specifications Assessment.

A factor analysis was carried out on the attitude scales for the assessment of alternative specification using principal components analysis with varimax replaced with the mean and Cronbach's alpha was used to test the reliability of the dimensions. The results are reported in Table 6.38. The number of factors to be extracted was obtained by inspecting the scree plot. The KMO and Bartlett's test of sphericity conditions were met.

Alternative spec acceptability assessment	Factor loading	% Strong agreement[1]	% Neither	% Strong disagreement[2]
Opaque performance assessment				
Steel frame alternative assessment	.685	47	38	13
Roofing and cladding Alternative assessment	.685	51	36	13
Mechanical and Electrical alternative assessment	.911	21	41	38
Cronbach's alpha=.80				
Transparent performance assessment				
Groundworks alternative assessment	.844	67	29	4
Flooring alternative assessment	.617	59	33	8
Bkwk alternative assessment	.913	77	20	3
Finishes alternative assessment	.780	73	23	4
Cronbach's alpha=.84				

[1] includes responses for strongly agree and agree
[2] includes responses for disagree and strongly disagree

Table 6.38 Factor analysis of estimators self reported ability to assess the acceptability of alternative specifications

To establish whether the respondents differ significantly in the assessment of alternative specification price assessment and specification acceptability assessment a paired t test was used for each workpackage. A paired t test is used when the research question calls for repeated measures of responses

from the same individual. The results indicated a significant correlation for all trades at $p<0.05$ between the reported level of agreement of alternative work package specification price assessment and alternative specification acceptability assessment. The null hypothesis was consequently not rejected and is stated as;

The average self reported level of agreement for of alternative work package specification price assessment is not significantly different from the average self-reported level of agreement of alternative specification acceptability assessment.

This indicated that the estimator had difficulty in the assessment of the technical trade workpackages that incorporate design such as mechanical and electrical, the difficulties were expressed in assessment of market price, specification price and performance. This suggested that where bilateral dependence occurred as a result of the client procurement route and project complexity, the subcontract/main contract power differential changes during ex ante product development. The incentive for the subcontract to economise and not be opportunistic due to information asymmetry during the ex ante processes relates more to the competitiveness of the overall tender rather than the workpackage itself. This dimension of transactional behaviour was impossible to uncover using the survey method and was considered in phase two or the research. It order to explore how the decision support systems were used during this ex ante phase, the survey sought information upon the IT systems in place.

6.10.4 Decision Support Systems

Respondents were asked to assess their IT systems for the following functions; Unit rate estimating, Contractor's design cost planning, Subcontract quote analysis, Risk management, Retrieval of information from previous estimates. A five point Likert scale was used, respondents were give the following categories, 1=excellent, 2=very good, 3=neither good nor bad, 4=poor, 5=very poor.

69% of respondents indicated that their IT systems supported the function of unit rate estimating as excellent or very good, 16% indicated a neutral response with 15% indicating that their systems were poor or very poor. 25.5 % of respondents indicated that their systems were excellent or very good when supporting the function of deign cost planning, 46.7% indicated a neutral response with 27.8% indicating that their systems were poor or very poor. 63.6% of respondents indicated that their systems were excellent or very good when supporting subcontract quote analysis, 18% indicated a neutral response with 19.4 % indicating that their systems were poor or very poor. 18.3% of respondents indicated that their systems were excellent or very good when supporting the process of risk management, 42.1% indicated a neutral response with 23.8 % indicating that their systems were poor or very poor. 63.7% of respondents indicated that their systems were excellent or very good at retrieving information from past estimates, 19.6 % indicated that they were neutral with 16.7 % indicating that their systems were poor or very poor

A further analysis was carried out to establish whether the respondent's assessment of the IT support for their decision-making was carried out. Two one-way analyses of variance for organisation size and procurement were carried out, there was a significant difference between the groups for unit rate estimating $F\ (2,264)=6.46$, $p<0.05$, design cost planning $F\ (2,255)= 5.14$, $p<0.05$ and subcontract rate analysis $F\ (2, 261)=16.77$ $p<0.01$. A post hoc Scheffe test indicated that the difference was significant for unit rate estimating between the very small, and medium and the very small and large turnover organisations. Contractors design cost planning between the very small and large organisations, Subcontract rate analysis the variance was significantly different between all three.

An analysis of variance indicated that there was no significant difference in organisations that were grouped by tender enquiry and IT support for the differing functions. This would suggest a null hypothesis that organisational IT systems don't adapt to the procurement environment was not rejected. IT systems were not supporting design cost planning or risk management although information retrieval from previous estimates was identified as good.

6.10.5 Respondent's Role in Subcontract Selection.

Respondents were asked to identify their role in making the decision on the inclusion of a subcontractor's price in a tender. Respondents were given four categories of response, which in declining significance represented their responsibility. The categories were final decision maker, key decision maker, key influencer or no input.

The 32% of respondents identified that they were the final decision maker, 53% of respondents indicated that they were a key decision maker and 14% a key influencer and only 1% indicated that they had no input.

In order to establish whether the estimators role varied with organisational size, a cross tabulation was carried out and it was found that the estimator role did vary significantly between organisations, a Pearson's Chi square value was 33.429, the measure of association Cramer's V was 0.202 at a significance level of 0.001.

The results indicated that in the larger organisations the estimator is less likely to be a final decision maker than in small organisations. This probably reflected the size of the tender team in small organisations, which was found when analysing respondent's answers to questions relating to risk identification and analysis. In the larger organisation, the estimator tends to be part of a larger group and perceives themselves as a key decision maker rather than a final decision maker.

6.10.6 Feedback and Decision-Making

Respondents were asked to indicate the influence of feedback from previous estimates on their decision-making. The categories of sources of feedback were identified as cost value reconciliation's, buying reports, cost reports, bonus records and other. A four point Likert scale was used for responses, which were indicated as very influential, influential, slightly influential and not influential.

75.1% of respondents indicated that the CVR report was very influential (31.2) or influential to their decision-making, 24.9% indicated that it was slightly influential or not influential. 63% of respondents indicated that the buying report was very influential (14.1) or influential to their decision-making, 37% indicated that it was slightly influential or not influential. 70.4% of respondents indicated that the cost report was very influential (25.1) or influential to their decision-making, 29.6% indicated that it was slightly influential or not influential. 15.8% of respondents indicated that bonus records were very influential (4.4) or influential to their decision-making, 84.2% indicated that they were slightly influential or not influential.

Organisational size and estimators experience were evaluated using a chi-squared contingency table to establish whether they were intervening variables. Organisational size was not, although the CVR was the nearest to being statistically significant between the two groups. Experience as an estimator had no statistical association with the influence of the feedback .It was found that organisational systems had developed to improve feedback to the estimators since the survey of Skitmore and Wilcox (1994) and Green (1989). The quality of the feedback was not explored or its influence on particular aspects of decision making as the CVR, however buying reports and cost reports were considered to contain biased information which was considered as unreliable by interviewees in the pilot study.

6.11 Summary and Discussion

6.11.1 Supply Chain

Construction is a highly interconnected industry (Langford and Male, 2001) through the suppliers of materials components, the use of subcontractors within a geographic market and the extensive social connections that are in place between individuals who work for the various organisations in construction. It has been claimed that low entry and exit barriers exist within construction that are different to other forms of industry, these relate to a low capital requirement, that the organisational capability that exists within organisations is difficult to protect and can be poached easily and that the products produced

are unspecific. Male (1991) however, suggested that the product in construction could be considered as a service product or an end product. A differentiation in competition for a service embodies reputation and product differentiation occurs through pre qualification mechanisms. As clients adopt pre-qualification processes that require an organisation to have a reputation and track record, this can be considered as an entry barrier to other organisations and as such organisations seek to ensure that their reputation is protected. This view is however countered by others, who suggest that the price is the final arbiter when selecting a contractor. There has been little recent empirical work considering the selection strategies employed by contracting organisations and their suppliers, which may be considered to be in a more open market place. The findings from this survey indicate that price is the main criterion for the selection of a subcontractor and that in order to assess whether the price is appropriate, other competitive quotations were sought. The information sent to the subcontractors upon which to base their price ranged from high to low codification. Most organisations had the capability to price groundworks and drainage and in some of the smaller firms had integrated this trade into the hierarchy.

The activities of the construction industry and the actors within it can be considered as a network of transactions or contracts. The nature of these transactions poses a challenge in the choice of the correct governance structure for the implementation The work of Coase (Coase, 1937) was developed by Williamson (1981) as outlined earlier and developed into a framework for the analysis of transaction costs, this was considered to include searching and gathering information about the buyers and sellers, writing and negotiating contractual agreements and administering the agreement. The governance structures available range from full internalisation or hierarchy to market. The framework as adopted for this research has suggested that several factors influence the adoption of the form of governance and that these can relate to the information asymmetry between the organisations, the procurement approach taken by the client and the trade of the subcontractor which were found to influence a subcontractor's project specificity. There have been a number of attempts to apply transaction cost analysis to construction as reported by Costantino and Pietroforte (2002) however few recent empirical

studies were uncovered during this research that considered the use of subcontracting in construction, the exception being Akintoye's study in 2000 (Akintoye et al., 2000). The extent of codified price information can be considered to have an influence on the type of relationship that exists between the main contractor and subcontractor, for example the finishes subcontractor may be considered to have low temporal specificity, low product specificity and the price information is codified to allow for the receiving organisation to appropriate it for post contract negotiations with others and it is also inferred that a tight financial control is in place. The groundworks subcontractor has a higher temporal specificity; the level of codification and diffusion within the buying organisation is high however the reasons for codification may relate more to ex post flexibility for control than for appropriation.

The empirical work of Eccles, who argues that a "quasi-firm" exists, defined as a stable organisational unit, which consists of contractor and specialised subcontractors, when conditions permit. The results of the survey suggest that the quasi firm existed up to a point and the market making of the firm and project specificity of the subcontractor were considered as factors that influence the integration of the smaller organisations into the main contractor.

The construction industry in the UK has many small organisations that work as subcontractors to larger organisations that act primarily as market traders. The size of these organisations is difficult to measure due to the lack of data of an appropriate quality (Greenwood, 2001) and the number within each trade within a region are also difficult to quantify. The buying organisation tends to have a large number and wide variety of organisations to trade with in order to ensure it has the capability to carry out the variety of work required on complex projects. The survey found that market transactions are affected by the availability of the sellers i.e. numbers of an appropriate size and technology, their propensity to trade which relates in turn to the relationships between the organisations and give estimates for work and also the basis for their selection. The data analysis suggested that types of relationships with trade differed with both turnover and with trade technology. The investigation of this aspect was impossible with the selected methodology for phase one of this study and was investigated in phase two of the study.

The practice of subcontracting offers many advantages over internalisation in that it ensures production efficiency and organisational flexibility (benefits that are related to the market governance mechanisms) but it adds coordination costs such as searching and gathering information about the sellers, writing, negotiating and administering contractual agreements to protect against opportunistic behaviour. The general trend to attempt to reduce these administration costs as seen in the survey has been to develop closer links with a smaller number of subcontractors. Eccles (1981) argued that the stable relationship that exists between the general contractor and the subcontractor is someway between the market and hierarchy. The four conditions that Eccles found were that a low number of subcontractors were considered for performing a trade, a long term or stable relationship existed between the contractor and subcontractors, extensive use was made of labour only subcontractors and that there was a low frequency of formal competitive bidding that was undertaken.

The data analysis from this study indicated that main contractors rely heavily upon competition to gather supply chain prices, this is in stark contrast with Eccles study in the USA where competitive tendering was used only by 20% of cases and which when repeated by Constantino and Peitroforte (Costantino and Pietroforte, 2002) in their survey of 16 house builders and 23 general contractors found that only 18% were procured using competitive procedures.

It has been suggested that social embeddedness is an aspect that is taken into account in the process of communication between contractor and subcontractor (Kale and Arditi, 2001), as parties cannot rely solely on a price mechanism with another party when conditions of high uncertainty and high asset specificity are in place. Relationships are seen as a strategic asset by Kale and Arditi (2001) when considering the economic performance of organisations. They carried out a survey in the USA in 1998 and analysed 107 responses to identify any association between relationships with the supply chain and found subtle empirical support for the operation of social embeddedness within relationships and suggest that this has benefits in organisational learning, they suggest that "*not only price mechanisms but also social mechanisms have important*

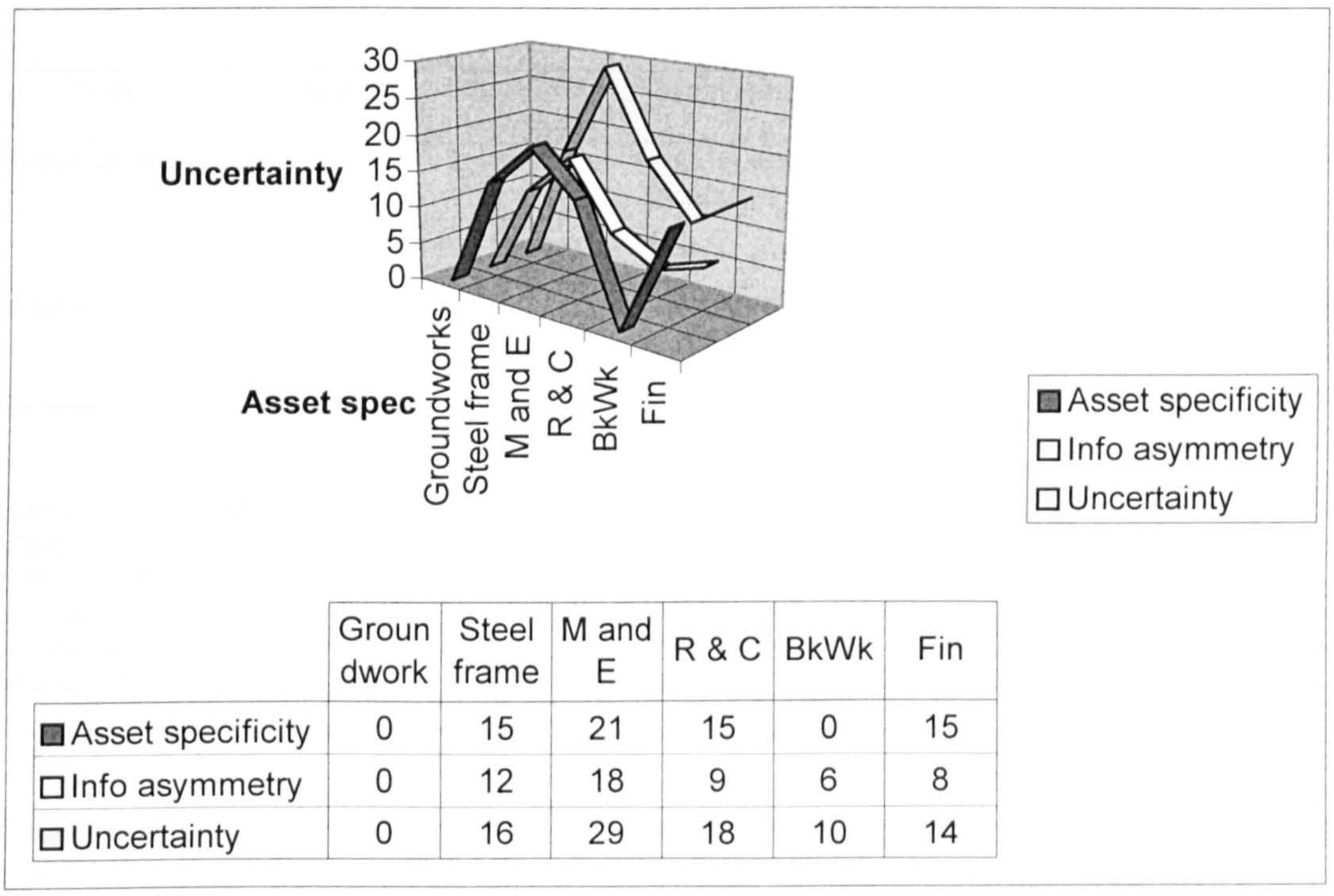
implications for general contractors performance." They did not consider the ex ante process in detail when arriving at an agreed price for inclusion within the estimate.

The data gathered by this study showed evidence that longer term relationships were developing between main contracting organisations and their subcontractors, this supported the assertion that some organisations are moving towards a more relational approach with their supply chain. The data analysis suggested that organisations tend to behave differently when sending out enquiries to a range of trade specialists and the procurement approach, project complexity and trade are all intervening independent variables that effect this behaviour. Larger contractors were found to be moving towards relational approach with their supply chains that may also be larger national organisations. Organisations indicated little evidence of approaches to increase project specificity within the supply chain and the practices of communication or price tended to be opaque for the higher technology subcontractors. The approach towards the mechanical and electrical subcontractors at estimate stage appears to be in contrast to all other trades, even those that carry out design such as steelwork. These factors are illustrated in Figure 6.15, which aims to draw together the data analysis from phase one.

6.11.2 Decision-Making

Estimators have self-reported poorer abilities to assess higher level technologies than lower level. Their ability to assess market prices, alternative specifications and associated costs of alternative specifications is poorer for higher-level technology organisations such as mechanical and electrical and steelwork. These organisations tend to communicate less detail and consequently have a higher level of information asymmetry. The consequence of this may relate to power differentials ex post, and the implication drawn is that organisational behaviour to ensure alignment and ex post governance, which is likely to be different than the lower technical subcontracting organisations. There were feedback mechanisms that existed however few related to economic performance of the supply chain and ex post governance.

In order to conceptually represent the interaction of uncertainty and the subcontractor, a distance correlation of the latent variable of project specificity, information asymmetry and uncertainty was carried out. Figure 6.15 below uses Euclidean distances to summarise how the data can be considered to conform to transaction theory and suggests a mandate for stage two. The overall analysis from phase one provided empirical support for the type and degree of subcontract project specificity and the identification of factors that influence type and degree of such are shown in Table 6.34 and which may influence the structuring of the project economic information .



	Groun dwork	Steel frame	M and E	R & C	BkWk	Fin
Asset specificity	0	15	21	15	0	15
Info asymmetry	0	12	18	9	6	8
Uncertainty	0	16	29	18	10	14

Figure 6.15 Emergent model of uncertainty and asset specificity

A further PCA was carried out on the data set relating to estimators decision making and organisational behaviour and enquiry send out (some 60 variables) which extracted 4 factors that can be considered to be related to supply chain asset specificity, the relative weightings of these are dependent on organisation size (project complexity). These are a subset of the project environment high-level factor model shown at the end of this chapter and were;

- Low technology, (independent of client procurement) e.g. Groundworks, Brickwork
- Design interdependence (high numbers), (related to market and client procurement) e.g. Steel frame and cladding
- Quantification (relates to client procurement) all trades full BQ
- Design interdependence (low numbers)(related to market and client procurement) e.g. Mechanical and Electrical D & B

Table 6.39 suggests how the emergent model illustrated in Figure 6.24 and factor analysis can be combined to identify some dimensions of subcontract specificity that may be studied in phase two or the study.

Trade	Uncertainty[1]	Information asymmetry	Asset specificity[2]	Governance	S/c opportunism[3]
Groundworks	Low	Low	Low, human, locational	Quants, high cost, integration, spot market	Desc, resource deployment
Brickwork	Low	Low	Low, human	Quants, high cost, integration	Desc, resource deployment
Finishes	Low	Low	Low, locational	Quants, high cost, integration	Desc, spec., resource deploy.
Roofing and Cladding	Med	Med	Low, locational	Package, alignment	Desc, spec., progr.
Steel frame	Med	Med	Med, temporal, locational	Alignment	Spec, prog.
Mechanical and Electrical	High	High	High, temporal, locational, interdependence	Alignment	Spec, prog.

Table 6.39 Emergent correlated factors influencing the specificity of the subcontractor

Lansley (1994) suggested that organisations could be considered as operating within two categories of environment, the general environment, which can be considered to be common to all organisations and relates to the economic and social background of the firms, their clients and government policies. This general environment includes the competitive environment, which considers the

[1] Uncertainty refers to the degree of difficulty in evaluating and monitoring the performance of a transacting party.(Williamson, 1981)
[2] Asset specificity refers to the degree to which an asset is specific to a given transaction, to the extent that is cannot be re-deployed easily for use in another context without appreciable loss in its production value.(Williamson, 1996)
[3] Opportunism has been defined as " self –interest seeking with guile" and " incomplete or distorted disclosure of information." *Opportunism doesn't cause information asymmetry; the latter exists because of bounded rationality.*(Dietrich, 1994).

structure of demand and relates to the procurement approaches adopted by organisation's clients and tends to be localised to the firm. The other category of environment relates to the operational or task environment of the organisation and relates to its competitive positioning. These categories have been used by others (Langford and Male, 2001; London and Kenley, 2001; Male, 1991; Moore, 2002) when investigating organisations and are used in this thesis for presentation of the model derived from the data in phase one.

The primary components that influenced the structure of the estimate were identified and classified as external environmental factors, project environment factors and task environment factors. As one moves from the higher order factors to the lower order factors, the level of specificity changes from more general to highly specific. The lower order factors in the external environmental category were found to be procurement, organisational capability, market intensity and small numbers. The lower order categories in the project environment were subcontract specificity, (this had a further sub level of factor category which was derived from an interaction of market, client procurement and project technology), subcontract specialisation, product development, subcontract capability, price codification, interdependence and project estimate constraints. The lower order factors of the task environment were found to be price veracity, estimator capability on market price assessment and technology performance, information impactedness and the need for competition.

These factors are indicated in Figure 6.16 and formed the basis for exploration in phase two of the research. The first phase of the research aimed at uncovering the contingency factors for organisational behaviour when structuring an estimate, the second phase was used to validate and explicate the existence of these factors.

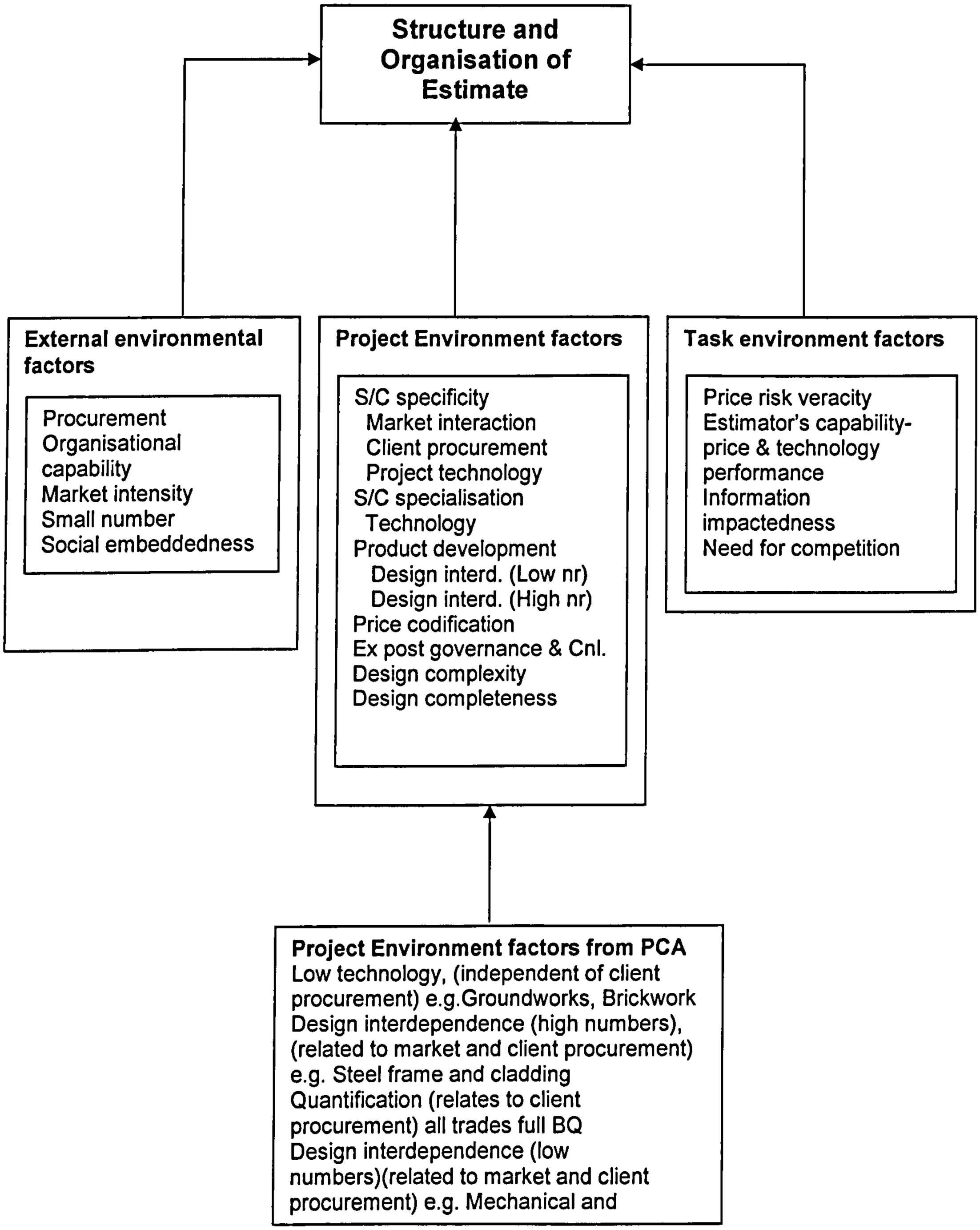


Figure 6.16 Hierarchical model of contingency factors affecting the structure of the project estimate from phase one

CHAPTER 7: MODEL EXPLICATION

7.1 Introduction

The model developed in chapter seven had been developed using a priori approaches to construct measurement, which then informed the quantitative analysis and development of the model. The use of survey methods as being unable to measure social processes and being essential limiting in research has been well documented by researchers in a variety of fields (Denzin and Lincoln, 2003; Dey, 1993; Dixon et al., 1987) and specifically in construction (Fortune, 1999; Seymour et al., 1997; Seymour et al., 1998). The measuring instruments rely upon a priori measurement of concepts that force the respondent to answer questions within the researchers frame of reference, are not good at uncovering processes and are weak in discovering causality.

The first phase of this research focused upon the identification of the contingency factors that affected the structuring of project economic information during the estimating process, inter alia, it also considered the nature of organisation's relationships with their supply chain, communication protocols used and identified the benefits that accrued from closer relations. The findings of this phase required validation and consequently a feature of the second phase included validation of existing factors or "what" questions, as discussed in chapter four, the second phase aimed to collect qualitative data from cases. The explanatory aspects of the case study approach required richer data to be collected that looked at putative causality, and the reasons that explained or enriched the theoretical model of factors developed in phase one.

A general strength of the multi methodological approach, as identified in chapter 4 was that it sought to triangulate the theory developed methodologically. Triangulation has been identified by Denzin and Lincoln (2003) as having four aspects- data source triangulation, where the data are considered to be similar in different contexts, investigator triangulation when several investigators consider the same phenomenon, theory triangulation when investigators with differing perspectives investigate the same phenomenon and methodological triangulation where one approach is used to

inform a second approach that takes a different methodological stance. In this study triangulation is from both the data source and methodological approaches. This chapter seeks to explain the rationale for using a multiple embedded case study approach, which aimed to gather qualitative data for explanatory purposes. It considers the case study method generally and then identifies how it has been used in this study

7.2 Case Studies for Theory Development

The case studies were not selected to represent a sample. The aim of the use of the cases in this study was to expand and generalise the factor model (analytic generalisation) and not to enumerate frequencies (statistical generalisation), which were used in the models development. This is not to suggest that the case study lacks an empirical basis, the use of data in case study research is eloquently stated by Yin (1994) who defined the case study as *"an empirical enquiry that: investigates a contemporary phenomenon within its real life context; when the boundaries between the phenomenon and context are not clearly evident; and in which multiple sources of evidence are used.* Case studies have been used for theory development (Eisenhardt, 1989; Glaser and Strauss, 1967) and also theory explanation. Travers (2001) suggested that the use of a case study approach was recognised as being appropriate when testing a theoretical position and can be used in either a positivist manner or in an interpretive way but that neither approach was inherently superior as it depended upon the research objectives.

A case can be either single or multiple and is categorised by Yin (1994) as one of three categories: exploratory- defining questions and hypotheses for a further study, descriptive- giving a complete description of a phenomenon within its context, or explanatory- explaining which causes produce which effects

As the aim of stage two of the research was to provide a richer explanation of the results from the quantitative work, the case study was considered to be explanatory. Yin (1994) identified three aspects of explanatory case studies, which are the identification of the components of the theory and their stability in

context and the elements of explanation. This is to suggest a number of causal links that "explain" a phenomenon. Yin also identified that the explanation-building process of explanatory case studies was "*not well documented in operational terms*" however he does identify that the final result is derived in a similar fashion to that of grounded theory, i.e. that it is derived from an iterative process. In the absence of well-documented processes, this study adopted a pragmatic approach, which allowed for flexibility in phase two that was not present in phase one. Strauss and Corbin (1998) encapsulate this approach in their quotation;

> *"Researchers in the human and social scientists are operational pragmatists. The more flexibly scientists work or are allowed to work the more creative their research is likely to be."*

The explanatory approach to case study design requires an articulation of the use of theory within the cases Yin suggested a positivist approach to the use of case studies that is at odds with the more interpretative approach suggested by other researchers who adopt a more interpretative approach (Seale, 1999; Denzin and Lincoln, 2003; Feldman, 1995). The approach taken for this study was essentially post positivist, in that the factor model was induced from the data in phase one and the researcher recognised the limitations of the methods used for measurement, collection and analysis of data. This is expanded upon in section 7.4 below. The theoretic factor model identified earlier was consequently put as a tentative framework for investigation. Harely (1994), below, usefully identified the use of a theoretical framework in case study research.

> *"Case study refers to an observers data: that is documentation of some particular phenomenon or set of events which have been assembled with an explicit end in view, of drawing theoretical conclusions...What is important is not the content of the case study but the use of which the data are put to support theoretical conclusions."*

Most of the theoretical observations concerning multiple case studies consider the case as a typification of other cases, the particular is not as important as the generalizations that can be derived from examination and comparison of the case with others. The alternative method, considered as "instrumental " case studies by Stake (2003), suggests that the case study draws the researcher into illustrating how the concerns of the theorist are manifested in the case.

There are three conditions for the design of case studies (Stake, 2003): (1) The type of research question posed, (2) The extent of control the researcher has over events, and (3) The degree of focus upon contemporary events. The approach to the design of case studies was also identified by Yin (1994) as either a single case design or a holistic single unit of analysis. The rationale for using a single case design is to test a well-formulated theory, or to examine an extreme or unique case or to observe a revelatory case not assessable previously or to use a multiple case approach.

Yin also suggested that a decision is made regarding the units of analysis, which are either holistic or embedded. The choice regarding holistic or embedded units of analysis relates to the objectives of the research question. In this study, the case studies were used in an explanatory manner to explore how a number of factors identified in the first phase affected organisations' behaviour. The decision was made to use a multiple case design as the theory, whilst being grounded in a larger scale survey, had not been validated by any other means and consequently did not fall into Yin's category of 'well formulated'.

The criteria for the assessment of the data were established prior to deciding upon which cases to select. The factor model suggested that the external environmental conditions varied with organisational size and that project complexity was a latent variable from the first stage. This approach of ensuring that robust "scientific" criteria were established prior to gathering data was similar to that taken in stage one of the research.

7.3 Criteria for Assessment of Case Study Data.

The criteria, illustrated in table 7.1,adopted for judging the quality of the studies research design were generally positivist in approach and were adopted to ensure that the criteria for rigour are satisfied (Miles and Huberman, 1983; Yin, 1994; Travers, 2001).

Tests	Case study tactic	Research phase
Construct validity	-use multiple sources of evidence	Data collection
	-establish chain of evidence	Data collection
Internal validity	-do pattern matching	Data analysis
	-do explanation building	Data analysis
External validity	-use replication logic in multiple case studies	Research design
Reliability	-use case study protocol	Data collection
	-develop case study data base	Data collection

Table 7.1 Criteria for rigour in case study design adapted from Yin (1994)

The criteria of construct validity of the case study approach required for the establishment of the correct operational measures for the concepts being studied are shown in Table 7.1. The three tactics suggested by Yin were to use multiple sources of evidence in a manner to encourage convergent enquiry, establish a chain of evidence and have the draft case report reviewed by the key informant. The approach adopted for this thesis was to use the interview transcripts as a basis for coding as evidence of the data analysis stance (the Nvivo codes are included in Appendix 11), comparison between the interviewee's responses and the results of the questionnaire were considered as multiple sources of evidence. The constraint of time meant that informants were not able to review the appropriate case study report, which was recognised as a limitation of this second phase. In order to ensure construct validity and reliability (Yin, 1994) suggests that a case study be constructed to enable an external observer to trace from the conclusions back to the initial research questions or from the questions to the conclusions. This was addressed by including a Nvivo coded model within the appendix as well as reporting the data in as rich a format as the limits of space within the thesis allowed in chapter eight.

Internal validity of the approach required the establishment of a causal relationship, whereby certain conditions are shown to lead to others. The difficulty here is that the reasons for the causal relationships may be misinterpreted. The approach that is suggested by Yin (1994) was to do pattern matching. The approach suggested by Glaser and Strauss (1967) when analysing qualitative data was to "flip flop" from microanalysis to conceptual

modes of analysis. Both approaches were adopted during the data analysis phase, a grounded style approach to coding and recoding the data as the theoretical propositions were supported or rejected helped to develop explanation logic to the design, pattern matching within and between the cases facilitated a cross case analysis. The technique was essentially a qualitative and logical deduction wherein an empirically based pattern was logically compared with a predicted pattern derived from the theoretical perspective drawn from phase one. Some of the coded patterns derived from the interview transcripts were validated with postgraduate students.

The external validity of the approach required the establishment of the domain to which a study's findings can be generalised. Case study research has been criticised for failing to demonstrate external validity (Stake, 2003; Denzin and Lincoln, 2003). The main criticism is that the cases do not satisfy the well-accepted quantitative criteria for sampling. It has been suggested that case study research adopts a logical approach to counter these criticisms (Yin, 1994). The case study used replication logic in multiple case designs to achieve this. The rationale underlying this approach is that the case must be carefully selected so that it either predicts similar results (literal replication) or it produces contrasting results for predictable reasons (theoretical replication). An important step in the replication procedure is the development of a rich theoretical framework. The framework must suggest when the condition under investigation is likely to be found and also when it is not likely to be found (theoretical replication)

If the approach used a sampling logic to attempting to gain rich data from a representative sample, it would be beyond the resources of a single researcher which is the case with this thesis, and it is due to this reason that it is recognised that case studies have well-acknowledged inferential limits (Ragin, 1989; Yin, 1994).

The reliability criteria required the demonstration that the operations of the study can be replicated giving similar results. Yin (1994) identifies that a problem with multiple units with embedded design is that the original research question can slip as the cases are analysed, i.e. failing to meet the reliability criteria. The method of ensuring that this didn't occur was to use a case study protocol suggested as being essential by Yin. A case study protocol, which included procedures for scheduling, gathering and analysing data was used to enhance the reliability of this phase and is included in Appendix 8 of this thesis.

7.4 Identification of the Theoretical Propositions

The role of theory within case study research is an area on which methodologists have a range of views, Yin suggests that the research design embodies a theoretical approach, in that the methods of data collection, propositions, units of analysis and also the logic of connection of data to propositions and the criteria for judging the validity of the findings all suggest or reinforce an a priori theoretical stance. Consequently this approach is suggestive of analytic generalisation, when multiple cases are selected and a previously developed theory is used as the template with which to compare the findings from the cases. If two or more cases are shown to support the same theory, replication can be considered to have taken place. Yin suggests that the researcher should have robustly developed the theory prior to the collection of the data. The explanation or validation of an a priori theoretical stance through the use of case studies was also supported by Miles and Huberman (1983).

The literature reviewed earlier suggested that the processes are undertaken by organisations in order to manage the price risks associated with projects. It was also identified in the quantitative model, that organisations were using the transactional approach to the procurement of their project resources. The second stage of the research sought to gain a further understanding of how the contingency factors identified in phase one affected the project economic organisation embodied within the estimate. In order to complete the second stage of the data collection a clear statement of the theoretical propositional was required.

The findings from phase one can be restated with a set of guiding propositions that guide phase two which are linked back to the hypothesis statements in section 3.6. These are then combined and restated to give a single proposition which is stated at the end of section 8.1.1.

Hypothesis one was accepted. The general linear model found that organisations send out fewer enquiries to subcontractors for projects procured under the drawings and specification and design and build approaches than the traditional approach. The higher-level technologies in the supply chain such as mechanical and electrical trades and steelwork trades were sent out least, as were groundworks and brickwork. Organisational size, which was considered as a proxy for project complexity, was found to be an intervening variable.

Proposition One: Project size and procurement environment combine as factors that influence an organisation's approach to the collection of supply chain price information.

Hypothesis two was supported. The procurement system of design and build requires an estimator to assess the financial information provided by the supply chain in order to develop a product price that allows for design development. This suggested that the estimator had knowledge about market price, technology price and the influence of technological change on price. The factor analysis of the estimator's self reported ability to assess information, identified groups of technologies that were considered as providing comparable and non-comparable information.

Proposition Two: Estimators propensity to develop expertise in pricing relates to the degree of risk exposure faced by the employing organisation if their judgement is incorrect, and is affected by the codification and diffusion of price information.

Hypothesis three was supported. The factor analysis of estimators working for organisations of different sizes was found to be similar, suggesting that this premise was correct.

Hypothesis four suggested that primary factors would be present in order to suggest a model of factors affecting the estimator's task environment. These primary factors were labelled uncertainty, subcontract project specificity, information asymmetry, design interdependence (high numbers) and design interdependence (low numbers).

The lower order factors categorised in the task environment were price risk veracity, estimator's capability (price and technology performance), information impactedness, and competition. In the project environment, procurement, subcontractor project specificity, subcontractor specialisation, product development, subcontractor capability, price codification, interdependence and constraints. In the external environment, procurement, organisational capability, market intensity and small numbers were found.

Hypothesis six was supported. Organisations with a turnover exceeding £99m had closer links to supply chain organisations.

Proposition three: The task environment doesn't differ significantly with organisational size however the subcontract linkages between the main contractor and subcontractor differ due to differing approaches to product development, which relates to the client procurement route.

Proposition four: The transaction between the subcontractor and main contractor is affected by factors that exist within the estimator's task environment, the organisations project environment and the external environment. The resultant effect of the transactional behaviour influences the economic organisation of a project estimate.

7.5 Selection of the Cases

The selection of the cases is vital to the research design and that they should be theoretically and literally selected. Stake (2003) suggested that a purposive sample should be drawn and that the major conceptual responsibilities of the qualitative case researcher were to ensure that each case assists in the informing of the theoretical propositions. Each case study has a conceptual structure; the conceptual framework should allow the framing of research

questions, which covers the main features (aspects, dimensions factors, variables) of the case study and their presumed relationship. It allows for selectivity, what to measure, it identifies which relationships are likely to be important, also what data needs to be collected and how it will be analysed. Stake (2003) identified when a researcher undertakes a study of a number of cases that this is called a collective case and the cases are chosen because it is believed that by understanding them will lead to better understanding of the phenomenon in question. Table 7.2 indicates the eleven cases and the criteria for their selection.

When theories are associated with causal factors, the researcher should select at least one case that falls in each category. The independent and dependent variables to be explained should inform the consequent case selection. In order to select the cases for investigation, reference was made to the data provided within the survey in phase one. Respondents were asked to identify whether they were prepared to undertake a follow up interview and this combined with the organisational demographic information allowed for their subsequent theoretic selection, i.e. to investigate whether the model predicted different results for theoretically predictable reasons and literal selection i.e. to investigate whether the model predicted similar results.

Case	Name	Organisational Turnover £m/pa)	Basis for selection
A		5-24	L(A),T(C-K)
B		5-24	L(B),T(C-K)
C		25-49	L(D), T(E-K)
D		25-49	L(C), T(A,B, E-K)
E		50-99	L(F,G) T(A-B,C-D,H-K)
F		50-99	L(E,G) T(A-B,C-D,H-K)
G		50-99	L(E,F) T(A-B,C-D,H-K)
H		>99	L(I-K), T(A-B,C-D,E-G)
I		>99	L(H,J,K), T(A-B,C-D,E-G)
J		>99	L(H,I,K), T(A-B,C-D,E-G)
K		>99	L(H,IJ), T(A-B,C-D,E-G)

Case study selection, T=Theoretic selection, L=Literal selection (XY)=cases

Table 7.2 Case study selection

The names of the organisations used as case studies have been kept confidential at their request.

7.6 Data Collection Protocol Design

Yin (1994) suggested that there are six sources of evidence, documentation, archival records, interviews, direct observation, participant observation and physical artefacts that should be collected from the case studies. Table 7.3 identifies the evidence base that was considered for this study.

Source	Strengths	Weaknesses
Documentation	Stable Exist prior to the case Exact Extended time span	Retrievability difficult Biased selectivity Access may be blocked
Interviews	Targeted Insightful	Bias due to poor questions Response bias Incomplete recollection Reflexivity
Direct observation	Reality-covers events in real time Contextual	Time consuming Selectivity Reflexivity

Table 7.3 Case study data collection opportunities after Yin (1994)

When considering the opportunities to collect evidence, the main constraints were the time available to the researcher and the potential difficulties in gaining access to an environment where commercial decisions were made. The use of direct observation was consequently rejected. The use of documentation was also rejected. The documentation that was considered to be available would have been archival records of past tenders, however, initial enquiries in the field revealed that due to the throughput of enquires and their perceived limited future value, such enquiries were not stored for more than six months. The respondents also identified that the stored information was an aggregate of the estimating notes, tender adjudication considerations and commercial reports and consequently contained information of a sensitive nature. This access to information concurs with the research by Tah et al. (1994), consequently inspection of documentation other than the completed questionnaire was not taken up. The questionnaire survey form requested if individuals wished to take part in a follow up survey that they include their business card. This information, when cross referenced to the returned survey form allowed for a purposive sample to be drawn and also gave the opportunity to target directly

individuals who could provide insightful data on the area under investigation, consequently interviews were selected as the main form of data collection.

7.6.1 Interviews as a form of Data Collection

Interviews for research purposes can take one of several forms, they can be open-ended, focused or structured. The open-ended interview considers an approach that is as naturalistic as possible and follows an approach that asks the interviewee for opinions on facts or events in a conversational form. A focused interview is used where information is gathered over a short period of time and the interviewer uses an interview protocol to gather the data. A structured interview is often used in quantitative research whereby the interviewee responds to a series of closed questions.

In a pragmatic sense the interview can be considered to be a structured conversation with a purpose. The approach adopted for collection of the interview data for this study was a semi-structured approach. This has been defined by Kvale (1996) as "...*an interview whose purpose is to obtain descriptions of the life world of the interviewee with respect to interpreting the meaning of the described phenomenon.*"

A criticism of the interview methodology is that they can result in interviewees being focused on the present day (Somekh and Lewin, 2005) and can consequently be unreflective of the true nature of social processes. In order to counter this difficulty, it has been suggested that the interview should be theme orientated, not personality orientated, and that when conducting the interview it is important to listen to the directly expressed descriptions, events and processes, to read between the lines, and then to formulate the message within the response into aspects which transcend the interviewees temporal limitations and communicate it back to the interviewee as a series of confirmatory responses. This allows the interviewee to either confirm or refute the interpretation of the responses given.

The interviewer had to approach the interview free from suppositions, as far as possible, and consequently adopted a "*deliberate and conscious naïve*" approach. This made the early stages of the interviews difficult, as there was a

tension between gaining access to credible and authoritative data by convincing the interviewee as to the relevance of the topic, and the knowledge of the interviewer and also ensuring that as far as possible interviewer bias was kept to a minimum. The interviewer is a chartered surveyor and chartered builder and has had seven years of experience of using structured estimates for the control of projects and consequently could develop a purposeful discussion with the interviewee relatively quickly.

An interview guide was used, which was refined as the interviews were conducted to ensure the questions were clearly worded and also in an order that would encourage the interviewee to think in a processual manner. Care was taken to ensure the difficulties of case drift suggested by Yin (1994) did not occur. The interview protocols are contained within Appendix 8. The interview questions can be considered as gathering data on more than one research proposition as illustrated in Figure 7.1, and the nature of the dialog that flowed also allowed the consequent data to be used to investigate more than one proposition.

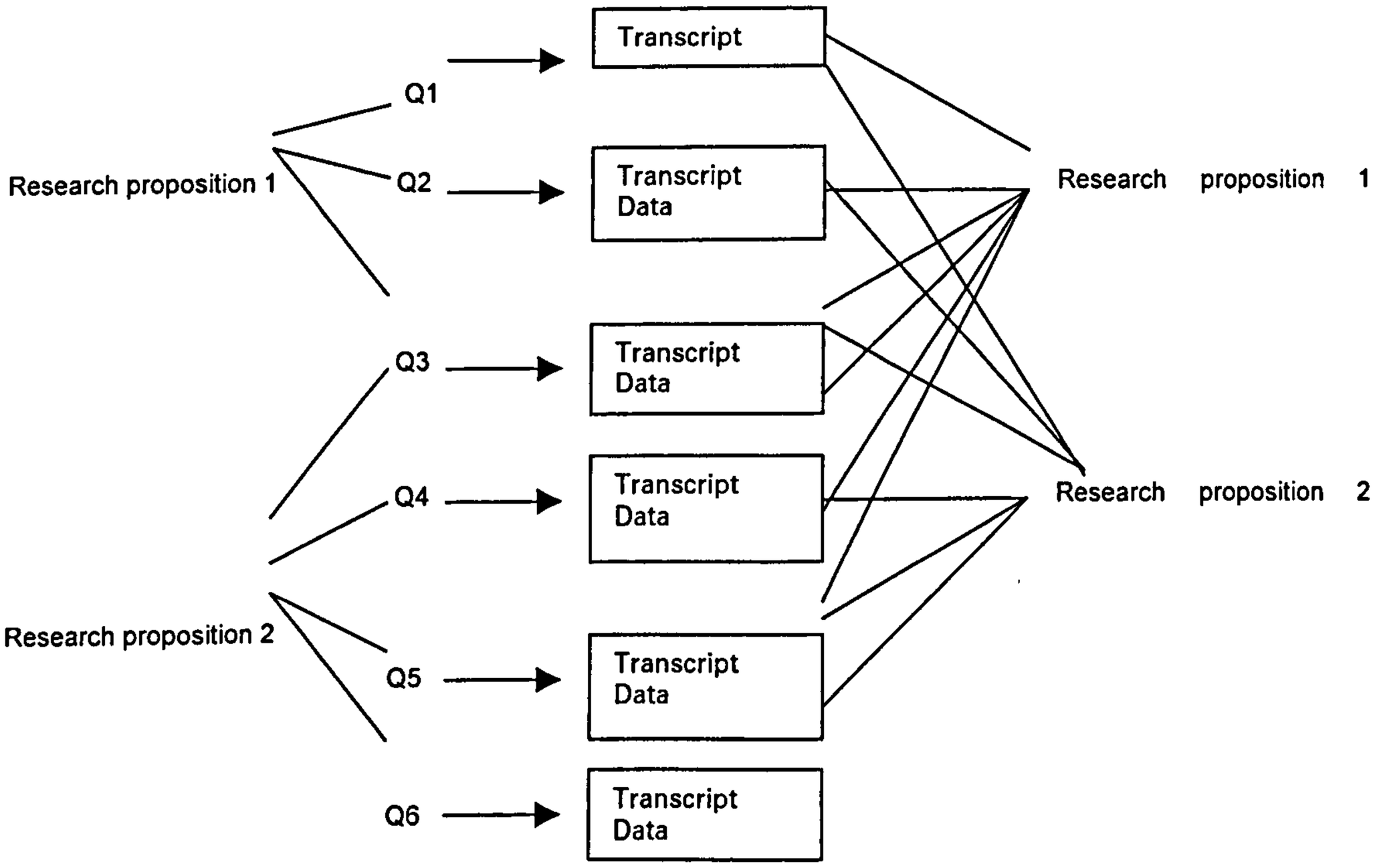


Figure 7.1 Relationship between propositions, questions, and data (after Kvale, 1996)

7.7 Conducting the Case Studies

Interviewees were contacted by letter or by telephone to organise a convenient day and time for the interview. A total of twenty organisations were contacted however it was only possible to interview eleven individuals. At the start of each interview, the researcher gave some personal background details in order to develop a rapport, the aims of the research were introduced as well as the structure for the interview. An electronic recording device was used to gather the interview data.

One of the difficulties encountered when interviewing, is that during the course of the interview the interviewee's opinion can change and the interview data is in danger of lacking a replication. In this study the data was collected within a case study context and focused as far as possible on objective behaviours of the organisation from the individuals perspective.

The interviewees agreed to have the conversation taped and transcribed however they asked for confidentiality in that neither they nor their organisations would be identified. The codes from the qualitative analysis are included within the Appendix 11 and the 'thick' descriptions in chapter eight have been amended to exclude identifiable features. The interviews lasted between thirty minutes to two hours and were conducted either at the interviewee's desk, the organisation's boardroom or by telephone. The data was considered reliable as a naturalistic approach was taken and a rapport was developed between the interviewer and interviewee.

7.8 Case Data Analysis

An analytical strategy for multiple case studies was required however as Yin (1994) identifies it is "*one of the least developed and most difficult aspects*" of the case study approach. Yin suggested that four dominant strategies are available, pattern matching, explanation building, time series analysis and program logic models. The reason for the strategy is that the data must be analysed for the unit of analysis and also across the cases generally.

The theoretical propositions shaped the data collection plan and therefore should be a priority when considering the relevance of the strategies available.

The particular analytical strategy that was selected from the four identified for case study research was pattern matching and as the case studies were explanatory ones, it has been suggested by Stake (2003) that if the patterns coincide this helps strengthen the cases' internal validity and that the patterns may be related to the dependent or the independent variable. As the approach adopted by this study was an explanatory one, the patterns were related to both the dependent and independent variables of study. A theoretical propositional matrix was developed to shape the coding of the data as suggested by Miles and Huberman (1994) and to assist with the analytic strategy of pattern matching. In order to retain the strengths of the open approach to data collection and remain committed to methodological triangulation, an initial approach to coding that used the open and selective coding of the transcript data was adopted. This approach to coding borrowed from the more interpretative tradition of qualitative research. The approach suggested by Yin (1994) and Glaser and Strauss (1967) is similar in the use of data, in that it is examined, categorised, tabulated and recombined to address the initial propositions of the study. The distinction is that Glaser and Strauss suggested that theory emerged from the data rather than the more positivistic approach of Yin. Interestingly in the latest text on grounded theory, Strauss and Corbin (1998) move towards a quasi-positivistic approach to the use of qualitative data. The researcher also adopted the more positivistic approaches of Miles and Huberman (1994). The quotation below encapsulates the researcher's position on this

> *"Unless researchers are extremely constrained by either external pressures or external mandates, they are pragmatists, connecting various techniques to obtain the desired results."*
>
> (Cresswell, 1994)

Qualitative comparative analysis requires a clear identification of independent and dependent variables with accompanying measures, for which a set of well defined analytical procedures determine how these data are to be analysed. It reflects the qualitative tradition whereby cases are preserved holistically as units of analysis (Silverman, 2005). As the approach for this thesis was explication of the a priori theoretical propositions, some of the data can be considered as explanatory and some of the data can be considered as developing a causal understanding. The coding approach of Glaser and

Strauss (1967) for grounded theory was useful in that it helped to establish categories, dimensions and the use of open, axial and selective coding supported the detailed analysis of the particular cases. The coding was carried out using an a priori theoretic perspective as suggested by Silverman (Silverman, 1997), the flexible use of grounded theory methods for qualitative data analysis has been suggested as appropriate by Denzin and Lincoln (2003). A propositional framework was used as a device and is included within the Appendix 10, and developed iteratively as phase two unfolded.

7.8.1 Implementation of the Strategy for the Cases

The case studies contained a number of embedded units of analysis. The units of analysis were the estimators who took purposeful action in structuring project financial information during the estimating stage. The method of analysis was planned prior to carrying out the case study data collection. This was considered and incorporated into the interview guide whereby clarification questions were asked and the focus was upon the dependent variables. The analysis of the qualitative data was an iterative analysis, unlike the quantitative approach adopted in phase one which was more linear and sequential. The overall aim of the analysis was for data reduction. The data reduction was a continual process that was carried out during the analysis of the case studies. The interview transcripts were coded, however, not all passages were coded and consequently decisions were made in vivo regarding what was considered relevant and what wasn't. The computer aided qualitative data analysis package, Nvivo was used for the management of the transcript data, which was substantial, 167 documents which included the open question results accounted for 65,000 text units overall. This was advocated by Fielding and Lee (1998) when managing large amounts of qualitative data. A similar approach was used for the data analysis as previously discussed, open coding created over 300 nodes, each node was described and memo's were used within to capture the analysts rationale for node creation. The nodes were merged when it became clear that conceptual agreement upon a nodal category was reached. The searching facility within the Nvivo software, allowed for selective and axial searching to take place across the nodes to compare and contrast the data for the case studies. The data that originated from the pilot interviews and from the open question answers provided additional

contextual information to support the analysis. The data display that was used was both extracts from the cases which were considered to illustrate the theoretical propositions, the theoretic propositions provided the framework for the display of these quotations and also the modelling tool of Nvivo was used to demonstrate conceptually, how the data were interrelated. The Nvivo modelling tool allowed for model layers to be displayed which assisted with managing the complexity involved with the analysis. Figure 7.2 illustrates the approach adopted.

Miles and Huberman (1983) identify that analysis has three strands, data reduction to distil the data to its essential components, data display and drawing conclusions.

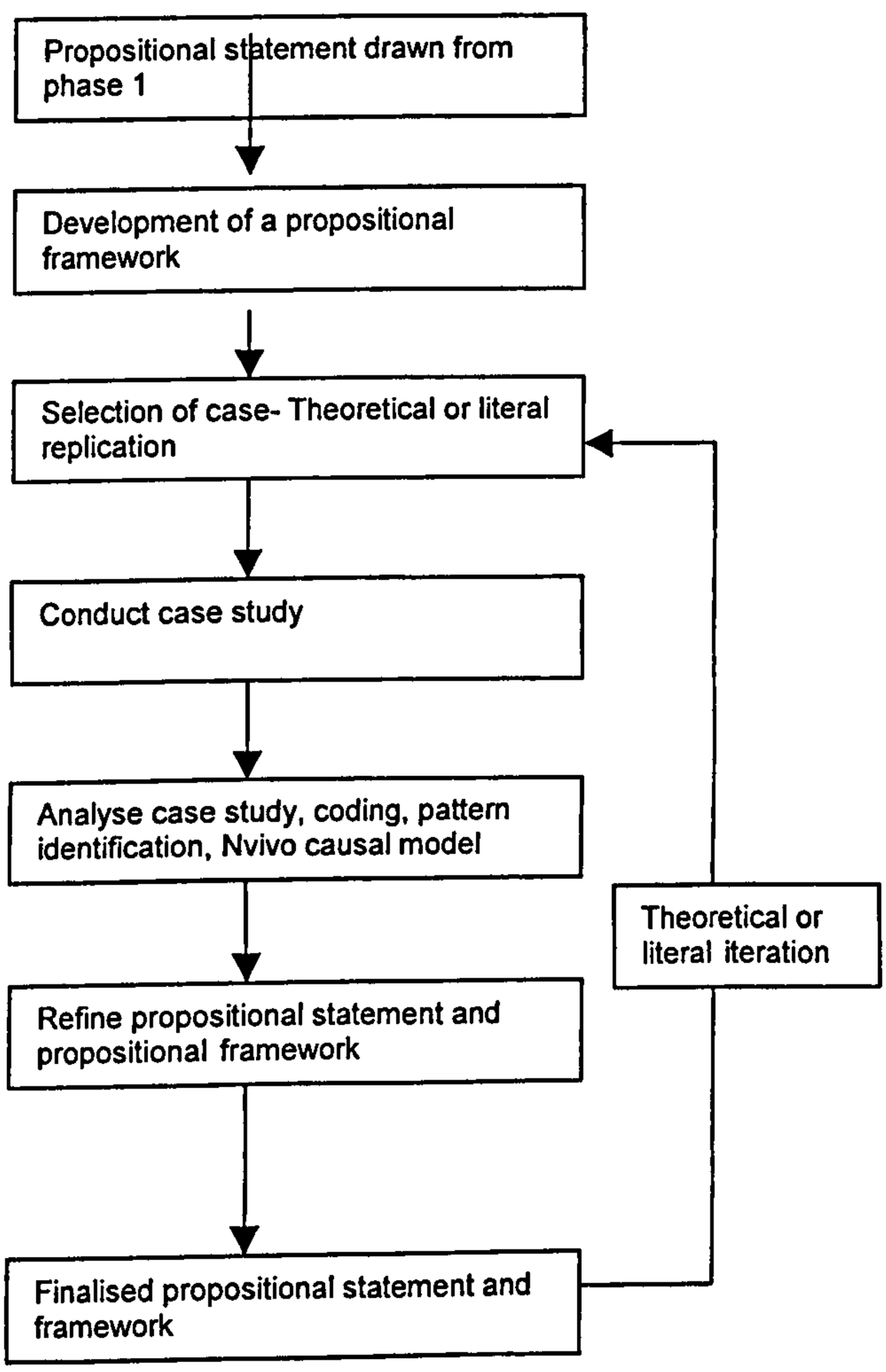


Figure 7.2 Analytic strategies for case study selection and analysis

The data were collected together in the Nvivo package that allowed for continual Boolean searching within and across cases. The data was initially

structured into 78 themes. Within each theme there was a series of categories that described the coding. The description of the nodes was recorded in the Nvivo package. The data analysis is displayed in the next chapter. The displays are a summary of the analysis, as restrictions of space do not provide for the display of the full transcripts for each case with the corresponding analysis.

7.8.2 Drawing of Conclusions from the Cases

This drawing of conclusions from the cases was considered as the third stream of analysis and requires the noting of patterns, regularities and possible causal flows. The conclusion development was undertaken over a period of time using a research journal that reflected on the contribution of each case and nodal coding used, the use of memo's as the coding and analysis took place which also assisted in the conclusion development. This approach to the conclusion drawing and development of explanation underpinning the quantitative first phase was similar to that advocated by Strauss and Corbin (1989), as a grounded approach in that the conclusions are grounded within the data.

7.8.2.1 Cross Case Comparisons

As the case study data has been gathered via interviews and transcribed, the ability of the analyst to code the data and assess the answers within Nvivo supported a robustness of approach that otherwise would not have been available. The explanatory aim of the case studies required that an explanation of the causal links that link to a phenomenon be given. The iterative nature of explanation building has not been well documented in operational terms. Yin (1994) suggests the following sequence, making an initial theoretical statement or an initial proposition about a phenomenon, comparing the findings of an initial case against such a statement, revising the statement or proposition, comparing other details of the case against the revision, again revising the proposition, comparing the revision to the facts of a second, third or more cases. Repeating this process as many times as required. This in very similar to the approach to developing a grounded theory however Yin (1994) suggests a critical difference is that one starts with an initial theoretical proposition rather than it emerging from the data as suggested by Strauss and Corbin (1989), in order to protect from research aim drift, one should clearly maintain the

evidence base, ensure the data are available for inspection by a third party and use the established case study protocol. In order to develop a critical interrogative approach to the data analysis, a propositional framework as illustrated in Figure 7.3 was used as suggested by Miles and Huberman (1994), this allowed the researcher to search for the particularity and the generalisability within the extensive qualitative data.

7.9 Theory testing and theoretical limitations

The final stated model has limitations as the complexity in social research is due to differing ontologies of the researcher and the researched, the use of language as a simplification device to describe complex constructs, the overlapping of constructs and the extent of their interdependence and interaction. A theory statement suggests a mode of conceptualisation. The categories of factors that were supported by the research and the hypotheses used were clarified through constant reflection and testing of the data. It is suggested that the factors could be operationalised and further hypotheses drawn that could be tested using appropriate techniques, which would form a project for further investigation after this study. The limitation from phase one of the research was primarily due to difficulties in measurement within a questionnaire of complex constructs, however, the methodological triangulation of phase two was adopted to address this weakness and suggested in chapter five considering the research strategy. The limitations of the case study method are the resources required in order to gather and analyse sufficient data to allow for "saturation". The eleven case studies were selected for theoretic and literal replication however additional cases could have strengthened this phase of the research. The theory testing was carried out in vivo, as were the theoretical limitations of the work. The consequent hierarchical model of factors is at a generalisable level and the specificity of the factors increases as the hierarchy is followed to lower levels. It is suggested that the model will be valid for such specificity however the extent of the effects of the factors may vary given particular organisational or project circumstances and as such limit the extent of applicability of the model.

Chapter 8 reports upon the qualitative data analysis that follows from this chapter.

		Effect on project economic → organisational structure	Org.Rel			Organisational structure					Project governance							Decision environment		
Cause ↓			Specificity	Governance	Opportunism	Alignment	Transfer	Ownership	Scale	SC Market	SC Governance	Procurement	Ex ante Process	Client Governance	Technology	Constraints	Bounded rationality	Motivation to learn	Information
Transaction	T1	Specificity																	
	T2	Governance																	
	T3	Opportunism																	
External environment	E1	Small no's																	
	E2	SC Partner																	
	E3	Competitive advantage																	
	E4	Supply chain technology																	
	E5	SC Market																	
	E6	SC Governance																	
Project Environment	P1	Procurement																	
	P2	Ex ante process																	
	P3	Client Governance																	
	P4	Technology																	
	P5	Constraints																	
Decision environment	P6	Bounded rationality																	
	P7	Motivation to learn																	
	P8	Information impactedness																	

Figure 7.3 Tentative propositional framework for cross case analysis.

CHAPTER 8: CASE STUDY DATA ANALYSIS

8.1 Introduction

The model identified a number of higher order and lower order factors that affect how an organisation structures its estimate and suggested that these fell into the categories of task environment, external environment and project environment. The first phase also identified that the factor structure would vary with project complexity undertaken by organisations of differing turnovers. In order to identify that organisational turnover (a proxy for project complexity) was a valid differentiator, the approach suggested by Seale (1999) regarding member validation, was used in that the researchers "*concepts to predict membership were used in the collection and analysis of the data and that the researchers account can lead to successful passing as a member*". The analytic device for converging the coded data from the case study was a propositional matrix. The data analysis in this chapter is presented descriptively under the factor headings, the propositional matrix was used to summarise the analysis and used for cross case analysis with those cases that were selected for literal representation. Each case study and unit for analysis was similar to those previously studied and only deviated in a clear operationally defined way, which were identified at the commencement of the descriptive analysis.

8.1.1 Multiple Cases for Theory Development

Multiple case designs have advantages in the data are more compelling, and the overall study can be considered to be more robust. The use of multiple case designs follows a replication logic as suggested in the previous chapter, the proposition commences with a linkage back to the theory, the case design includes embedded units and subunits of analysis that are clearly linked. The flexibility of the case study approach is related to the selection of the cases rather than changing the theoretical concerns or objectives of the study. Theory development does not only facilitate the data collection phase to the ensuing case study. The appropriately developed theory is also at the level at which generalisation of the case study results occurs. The approach to this phase was to have multiple cases and consequently, the method of generalisation

was "analytic generalisation" i.e. a previously stated theory was used as a template with which to compare the empirical results of the case study. If two or more cases support the same theory, replication may be claimed Yin (1994). The empirical results may be considered to be more potent if two or more cases support the same theory but do not support a rival theory Stake (2003). The data analysis concluded with a cross case analysis, which used the propositional matrix as a device to illustrate theoretic support from and differences between the cases. The Nvivo model derived from the case study data was then presented. The ontological position of the researcher during this phase was objectivist, logical post positivist. The assumption was made that a systematic set of methods could lead to the triangulation and construction of a provisionally, testable and ultimately verifiable model of factors grounded within the data. The term generalising to a theory can be considered as misleading, the generated model was considered as the generation of a theory, whose general relevance required to be tested by further empirical study (Seale, 1999 pg 112). Its preliminary validation was carried out within phase two however. The theoretical model of factors not only provides understanding but also prediction and being grounded in data offered an approach that answers the criteria of reliability and validity (Denzin and Lincoln, 2003).

The major difficulty that was faced when analysing the case study data was that the search for the particularity of the factors competed with the search for their generalisability. Triangulation within the case studies was a process of using multiple perceptions to clarify meaning, verifying the repeatability of an observation or interpretation and referencing back to the literature review and results from phase one. The researcher decided to present 'thick' detailed case study descriptions regarding the factors, which Seale (1999) suggested that can give the reader "*the vicarious experience of being there so that they can apply their judgement to assess the likelihood of the same processes applying to other setting they know,*". The quotations from the interviews were paraphrased and edited to aid clarity and to ensure the thesis kept within the prescribed word limit. This would increase the internal reliability of the study, defined as the degree to which other researchers would match given constructs to data as original researchers. Reliability and replicability were valid criteria to

use for the qualitative data, external reliability however was difficult to achieve, as this would involve the replication of the entire study, a reflexive account of the procedures was used to show the readers how the results were arrived at.

The propositions indicated in section 7.4 were combined into an initial indicative proposition, which was that;

Organisations take a contingent approach to the structuring of the subcontract components of a project's estimate that is affected by the interrelationship between factors that relate to the project environment and external environment and is also affected by factors that relate to the external environment, the project environment and task environment, which exist in the context of an organisations size.

8.2 Comparison of the Theoretically Based Proposition and Case Study Data.

The data display adopted was to describe how the data collected from the case's confirmed or refuted the proposition and as suggested by Yin (1994) refine and restate the proposition iteratively. This allowed the proposition to develop in a similar fashion to a grounded theoretic approach. The data are presented in the order shown in table 8.1 and the quotations included are referenced to the text units included within the Nvivo project files. At the end of each series of cases the factor model was restated and the display concludes by using a propositional matrix, which was used for a final refinement of the proposition.

Case	Organisational Turnover £m/pa)	Location	Turnover	Procurement	Competition	Interviewee
A	5-24	Surrey	15m	40% D&B	75%	Director
B	5-24	Brighton	11m	50% Trad	40%	Director
C	25-49	Midlands	34m	50% D&B	50%	Director
D	25-49	London	45m	80% D&B	75%	Snr. Est.
E	50-99	Wales	80m	50% D%B	70%	Snr. Est.
F	50-99	N.W.	60m	50%D& B	60%	Snr. Est.
G	50-99	N.W.	85m	40% D&B	60%	Director
H	>99	N.W.	>99	40% D&B	60%	Snr. Est.
I	>99	Beds.	>99	70% D&B	40%	Director
J	>99	London	>99	70% D&B	60%	Director
K	>99	NW	>99	40% D&B	40%	Est.Director

Table 8.1 Case study summaries

The approach to the qualitative data analysis is indicated in Figure 8.1, all the data were gathered using a purposive interview schedule designed to yield richer data regarding the propositional factors, confirmation of their effect upon the structure of the estimate and some indication of the strength of effect.

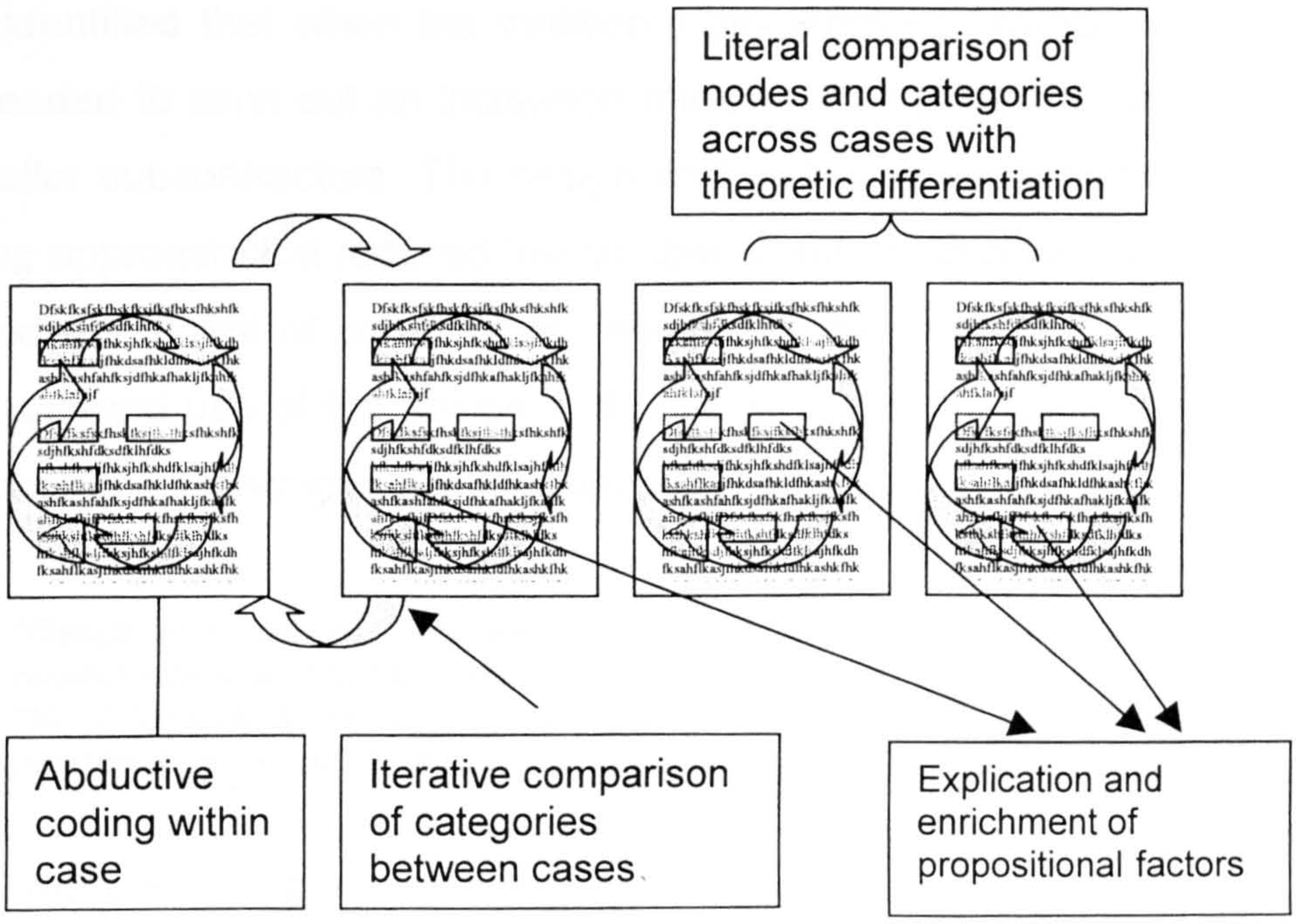


Figure 8.1 Qualitative data analysis within and between cases

8.3 Case Study Data

8.3.1 Case Studies A and B

Case studies A and B were similar in turnover and were selected to provide literal replication in that the similarities should be predicted by the model and theoretical replication in that the differences between them and the rest of the case studies should be explained by the theoretical model. The analytic generalisation from the case studies is considered at the end of the chapter.

8.3.1.1 External Environmental Factors

The external environmental factors that were identified in the cases related to small numbers and market intensity the effect of which was evidenced by the propensity of subcontractors to provide prices. The external environmental factor of procurement on organisational behaviour was validated in both cases. They identified that when the traditional procurement arrangement was used they tended to send out an increased number of enquiries to the market place to smaller subcontractors. The design and build approach was identified as a unifying approach that reduced the number of subcontractors involved and also reduced the extent of coordination required at the early stages of estimating. The increased use of the design and build procurement route was singled out as changing estimating practice as illustrated below.

> *"Design and Build has changed contracting and the approach to contracting,.. We've moved further and further away from the old fashioned approach where you'd receive a Bill of Quantities and you'd chop it all up in to little bits ... the main contractors are becoming more and more just management contractors. "* Case A

One of the underlying reasons for this change in behaviour was that the design and build procurement route was more integrating however the traditional procurement was identified as securing more competition as suggested by the text unit below.

> *"We would ..... look for a bit more competition and send out, one or two more enquiries to others. .. because there are always others sub contractors who may be able to provide us with a better price." Case study B*

The quantitative model suggested that the number of subcontract enquiries sent out by these organisations tended to be lower than organisations in the mid range of turnover and similar in number to the larger organisations whose turnover is in excess of £99m and was affected by the project technology for steelwork and mechanical and electrical. This was confirmed by both cases as the quotation below suggests.

> "*Well the approach where it works best* [reduction in the number of enquiries sent to the market] *is with the large complicated very integrated trades like for instance mechanical and electrical services. Structural steel work, that sort of thing, where it is vitally important that you get it right because it's a major element of the job. There's a lot of work involved in producing a tender for mechanical and electrical services and therefore a sub contractor is going to be reluctant to do too many of those if he thinks he is just one of six." Case A*

This suggested that the external environmental factor of a network work effect that informed the supply chain organisation of competitors was in existence for small projects and this influenced the opportunity of the contractor to receive bona fide quotations and was considered as a lower order factor of small numbers. It could be suggested that this related to the size of subcontract organisations used by these types of organisation. The cases made a particular effort to develop stronger strategic linkages with these types of organisations, this was considered to be an factor within the external environment which increased the specificity of these trades and suggested that the factors that affected this specificity were within the project environment and were temporal and technical. The network effect was also identified as having a negative affect as unsolicited quotations were considered although they were cited as not being used.

> *"We would look at it,*[an unsolicited quote.. *but if we've already said to one of our partner sub contractor that this project we're doing you're doing then we would take a hit. The other contractors look at it and say we unfortunately on this occasion we are already negotiating with our preferred sub contractor but we will obviously put you on our records ...." Case B*

8.3.1.2 Project Environment Factors

The size of projects these organisations undertook was stated as being limited to an approximate maximum value of £5m. These were less complex that those undertaken by the larger organisations and they made extensive use of outsourcing design as they did not have the in-house resources such as design and build coordinators. There was a difference cited in the approach to the steel frame and mechanical and electrical workpackages that related to the availability of subcontractors and their particular specialism and their propensity to return estimates. This suggested that the specificity of a subcontractor originates from the technology as well as organisational relations. This would suggest that the organisation selects the mechanical and electrical organisation in a different manner to the steelwork subcontractor and the influencing factors were identified as the market and external environment.

"So they're the sort of trade or work packages [Mechanical and Electrical and Steelwork] that we get most cosy with. Because of the complexity of them ...d at the other end of the extreme things like perhaps the ceramic tiling or the mastic pointing or something that quite frankly you don't even bother organising until you are well in to the job. Those sort of things are quick and easy to price and you can afford to shop around a bit." Case A

" ... mechanical electrical they are complicated time consuming to produce an offer. . Not quite so with steelwork. Steel work sub contractors tend to be fairly adaptable within limits of size and things they can pretty well tackle anything that you ask them to do whereas mechanical and electrical sub contractors do tend to specialise in one type of building or one type of service in a building." Case B

The organisations, when asked about the approach taken during design and build projects, identified that they would partner with a very limited number and usually would align their offer with the subcontractor's estimate. The sizes of steelwork subcontractors used by these organisations didn't appear to carry designers and the main contractor organised the design using independent consultants. The phrase" at risk" was used to indicate that the main contractor would only pay for design work if the job was secured. This was used as an incentive to ensure that the design was kept as economical as possible. The decision on whether to partner with a reduced number of supply chain organisations was based upon the extent of the design work completed

"And probably go one to one ..., it depends how much design work had been done on the job when it comes to you. If it had been pretty well designed but no structural then I would, two things, I would identify the best steel sub contractor I thought is the best person to do the job. And the next thing would be to probably would be do talk to one of our trained Structural Engineers who do a certain amount of pre-tender work for us on a no win no fee basis. So when we get the job they get the job Case A"

8.3.1.3 Task Environment Factors

One of the key value added processes that case A used with its supply chain was to develop documentation that helped subcontractors to respond. The quality of the documentation from client organisations was identified as being poor and required considerable augmentation in order for the subcontractors to respond clearly. The procurement documentation consequently had an influence on the governance of the supply chain. In order to assess whether the prices received were at an appropriate market rate, the organisation tended to price groundworks, brickwork and woodworking trades using their own database of information. The estimator identified that personal experience of

pricing these items had contributed to expertise that was reliable and required minimal updating. Expertise at recognising competitive market rates for items that were un-quantified was not present, suggesting the informational impactedness factors were affecting the price assessment.

> *"As far as the sort of traditional trades that I have always priced myself like ... I know whether their rates are right or not because you know they're things that I've been pricing for years...so that's not too difficult. The problem comes when you get a large complicated un-quantified thing like for instance a complicated mechanical electrical installation. Very difficult to know whether you have got the right number. And very difficult to know that what you have actually got is a competitive bid" Case A*

This supported the existence of the lower order factors within the task environment of price veracity, informational impactedness and estimator capability. The difficulties that the estimator had in developing the price during the design and build project and the compromises that had to be reached were related to factors from the external environment regarding the ability for subcontractors to provide quotations and the need for a competitive bid from the project environment. These were eloquently stated in the quotation below.

> *"I may not be absolutely rock bottom because I haven't gone through this competitive bid process with all the sub contractors. There are doing to be all sorts of things that are going to come out of the design during the design development. Those are going to be swings and roundabouts so at the adjudication when we are adjudicating the level of pricing we've got from the sub contractors, our gut feeling about them and about their prices and about the overall price of the job. What we think we can do to improve it during the Design Development". Case A*

The reliance on judgement, as an aspect of pricing, and the unique nature of a project was identified by the estimator in case A as being essential. This supported the difficulties of codifying information to support this process as a "gut feel" was relied upon and also a lack of quantifiable information upon which to judge the veracity of the prices.

> *"In something as uncertain this gut feeling and information that you got from old jobs and feedback from current jobs and all those sort of things that are, its not a science. Those things are as important as all the measurement and the rates and the extensions and the totalling up of pages and things of all of the rest of the work. The two things are as important because a Design and Build by very nature of the fact that it is Design and Build you as a contractor, as a Design and Build contractor you can't fully design the thing before you then fully measure it and price it and nobody is expecting you to. And certainly not in six weeks so its really a balance between the things you know to be certain, the things that are easily measurable and priceable and you've got a fairly you know cost certainty on and those things at you don't. And the*

things that you don't you tend to use feedback from other jobs, feedback from similar jobs even if you do nothing more than take the figure and divide it by the floor area and see how much a square metre it works out at." Case study A

The estimator in case B confirmed that there was no difficulty in pricing those elements that are labour only and that the rates would generally originate from the organisation's database. This would suggest that the task environment factor of motivation to learn about these trades was present, as feedback would be provided from the cost value reconciliation forms.

"....other carpentry, brick laying we have ongoing relationships with those sub contractors. Other types of trades i.e.: steel work we would still go through the tendering process." Case study B

The main contractor's role was considered as design coordination, between the structural engineer and the steelwork subcontractor, consequently the capability of the organisations subcontractors determined the approach taken. This was a factor that was related to the case's subcontract capability, which differentiates these cases from the larger organisations. It was considered to be unlikely that the organisation would be able to go to more than one subcontractor as there is a large element of coordination of design required by the (unpaid) structural engineer as illustrated in case A.

"So dealing with the steel frame we have identified a sub contractor who is very keen to do it. I've found a Structural Engineer who is one of two because you know they work an awful lot for us on Design and Build jobs so they reckon to do a bit of up front work for nothing anyway. .... And put them together and actually say to the sub contractor you know you know xxxxxxx xxxxxe he is doing the Structural Engineering for us he will be doing the dealing with you know foundation, steel frame all the structural elements of the job so any queries, talk to xxxxxx, he will be producing this stick diagram and then you can develop the thing and come up with a sub contract package for it. ...they have worked on countless jobs together anyway in the past so its all part of the family really". Case A

This aspect of strategic interdependency was a feature that emerged strongly from these case studies and the types of linkages are more related to goodwill and continuity of work than the larger organisations. The subcontractors tended to be smaller and consequently didn't carry professional indemnity insurance and there was a consequent requirement to use consultant designers, this had a consequent affect on the selection and approach to estimate development. The quotation below illustrates the main contractors coordination role during

estimate development, which increased the specificity of the trade organisation and also the role of the social aspects of transactions.

> *"And between them, and they know that at the end of the day I'm looking to making the best bid that I can make so they will not just come up and work on the first solution that comes to hand they will you know work it around and talk through it and then I'll meet them and talk through it until eventually we get probably maybe the best solution that we can get in the time that we've got to get it." Case B.*

The organisations didn't have any formal linkages with subcontractors that would indicate a supply chain management approach however the estimators agreed that there was a movement towards a more focused approach to estimate development. They identified that the relationships were more stable and identified that the key attribute was the length of time that the organisations had been working together and also the notion of shared economic interdependency. This social style, market-making role of this type of organisation was a key aspect to ensuring responsiveness from its subcontractors and appeared to be a differentiating variable from the approach taken by the larger organisations.

> *"I'm sure that there is definitely a movement towards a more stable relationship between contractors and main contractors without a doubt. Certainly as far as this company is concerned there is. And we don't have any formal partnering arrangements with sub contractors but we have a good deal of informal partnering arrangements with sub contractors that we have been working with over many years." Case A*
>
> *"We've over the years formed a ... working relationship with sub contractors who actually tend to look to us for their work and nowhere else." Case study B*

A graphical model assisted with the analysis of the case interview data, the positivist approach of the first phase did not allow for the complexity and interaction of the factors upon the estimate structure. The model has been directly imported from Nvivo for illustrative purposes, the graphical modelling tool is recognised as not being a strength of the software package as illustrated in Figure 8.2. The Figure shown in 8.3 was induced from the qualitative data from cases A and B and illustrates the interacting effect the factors have upon each other and upon the estimate structure.

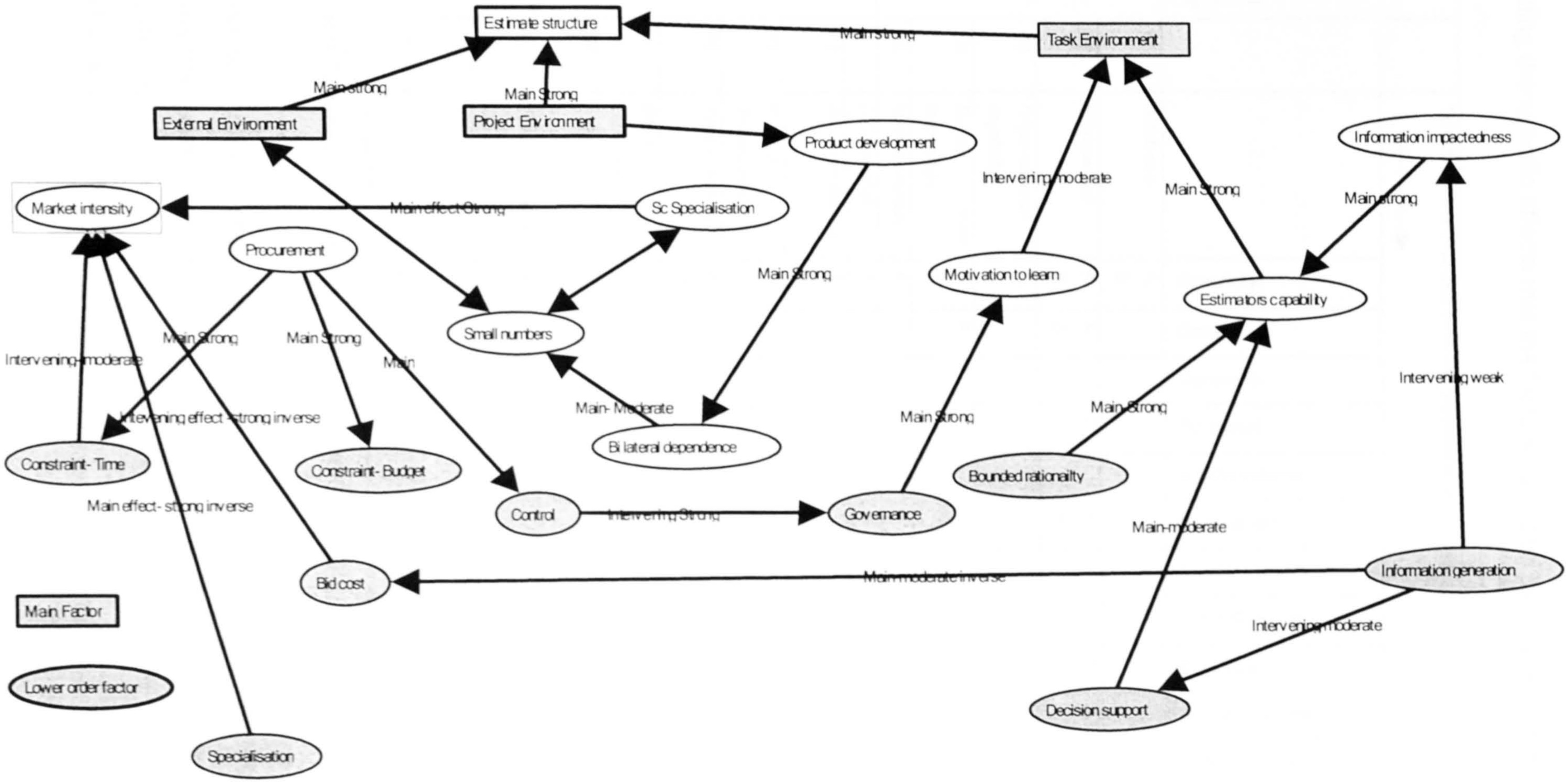


Figure 8.2 Nvivo model of interaction of factors for cases A and B

Modelling the specific effects that the factors had upon the structure of the

Cause ↓		Tentative effect on project economic organisational structure →	Specificity	Governance	Ownership	SC Market	SC Governance	Procurement	Ex ante Process	Client Governance	Constraints	Bounded rationality	Motivation to learn	Information impactedness
External environment	E1	Small no's	A, B											
	E2	Procurement	A, B	A, B		B		A, B			A	A		A
	E3	Organisational capability	A, B			A								B
	E4	Supply chain technology	B	A								A		A
	E5	Market intensity	A											
Project Environment	P1	S/C specificity	A					A	A		A			
	P2	S/C specialisation	A, B						A			A, B	B	A,B
	P3	Product development			A									
	P5	Price specificity	A, B				A		B					
	P6	Bilateral dependence	A, B											
	P7	Constraints	A, B											
Task environment	T1	Price risk veracity	A, B							A				
	T3	Information impactedness	A, B											
	T4	Need for competition	A, B											

Figure 8.3 Summary of the coded factors from Case Study A and B

estimate was outside the scope of this thesis however, a tentative effect summary was used as organisations clearly took a contingent approach. They are illustrated in Figure 8.3 and are included as an emerging result of this second phase of the study.

The propositional statement was supported by the cases studies however can consequently be expanded upon relating to context of organisational size:-

Organisations take a contingent approach to the structuring of the subcontract components of a project's estimate that is affected by the interrelationship between factors that relate to the project environment and external environment and is also affected by factors that relate to the external environment, the project environment and task environment, which exist in the context of an organisations size.

The complexity of the projects undertaken by contractors with a turnover between £5 and £24 m and the social embeddedness of their relations with the supply chain result in higher subcontract specificity.

8.3.2 Case Studies C and D

Case studies C and D were in the category of £25-49m and were based in urban conurbations in the Midlands and London. They were both extensively involved with design and build work and secured over 50% of their work through competition.

8.3.2.1 External Environmental Factors

The quantitative model within phase one predicted that organisations of this size would behave in a similar way to the larger organisations exceeding £99m in that they would send out fewer enquiries and would be involved in less complex projects than organisations of a large size. The model also predicted that they would be differentiated from organisations of a smaller size. The contextual factor of organisational size was identified as affecting the type of relationships with the supply chain and that it may be dissimilar to organisations of a larger size.

Case Study C did not differentiate between steelwork and mechanical and electrical subcontractors when sending out enquiries. This was supported the findings from phase one. It was suggested that small numbers was not an issue

due to numbers of steelwork subcontractors prepared to bid. The quotation below illustrates this point;

> *"We might send three or four steel frame enquiries out but we would probably send three or four M&E enquiries out. I think its partly because its perceived that there are a lot of steel frame companies around." Case study C*

This was in contrast to case study D of a similar size that identified that the external factor of market intensity was a feature when gathering price data, and particularly highlighted resource availability as a limiting factor for new entrants into the subcontract market.

> *"When you talk about steel work and M&E work we, that's one of the trades and in both disciplines where its saturated. We've got an international situation were there is a shortage of steel and we've got a shortage of skilled operatives on the M&E side ." Case D*

Both case studies had changed their approach over the last five years and were sending out fewer enquiries to the market place. The relationships between these organisations and their subcontractors tended to be more about understanding the nature of the organisations business and the requirements for comprehensive quotations. The interviewee for case study C identified the organisation as a market maker for a number of smaller organisations and as such the interdependency that developed related to longer-term commercial survival.

> *"...because it developed relationships with certain major sub contractors. It also means that they understand our business and we understand the other sub contractors that we are likely to use. ." Case study C*

> *"We've changed the database, the company has grown bigger. And we are removing those ones that aren't able to comply with the current regulations for Health and Safety.... ." Case D*

The main difficulty faced by organisations of this size was finding organisations who were prepared to price for projects in their price range. The major contractors had specialised departments coordinating national prices and could offer more continuity of work than the smaller types of organisations such as these cases. Consequently the small numbers factor related not to the numbers of organisations in the market place but to organisations prepared to price projects for a given contractor. The difficulty in being competitive, when using

the supply chain was highlighted in the quotation below, which could be considered as a sub factor of organisational capability through strategic links.

> *".. its fact because a lot with the major sub contractors there are limited numbers nowadays of specialist sub contractors who do various things. You are all going to end up with the same sub contractor [as competitors] anyway. Case Study C*

Case Study D took a different view to supply chain linkages and it related more to the supply chain market and their capability. This was illuminating as it suggested that there was a churn in subcontract usage, which was due to external subcontract market factors that were beyond the control of the main contracting organisation.

> *"When they are looking for work they are asking for enquiries but if they have got a lot of work on we don't get them asking us for enquiries at tender stage. And we have got quite a few contractors and when you send them enquiries they say don't send any more enquiries at the moment I have got my capacity, I can't do any more enquiries until the end of and they tell you when." Case D*

Both organisations recognised the need for maintaining good strategic links with their subcontractors and these were identified as providing strategic advantage. The quotation from Case D illustrated this succinctly,

> *"It does effect you seriously because if you've got a good relationship with two or three main contractors and main sub contractors and you lose a couple it means you are stuffed then with getting a competitive tender out." Case study D*

The interviewees in both cases identified that the post contract teams retendering the subcontract packages could compromise their relationships. This would appear not to be a feature for the more complex packages however it was identified that this was a common occurrence despite company policy being otherwise.

8.3.2.2 Project Environment Factors

When considering the effect that client procurement arrangement had upon the organisations approach to price risk, the interviewees identified that few traditional enquiries had been priced recently, however that the reasons for a higher number of send outs at tender stage for a project using the traditional

procurement approach was the need to ensure everything had been priced and the lack of potential for subcontract innovation which had a consequential effect of reduction in subcontract interest.

> *".. if it's a traditional job you have got to have absolutely everything right down on the bottom price…. here's the quants here's the bill. I mean you can still come up with alternatives obviously to try and cheapen it up...whereas with the designer build job you can put some innovation in to the design …." Case Study C*

The reduced numbers of enquiries sent to ground workers was due to the estimator pricing these items. The interviewee suggested that the ground-working subcontractors would accept the prices given rather than price the works themselves due to their capability, this was considered as validating two aspects of the model in phase one, firstly the reason for low number of enquiries to groundworkers and secondly the task environment factor of estimator capability. This was a similarity to other cases of a larger size and suggested that main contract organisational size has less of an effect upon the information that is exchanged between the main contractor and ground working subcontractor. The following quotation also illustrates the estimator's propensity to learn about pricing levels, a factor within the high-level task environment factor category.

> *"... The sub contractors know my pricing levels so well, they still moan about it, but I tend to price all the ground works myself. And we've got sort of two or three ground worker contractors who work with us all the time. … over the period of doing the same sort of work … if I've made a mistake they say that rates not right and I get to know and so do they." Case Study C*

The personal knowledge of the subcontractors was a matter of pride for this type of organisation; an upper limit of four enquiries sent to subcontractors was identified. The price criticality of the major trades was identified as an issue relating to the asset specificity of the organisation. Lower price trades were seen as having less influence on the project and consequently were less likely have as high a project specificity than the larger workpackages. Consequently subcontract scale was a lower level factor influencing subcontractors project specificity as illustrated in case D.

> *"… take painting and decorating for instance it would be a fairly minor element so if we were 5% dearer than the next man on the painting it wouldn't loose us the job. On the very big packages which you know we still go out to probably three or four sub contractors but we know each one of those sub contractors. Case Study D*

The interviewee in case C identified that the ex post performance of the main contracting organisation had an influence on the prices provided by the supply chain. The main issue relating to the payment mechanisms that were in place, this was felt to be an issue of competitive advantage when compared with other organisations. The tendency to align tenders was identified by both cases, the organisations used the tendering process to identify the cheapest and then would develop a bilateral relationship; this would give the tendering subcontractor an incentive to provide the best price during the estimate development stage. There was no evidence of other criteria than price being used for subcontract selection.

> *"But we might do a deal during the tender process. We might go out to three and say we'll talk to the cheapest and then do a back-to-back deal with them. ... normally they will actually tell us they have given us a better price than they have given somebody else." Case Study C*

The interviewee in case C also identified that although competition was used to procure prices for aspects of design and build projects that were designed by subcontractors, he identified that any ideas for product development would remain with the subcontractor and not be shared with other competing supply chain organisations.

> *"…. If we've got out of three and one of them comes up with a suggestion we will keep that suggestion to that sub contractor." Case Study C*

The subcontract market network factor was suggested by case D as constraining organisations ability to receive bids, the source of the knowledge of the subcontract market was the specialist suppliers particularly of mechanical and electrical equipment.

> *"Because they have got a limited source for securing quotes for equipment specified by the consultants. ... But what they don't do if its complicated they don't notify the source supply that everyone has got to use what their specification is. And they then send it to the M&E or the main contractor and by the time it gets back to the source supply, he's got a queue of enquiries in front of him ..." Case D*

8.3.2.3 Task Environment Factors

The interviewee in case C identified that the highest price risk that the organisation was exposed to was from the mechanical and electrical

subcontract trades. This supported the data gathered by the quantitative model, which identified that the mechanical and electrical was the trade with the highest level of variability in prices and also paradoxically, the trade with the lowest extent of comparable price information or organisational expertise in order to interrogate the quotation. The organisation used external consultants to verify the quotations as bona fide, as the estimator's ability to assess this information was limited.

> *"... the one that we get the biggest variation in. And you don't tend to get huge variations in things like steelwork and cladding and floor slabs etc. Its M&E, you can get M&E quotes where one will be 60% of the other."* Case Study C

The interviewee identified that his organisation's tendering subcontractors had high levels of project specificity. He suggested that this personal approach helped in post contract performance. This was validated by information given in the questionnaire. The quality of the relationship was espoused to be unrelated to the trade of the organisation or the value of the workpackage. This was in contrast to larger organisations approach to the supply chain.

> *"I don't think it matters particularly what the trade is I think its just a question of use ... there are painters and decorators who we've got as good a relationship with as fixed structural steel companies you know doing a hundred times the value of work that the painters doing." Case Study C*

The project specificity of the mechanical and electrical subcontract was related to the price dependency that developed, as the interviewees identified a lack of expertise in order to assess market price of alternative specification approaches. When asked as to the reasons why firms differentiate between mechanical and electrical and steelwork trades, case study C identified that the main reason was the propensity of organisations to provide a quotation. An emerging external environmental factor that influenced an organisation in its send out behaviour related to how it was perceived within its supply market place. Organisations perceived as "bid shoppers" had less chance of receiving a bona fide quotation than organisations that use a more relational approach to the gathering of price data. This was not relational contracting as the transactional approach predominates, it related more to the collection of information and offsetting of prices as quotation from case D suggested.

> *"I also think its partly because being honest I don't think many people understand M&E. .. I think they perceive that there's a lot more work in putting the M&E package together. On the average job than there is to put the steel frame together…..and to try and scatter-gun the market as we would call it, putting out six or seven they would very quickly find out that you'd sent it out to six or seven. Because they will be going to suppliers of certain bits of kit …." Case Study D*

The cases of this size aligned their estimates with the subcontractor's quotation conditions to avoid difficulties due to misalignment ex post. The reasons cited by the interviewees were a lack of understanding of this type of technology and a lack of comparable information. When contrasted with the groundwork trade, the interviewee for case C responded.

> *"…because everybody understands the groundwork but nobody understands the M&E so they get away with blue murder." Case Study C*

There was however a strong assertion that the subcontractor would not act opportunistically, as this would have a negative effect upon the relationship of the main contractor and client. This may relate to the size of project as much as to the type of relationship that existed between the organisations

> *"Yes. I think know with the ones that we use most of the time we are quite careful on who we choose. And we'd know our M&E subbies well enough to know they wouldn't do that[be opportunistic]." …". You know or any areas of sort of vagueness between what we think we're getting and what they are giving us. So I can't think of a job that we've had a dispute on in that sense." Case Study C*

The estimator working for case study D identified the role the estimator played in communicating the complexity of a project to a director during the adjudication of the bid. The responsibility for assessment of price risk veracity was shifted to the director when referring to difficulties in the assessment of lump sum subcontract bids.

> *"The complexity of it goes with the pricing of the projects and you don't worry about it. As long as you've got a price that appears to be compliant with the tender and you've spotted areas which you need to talk to with the sub contractor, you talk it through and then you pass … to the director and let the director make a management decision on how we approach the tender". Case D*

8.3.2.4 Summary of Analysis of Cases C and D

Both cases displayed similarity in their approaches; they were not dominant market makers to their subcontract organisations. They both recognised the strategic advantages to be gained from links with the supply chain and that

their project teams compromised them due to opportunistic behaviour ex post. The factors identified in the proposition were found to be supported however there were influencing factors of subcontract market intensity and inter organisational relationships emerging as factors in the external environment, subcontract innovation emerging as a factor in the project environment and trust in coherence of price emerging in the task environment. In a similar fashion to the previous cases the Nvivo model is presented for illustrative purposes in Figure 8.4.

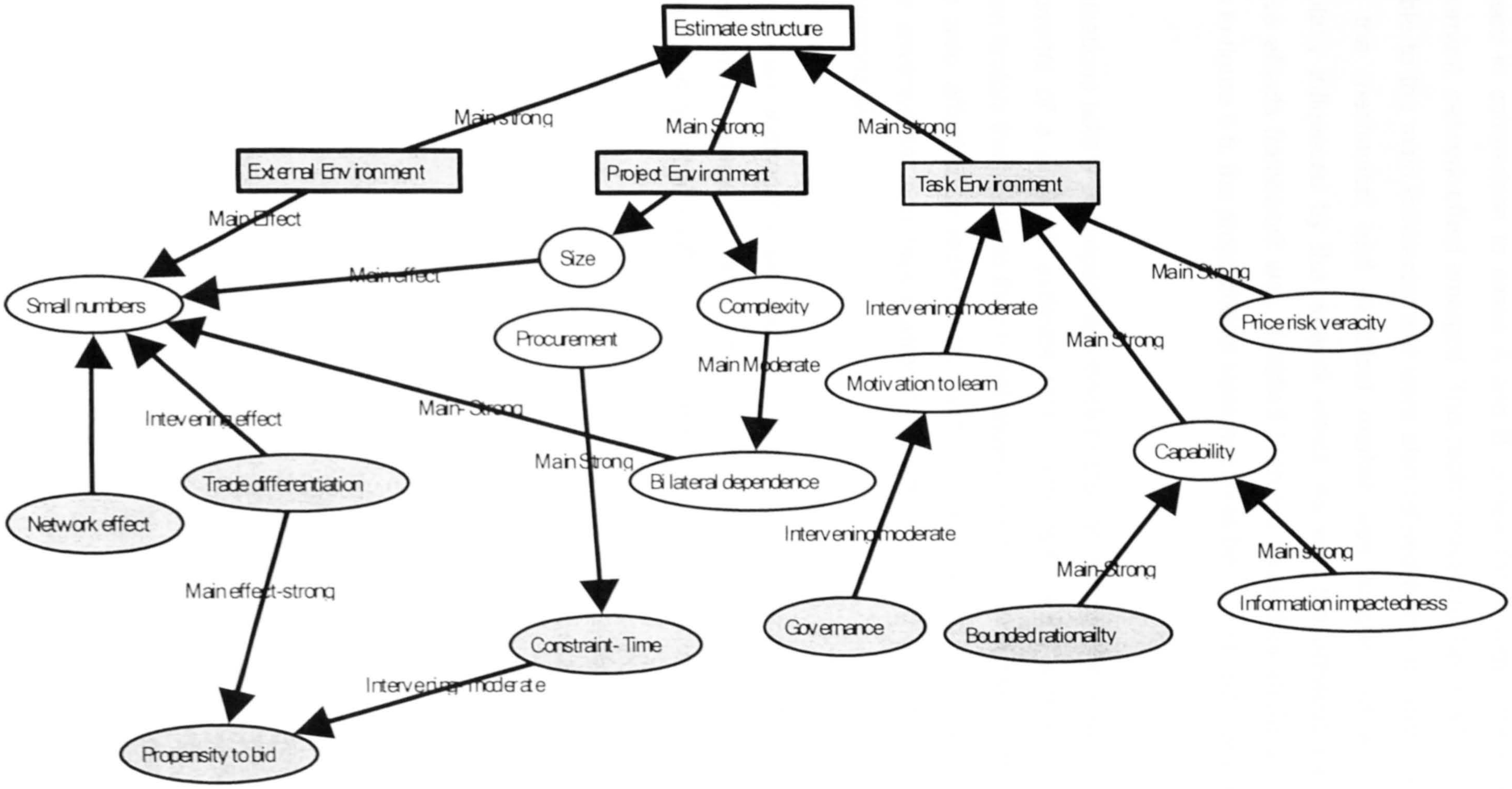


Figure 8.4 Nvivo model of factors influencing estimate structure from cases C and D

The Figure 8.4 above illustrated as the size of the projects competed for increased in comparison to cases A and B, a new factor within the external environment, network effect emerged. This factor related to the small numbers available to the main contractor and were also related to the differentiation of trade, the mechanical and electrical market was singled out as being particularly influenced by the network effect. As with the previous cases a tentative effects framework was identified from the case data analysis and is shown in figure 8.5, the propositional statement was be refined and restated as: -

Organisations take a contingent approach to the structuring of the subcontract components of a project's estimate that is affected by the interrelationship between factors that relate to the project environment and external environment and is also affected by factors that relate to the external environment, the project environment and task environment, which exist in the context of an organisations size.

There is an interaction between the project environment and external environment for complex projects that is related to subcontract tendering costs and results in a network effect that influences a subcontractor's propensity to bid.

Figure 8.5 Summary of Case Studies C and D

		Effect on project economic organisational structure →													
Cause ↓			Specificity	Governance	Opportunism	Scale	SC Market	SC Governance	Client Governance	Technology	Constraints	Bounded rationality	Motivation to learn	Information impactedness
External environment	E1	Small no's	C			D	D							
	E2	Procurement	C					C, D						C
	E3	Organisational capability	D				D			C				
	E4	Supply chain technology	CD				D				D			
	E5	Market intensity	D				D							
Project Environment	P1	S/C specificity	CD	C,D	C									
	P2	S/C specialisation	D	C,D								C, D		D
	P4	S/C capability	C,D											
	P^	Bilateral dependence	D											
Task environment	T1	Price risk veracity	C.D											
	T2	Estimator's capability	C											
	T3	Information impactedness	C,D											
	T4	Need for competition	C,D											

8.3.3 Case Studies E, F and G.

Case Studies E, F and G were in the turnover category of £50-99m and located in Wales and the North West of England. They were identified by the model in phase one to send out the highest number of enquiries than any other group.

8.3.3.1 External Environmental Factors

The quantitative model suggested that organisation of these sizes would make the most use of the market place by sending out many enquiries. The interviewees were senior estimators with over thirty years experience and had both been working for their respective organisations for over twenty years. The organisations recognised that they were in a more complex market with less standardised arrangements, as illustrated by case study G when discussing the difficulties of managing the complexity of projects.

> *"No it is more difficult to assess, for example we are involved with a number of projects which we are involved with a GMP and we are taking on a novated design team, and we essentially have a limited period to assess the state of completeness of their design. There are higher risks. It is becoming commonplace for developers to heavily amend the standard form of contract such that the only risk they carry is if they change something and sometimes they try to avoid that as well. But all the routine risks they try to push across to us which we are prepared to do and which we have to try to assess."* *Case Study F.*

Case study E gathered as much data as possible from the market in order to offset price risk. They sent out a minimum of six enquiries irrespective of trade and often gathered the information at a very late stage during the tender process. The organisation was also subject to a large churn of subcontract organisations; this churn appeared to be due to supply chain organisations being unwilling to provide resources as they had been subject to difficulties in the past.

Case Study E was an interesting case that was selected to try to develop a better understanding of whether geography had an effect upon the behaviour of the organisation. It was one of only a few only major contractors in its operating area and consequently had a large market effect upon its subcontractors; it used this power to ensure that its prices were achieved through extensive competition. It didn't have a strong policy of managing the supply chain. Feedback regarding subcontractor's performance was not sought and it was very commercial with its subcontractors that had led to difficulties in getting prices from them for future tenders. A subcontractor's propensity to provide a price was consequently identified as being based on their perception of the organisation. This perception would appear to spread around particular trade

organisations and was considered to provide additional context to the external environment competitive advantage factor.

The interviewee in case F, which was in an overlapping area but one where there was more competition, identified that they used the market extensively but only limited the numbers for ground workers for whom they acted as a market maker. They suggested that they acted responsibly to ensure that good relations were maintained,

> *"Well, we don't tend to saturate the market that much we tend to stick with two or three ground workers who we know and who are working for us virtually all the time and if there is a difference between them and one has dropped a mistake." Case F*

This supported the model developed in the first phase of the research, which predicted differentiation, by subcontract trade.

The interviewee in case G was the only one who identified the used of incentives in order to develop a bi lateral agreement in order to make the overall bid more competitive. This dialogue increased the subcontractors project specificity and was based on an element of trust, i.e. that the extra effort made by the tendering subcontractor would yield a post contract benefit at a later stage.

> *"To an extent it is, but it then, sometimes you have to promote the question yourself, so to take an example you might have a cladding enquiry, you might have somebody doing the specification and bearing in mind the throughput of those organisations they will give you a price for what you want you have to lean on them a little bit...: If you don't push them commercially they will give you the bog standard, as they have always done, if you say you want to make some savings here what can you do and if we win the job we will give you the job, they start to look where they can find savings and this will give you an edge." Case G*

The case E interviewee indicated that subcontractors were innovating by developing more inclusive work packages, which provided an advantage to the main contractor by reducing transaction costs. This suggested that subcontractors who were competing in this market were expanding in their capability. The external environment factor of subcontract capability consequently was supported by this case.

> *"There are people out there, there are a lot of subs coming up with packaging especially the mechanical and electrical, we have done one or two recently, let the*

steelwork and the floor to xxx as a package at the end of the day it saved 15K between the subcontract packages ..., " Case E

8.3.3.2 Project Environment

The effects of technology within the project environment interacted with the decision environment. The difficulties, the estimator was faced with related to opacity of the estimates from the larger high technical organisations. Case study F identified that the biggest difficulty that faced the estimator was assessing the compliance of the subcontractor's quotation with the main contract. The interviewee suggested that they felt that there was an element of commerciality involved with the larger subcontractors that made the assessment of the quotation vital to risk analysis. The organisation employed an internal specialist who was able to assess the technical compliance of the quotation in order to the check the validity of the quote and the consequent exposure of the organisation.

"Getting to the bottom of their quote, what they haven't or have included. A lot we find well on the a lot of the smaller band of subcontractors are not too bad as they are fairly open and honest but the bigger the subcontractor the more commercial they get as you well know and they basically they have to be more commercial to cope with the commerciality of the builder. On the normal ones you flooring, plastering, decoration, no problem there is not a lot of risk that they can hide or identify, It is the big M and E, piling steel work packages that have to be read very carefully. We do have an internal M and E consultant which if we are struggling with quote he will go through the terms and conditions with a fine toothcomb." Case F

The projects, the organisations tended to be involved did not have any technical requirements that influenced the project specificity of the subcontract organisations. Consequently the market was used extensively for prices for the subcontract work packages. The project specificity of the mechanical and electrical subcontractor was higher however the organisation went to some lengths to ensure that they were not exposed to technical opportunism, this text unit also refers to the informational impactedness of the estimator.

"If it's your usual subcontractors, I don't think that's a big risk as they are so standard I could go through plastering painting, floor tiling. Unless there is some obscure spec, ...The big risk is M and E .They tend to be commercial, not very transparent...A brief spec and very big figures, that's then main risk if you only have one quote it could be miles off or spot on. Even if you have two they could be at different ends of the spectrum, we do have an M and E coordinator who's got a good idea, the risk is high but off laid." Case Study E

None of the organisations demonstrated any firm commitment to the tendering subcontractors, the interviewee in Case F identified that a price would be considered from subcontracting organisations that were unknown and had not undergone the pre qualification process. Consequently the project specificity of organisations would be low. The reasons given for this was that the subcontractors tender would be within the market place and that other main contractors would have an opportunity to use the quote. Consequently the price remained the key criteria for subcontract selection for these cases.

> *"We would give them* [unknown subcontractor providing an unsolicited quote] *a ring, we are in theory only meant to use the subcontractors used by the xxxx system., they should therefore all be trustworthy. There comes at time when you get the unsolicited quote 24 hrs before the tender a lot of money cheaper, we have taken them and won the job and made lots of money and we 've taken them and gone 50/50 I.e. split the difference. That limits the risk but still take the opportunity because basically we have to look at it. If we have got the quote 5 other tenders all have the quote and they are all thinking we are going to use them. So everyone is running with the same risk. …. " Case F*

The overall position was at the tender stage an element of 'opportunity' would be priced and allowed for within the tender. The opportunity would be a sum of money deducted from the bid in order to appear more competitive. This sum would hope to be achieved through post contract negotiations with the supply chain subcontractors, this was considered as buying power.

> *" They are willing to take a risk so long as they can squirm a little bit, we don't take out and out risks its like a 50/50 chance what we loose that one we try to cover our backsides somehow. Risk: It depends what you class as risk, most of the main contractors will take 2.5 of subbies, and they will go off the list of subbies and identify a further percentage as buying power. That is a risk, which we will take." Case F*

> *"There is always a price risk, there is nothing worse than getting two returns back one price that 150K and a document that this thick to back it up and one that's a line of a fax at 97K. And when you come to make up your mind you can never get hold of the guy on the phone, it's a straightforward commercial risk as to what you believe the right price for the job is." Case G*

These organisations appeared to be in a very competitive commercial environment with little project partnering of subcontractors, the phase one model predicted this. The only differentiation by trade was with the ground workers for whom they acted as market makers.

8.3.3.3 Task Environment

The complexity of the structure of the estimate was indicated as being an area that the post contract team had difficulty with. This suggested that another difficulty in arriving at feedback was the potential for misunderstanding where the estimated allowances were derived from. Case Study E had extensive procedures for moving allowances around within the estimate; the movement caused difficulty in the assessment of the coherence of the estimate and the ability to feedback to the estimator. This could be considered as relating to the informational impactedness of the estimators environment that originated internally.

The 'plugging' of rates from a range of contemporary project subcontract quotations, allowed the estimator the opportunity of pricing the risks by using other data. This data however was incoherent. The estimators acknowledged that changes in structure of the supply side had occurred; subcontractors in recognising the difficulty of main contractors had started to estimate for integrated aspects of their work. The estimator in case E identified structural steel and concreting as particular examples that had recently changed and that one of the benefits was the post contract coordination of the organisation.

The interviewee in Case F, identified that one of the difficulties in making decisions was the lack of reliable information within the organisation. It tended to be skewed by the differing objectives of the production team. The feedback systems were unreliable when providing information on the appropriateness of rates or on the performance of subcontractors. In the former case, this was due to the site team wanting to mask production problems; in the latter case, the site team were suggested as preferring a particular subcontractor. The organisation also tended to take a non-atomistic approach to prices; the overall profitability was identified as the main indicator of performance of projects rather than of particular items or work packages.

> *"They will only tell you bad news, ... The only time you only hear something, is at the end of the job..we are not worried if that makes or loose 10k, all I'm worried about is the end figure. .., you will have your ups and downs and one guy wants to make money on every single rate and if he doesn't the jobs gone bad for him. Its different attitudes with different people." Case F*

This lack of precision was not perceived as a problem. The estimators acknowledged that they operated in a closed system with feedback being limited to negative aspects of the judgements that had been made at the time of tendering. The feedback could be external to the organisation, i.e. from subcontractors. The interviewees identified little incentive to learn about prices or attempted to regulate their judgement. This supported the emergence of the motivation to learn as a factor within the task environment. The following extracts from the interviews suggested that the inability to influence events once the estimate was completed also formed an aspect of this inhibitor to learning. The notion of wanting feedback was also unsupported as the view, a common one amongst estimators, was that the post contract team involvements lead to an uncompetitive estimate due to added contingencies.

> *"I tend to go to site at least once because it is of no benefit if I am in error or in betterment ... its gone, its water under the bridge and ..."Case E*

> *" it usually adds money even if I was to do a job I would want Fred to do it, this piece of plant to make things easier for themselves, it adds money adding labour and all the plant that you can have" Case F*

> *"So many things happen after the job has been won and it's difficult to establish the role of the estimator in terms of the profitability of the project. I think from the culture of our organisation, the estimating department does have to win us some work, we have to deliver a budget, we have to deliver a margin, neither are available if we don't win some work. So there is a degree of pressure." Case Study G*

The Nvivo model in Figure 8.6 was developed by considering the nodes for the three cases and carrying out a search across the cases. This yielded text, which allowed for a comparison of the factors, which gave a literal replication within the organisational size category. The theoretical generalisation occurred due to the external environment when compared with the other cases and is summarised at the end of this chapter. The model is for illustrative purposes only.

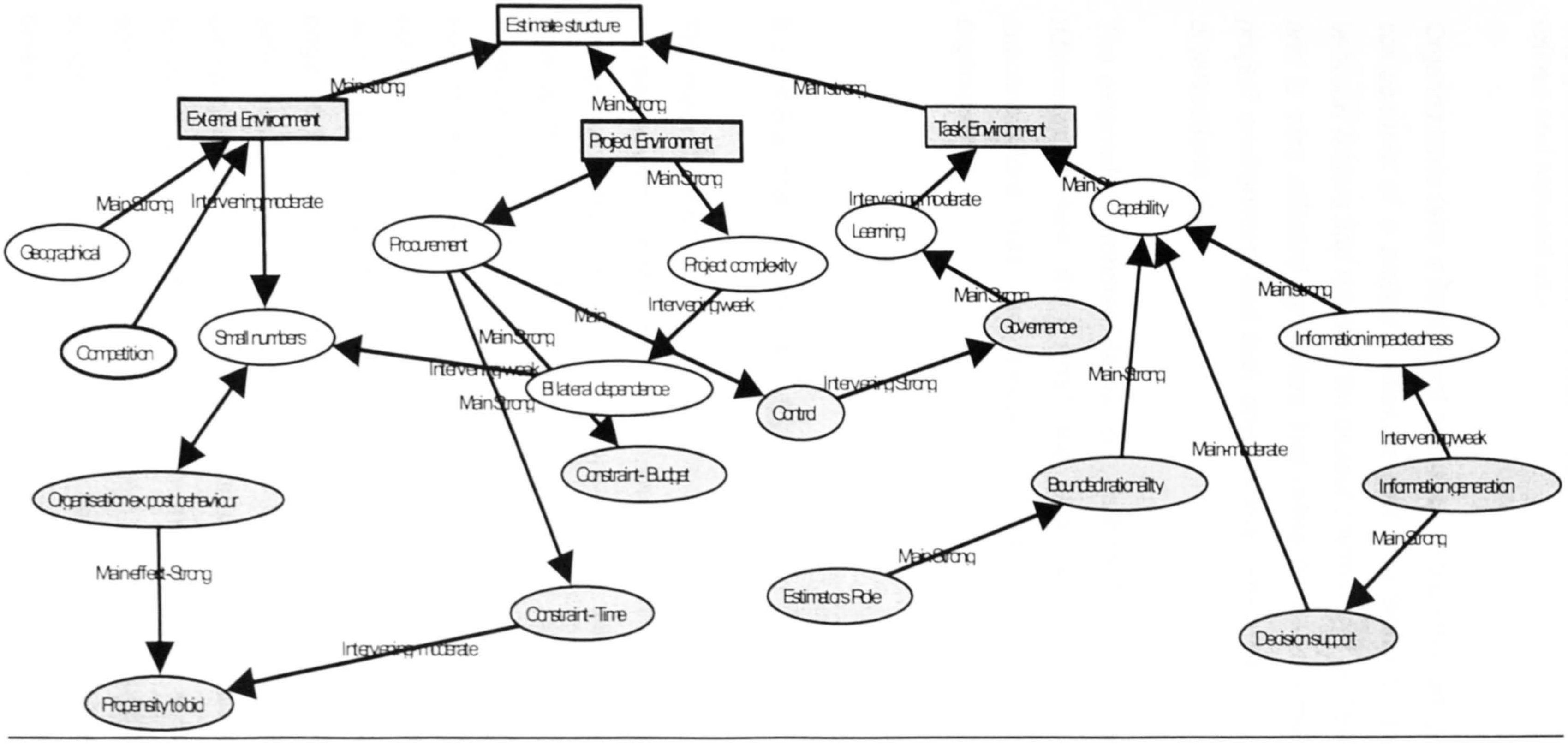


Figure 8.6 Nvivo model of factors for cases E, F and G

The propositional statement was supported for Case Studies E, F and G was refined and restated as:-

Organisations take a contingent approach to the structuring of the subcontract components of a project's estimate that is affected by the interrelationship between factors that relate to the project environment and external environment and is also affected by factors that relate to the external environment, the project environment and task environment, which exist in the context of an organisations size.

The external environment factor, competition, for medium sizes organisations differentiated them from small and large organisations. The specificity of subcontractors was the lowest when compared with small and large organisations.

8.3.3.4 Summary of Cases E,F & G

The theoretic explanation for the difference that existed for these cases when compared with the preceding cases was considered to relate to the external environment that these organisations existed within had allowed them to develop the capacity to bid for a high variety of projects for which they make extensive use of their subcontract organisations. This environment however was more competitive than the smaller and larger environments and consequently greater use was made of the subcontractor's market place. This was validated when considering the extent of competition that the organisations engaged in to win work. The type of client may be an underlying factor in this differentiation, this emerged following an interview with a case study K in the category of >£99m who suggested that the clients in this category of market tended to be developers whose criteria for selection of a main contractor was only price. The data collected and analysed regarding business sector did not suggest a differentiation by type of client and would form a useful further research study. The line of enquiry was however, considered outside the scope

of this study. One of the cases was a market maker and used this position aggressively to gather price information and to yield additional discounts. There appeared to be less of a social aspect to price development and little evidence of bilateral dependency developing. The quantitative model did not suggest that this group were differentiated by client type, market sector therefore project size and client selection criteria may be related factors in the external environment of these organisations.

Figure 8.7 Propositional matrix for cases E, F and G

		Effect on project economic organisational structure →																	
Cause ↓			Specificity	Governance	Opportunism	Alignment	Transfer	Ownership	Scale	SC Market	SC Governance	Procurement	Ex ante Process	Client Governance	Technology	Bounded rationality	Motivation to learn	Information impactedness
External environment	E1	Small no's	E, F G								E	E			F			
	E2	Procurement	G							G			F					
	E4	Supply chain technology	E, F			G												
Project Environment	P1	S/C specificity				G			E									
	P2	S/C specialisation	F, G															
	P3	Product development	G		F					G	G				G			
	P4	S/C capability	E											G				
	P^	Bilateral dependence	G															
	P7	Constraints								E				G			E ,F G	
Task environment	T1	Price risk veracity	E, F														E ,g	
	T2	Estimator's capability	E, F, G			G							G				E G	
	T3	Information impactedness	E, F, G				F										E ,F G	
	T4	Need for competition	E				F		G									

8.3.4 Case Studies H, I, J and K

Case Studies H, I, J and K all had a turnover exceeding £99m, the predictive model suggested that they developed closer links with the supply chain by sending out fewer enquiries and the subcontract specificity was considered to be consequently higher. Case study H was a large organisation that had a varied workload of which 60% was derived from competition, it fell within the category of large contractor and was expected to send out to a lower number of subcontractors than contractors in a smaller turnover group. Case studies I and J were based in the south of England and design and build contributed 40 and 60% respectively of their annual turnover. Case study K 's regional office was in the North West of England and 40% of its annual turnover was design and build.

8.3.4.1 External Environment; Procurement

The design and build procurement route was predominantly used by these organisations clients which concurred with the analysis within phase one of the study. This was client driven and was considered by a number of the cases to be a factor in the type of relationship it had with its supply chain. Case J explicated a reason why the use of the market was supported as a differentiating factor in phase one of this study.

> *"... obviously the majority of work is now looking to go Design and Build and obviously you've got to have some relationship there with the supply chain because you are going to expect them to expend quite a lot of money and time on preparing a bid and certainly from our point of view we would look, shall we say, not to flood the market." Case J*

The procurement environment was identified as being in dynamic change, clients were considered as being opportunistic in combining different approaches to tendering and procurement to yield prices obtained through competition and to get the involvement of the contractor early on in the project. Case K supported the findings from phase one regarding the change in the use of procurement arrangements and identified the need for continual leaning about how the external environment influenced the project environment. Clients

were perceived as mainly using competition as a means of developing project specificity from contractors albeit by using differing tendering processes.

> *"When building quantities were out of fashion and clients decided to put the emphasis on moving the risk across to the contractor they went Design Build. So for a number of years we had single stage D&B. Which is a complete transfer of risk. Obviously with single stage D&B the clients felt that they've lost a little bit of their involvement and they weren't able to influence the design. I think that they realised that they were, whilst they were passing the risk to the contractor they were paying a premium for that. ... So what came out of that was the two-stage approach as I see it. Clients recognised that they wanted to get early involvement with contractors, there was a benefit to that on the buildability, there was value engineering and in order to get that involvement they had to eliminate some of the other competition and run one to one with somebody. The problem we have is that there are various interpretations with two stage contracting ". Case K*

8.3.4.2 External Environment: Market Intensity

The external environment was affecting the contractors gathering of price information, the supply chain management requirements from clients was suggested as the main imperative for using a supply chain approach by Cases J and I.

> *"It depends. I think it depends on the market place. Certainly the market place that we are working in, the employers are encouraging us to go down this route. So if you are say working on a xxxxxx will be wanting to know your supply chain. How you are managing your supply chain. So whether contractors want to go down that route or not they are being obliged to follow that route because of their customers." Case I*
>
> *"Most of the clients on the public sector side are quite stringent supply chain on them. Now what we do on tenders is that we would take maybe a couple of names off and would introduce someone who I would feel would be more competitive in a tendering environment."* Case J

The differentiation in the external environment from other sized organisations was validated as a factor when considering the approach smaller organisations to their supply chain. The response below from Case I identified that the factor of external environment, market differentiation was supported as affecting the estimate structure and the effect was upon the criteria for selection of subcontractor. The larger organisations required more bilateral dependency in the project environment in order to manage the complexity of their projects.

> *"Because at the lower end of the market place a £5 million pound office, factory development which probably we wouldn't be involved in as xxxx Construction. That tends to be well the cheapest building supplier and cheapest fabbing supplier and if a*

contractors trying to compete in that market place he has really got to go down that route. The supply chain really comes in to its own when the jobs are larger and more complicated. And you need the co-operation between the parties." Case I

Case K, who suggested that the overhead costs of the larger organisations made it impossible to compete in the smaller organisations market, also suggested this as a differentiating environmental factor. The interviewee identified that the organisation's approach was to try to select particular clients, a trend that was not supported by the first phase.

"We try not to differentiate by way of size and value but it goes without saying that at the smaller end of the market it is difficult for us to compete in down the lower end of the market. For obvious reasons, there are more contractors that can do that type of work and there are smaller contractors with lower overheads. So predominantly I suppose we've moved towards the £10 million pound plus market place. ...we are trying to get away from the more speculative open tendering." Case K

The external environment was identified as determining how the estimating process had changed and suggested that earlier skills in cost planning were now required and that this strengthened the need to develop organisational capability through strategic links with the supply chain as illustrated by the quotation from Case K below. This was supported by the findings from phase one. These strategic linkages tended to be with larger key trade national subcontractors which reduced the extent of competition used and consequently increased these subcontractors project specificity, the local smaller subcontractors tended to be involved later in the project estimating process.

"So there's two sides to the reasons that have changed because there's procurement routes and therefore the emphasis on the cost planning techniques that we have to employ. In which case there is certain reliability on the sub contractors for assistance at that stage." Case K

8.3.4.3 External Environment: Network Effect

The issue of how the external environment factors influenced the project environment factor of subcontract specificity was an area that required further explanation. There appeared to be an element of moral tie in between the estimator and the subcontractor who provided the quotation that suggested that the incentive was that the organisation place the subcontract with the quote provider was almost guaranteed, if the job was won. This moral tie was put

under threat by the market place, as the market network provided the estimator with a number of unsolicited quotations. If the quotation was contractor specific, i.e. there had been an element of product development that was not easily transferred, the moral hazard would be lower however the knowledge that an alternative price was "out there" would be communicated to an adjudication meeting. This was considered to influence the decision regarding the subcontract selected at tender stage.

> *"...obviously we get you know as you are probably well aware you get sort of get other quotes that are out there. You get phone calls from sub contractors saying I'm pricing so and so do you want a copy ....." Case J*

8.3.4.4 Project Environment; Subcontractor Specificity

The project environment factors that were identified as having an effect from phase one were related to subcontracting specificity and the interviews for the cases focused in more detail on this area in an attempt to expand the concept and provide richer detail. The cases did have a strategy to develop close links with their supply chain and a range of terms was used.

> *"... most main contractors now they have a select list ... they have clusters and all sorts of things ... of sub contractors and preferred sub contractors." Case H.*

The reasons for the establishment of the strategy were primarily to get prices back rather than to develop longer-term strategic interdependence.

> *"I think one you're guaranteed you get something back .I would say 95% of the time obviously there are other work pressures and other things on it but I would think you would certainly get a better service from someone in an approved supply chain than you would through say just cold calling someone and saying have you got the capacity to turn a quote around for us." Case J*

This validated the findings from phase one regarding the benefits of linkage with the supply chain and differentiation by trade when using the market place to gather price information. The cases implied that project complexity was an intervening factor however when using the scenario to gather comparative data case H identified that the contractor's estimator used his judgement about the keenness of the market for the different trades, as illustrated by the quotations below.

"I think steel people get quite excited about that type of building that you have just described. I mean they need jobs like that, they are much hungrier ... and you have that ability therefore to be able to go to a number... if we felt that we were guaranteed going to get a price probably four on the steel." Case H

"It would vary on the project itself. First of all M&E is a notoriously difficult trade to actually get quotes for because there's more work than M&E sub contractors basically, ... So quite often it is a matter of trying to get one or two quotes rather than saying well which of the six are we going to use. " Case I

"Well the thing with the steel work we would try on the steel work and approach the supply chains so we would go to a limited number on the supply chain, maximum of three.... " Case I

"Certainly I mean depending on what the type of project is but certainly if there is a large design involvement from any particular trade we would certainly look to go to no more than two or three." The area where we would probably go away from the two or three approach would be finishing trades, painting, plastering stuff like that." Case J

There was more interdependency with the mechanical and electrical subcontractors, the cases identified that these subcontractors would only get involved if there are some sort of guarantees that they would be involved at the later stages. Consequently the subcontractor, recognising the bilateral dependency requirements of the estimating organisation, influenced their asset specificity. This was illustrated in the quotation below.

"We might have to go to one M&E because it is very much on the demands back from the market place as to the guarantees they want if they become involved in early days." Case H

The costs of completing a design to a stage that will allow for a reasonable budget estimate was cited as the main reasons why the subcontractor wasn't prepared to be involved in too much competitive speculative work without a return.

8.3.4.5 Project Environment: Subcontract Specificity, Information

The extent of change of information as the project progressed was identified as a factor that was categorised in the project environment. This was unrelated to the certainty of the products development and the validity and reliability of the price given from the subcontractor. The quotation below from case H identified

that provision of a price did not always influence the propensity of the organisation to place a contract with the price giver.

> *"Well in the Estimator's view it might not be uncertain because he built it up as he's gone along but it could be a whole series ... of emails, faxes and bits and pieces of information. .., obviously by the time they* [post contract team]*have read through it all and understood it, they think well I've got a complete package here now I'll go out to rebid...." Case H"*
>
> *"And I would say that generally, if the information is all in place it wouldn't go out to re-tender. But what tends to happen is that information is then produced at the eleventh hour which we should have had in at an earlier time and people only take comfort from the fact that if they go out to tender again. Or the estimate might perhaps have been built up in a whole series of information flow on the drip. And so people say .. I need a clean start and so that's what often happens." Case H*

8.3.4.6 Project Environment: Subcontract Specificity, temporal Factor

The temporal specificity of a subcontractor, or ability to hold up was identified from the literature review as an aspect that affected the specificity of the subcontractor within the project environment. Case H as an example of this factor cited the landscaping contractor

> *"...the best example is Landscaping Design. You know that's always eleventh hour isn't it and so that would be probably rebid. But there's another reason why that all occurs is because of overspend on the budget and you know cutting back in other areas. It could be contract to VE couldn't there you know finishings and whatever changes, and just client finally deciding what he thinks he wants." Case H*

8.3.4.7 Project Environment: Subcontract Specificity, Price Specificity, Trade Differentiation

Generally organisations showed little loyalty to their supply chain, the price was the overriding criterion for selection and if an unsolicited quotation was received they would base their tender upon it with qualification if received late. The quotation from Case J illustrates that only on "back to back" relationships would the subcontract be let

> *"Well on back-to-back arrangements I would say 95% of the time. There would have to be a really good reason or such a rogue low quote out in the market place that you just can't ignore it. But having said that I would at least have the discussion saying look yes we are back, we've got this and we can't find any fault with it, it might well be that we, in putting our bid in we would clarify that point. Saying you know this is our price however we have a very low quote but you know again we need further discussion to bottom it out fully." Case J*

The cases also suggested however that their relationships with the supply chain would help protect their bid as the subcontractors were requested to inflate their prices for other organisations. This was recognised as being impossible to verify. The organisations did not use incentives of guaranteeing that the subcontracts would be placed with the tendering subcontractors and alluded to the fact that there would be an element of re-tendering if the contract was won

> *"No no we try not to do that. No we have, I wouldn't say it's a total guarantee but what we do say is that they will be given every opportunity at the second stage." Case J*

Case H suggested that it was unfair however that the vagaries of pricing would mean that the second estimate may vary significantly

> *": you've gone from being in a competitive situation to having to secured the work and a pound to a penny the sub contractor who priced it to you at an estimate at the earlier stage will come back with a totally different price." Case H*

Groundworks appears to be this type of trade, re-tendered, although asset specificity would appear to be high due to temporal aspect of works, the relational approach to working with this trade was higher than others due to the need for flexibility and almost quasi integration ex post. The bilateral dependency thus occurs during the site construction phase and the relationship was between the site team and subcontractor.

8.3.4.9 Project Environment: Subcontractor Specificity, Asset Protection

The contrast between the ground working subcontractor who was not in a position to protect its specificity due to the numbers involved and the level of knowledge of the market prices that prevail and the steelworking subcontractor was illuminating. When asked about the information sharing of other trades, the interviewee in case H, identified that steelwork subcontractors would protect their asset by communicating enough information to allow the price to be used but not enough to allow the information to be used against them and passed to others. The last sentence was stressed ironically to make the point that the price tended to be the overriding criteria, irrespective of design information.

"., no they wouldn't no no[pass on steelframe design details]. They may loosely, we may need to know about obviously column strengtheners, and the size of section for things like fire protection and they may provide some information to enable us to do that [cost plan] because we asked them for it ...One or two steel sub contractors, I think its xxxxxxxxx Structures or xxxxxxxxxx xxxxxx one of those. They used to provide some very good information. Isometrics, you know they had some good software, but they would never be the cheapest anyway!" Case H

Some organisations clearly try to protect their transactional asset, interestingly the steelwork subcontractor was identified as protecting their quotation by only providing the minimum required and leaving the steelwork tonnage information out of their quotation.

"Generally speaking they will give you the price but the one thing they won't give you is the weight of steel. Because obviously that dictates the design they are adopting and what have you. So you can speculate as to what the weight of steel is. But that's the most crucial piece of evidence is normally withheld on a commercial basis. Understandable as well in the circumstance." Case I

8.3.4.9 Project Environment: Subcontract Specificity, Ex Post Relations, Differentiation by Trade

A number of organisations identified that the relationship that they had with the subcontractor differed with trade, this is illustrated by the quotation below which identified that the organisation develop a quasi integrated approach to the groundworker which was differentiated by the arms length approach taken with the mechanical and electrical contractors. This may assist in the explanation why contractors use more information to procure these prices, as the contractor retains the risk and there is a greater need for ex post negotiation on costs due to changes in design and production conditions

"... the main contractor needs to rely a little bit on the ground worker to help him solve a lot of problems. Its almost become like his own direct labour force. And they never get off the site. ." Case J

8.3.4.10 Project Environment: Subcontract Specificity, Bilateral Dependence

Case I suggested that their organisation was aware of the opportunities that arise due to informational asymmetry and as identified in the section below this is limited to certain trades.

"So we attempt to get a dialogue. If we actually go down exclusive, which sometimes we do, I mean sometime we have limited competition amongst the supply chain. In others instances we go for an exclusive position. And if we go exclusive we normally have a one to one discussion at a high level and say we are going exclusive with you,

we want your best price, will you open up your books you know if necessary because it's a significant job or whatever. And quite a lot of the supply chain are more than happy to do that. ". Case I

8.3.4.11 Project Environment: Subcontract Specificity, Geography

All the cases had an espoused supply chain policy and limited the numbers of subcontractors involved at tender stage. Their policy was national however the interviewees recognised the difficulties in getting a national spread of coverage of a sufficient range of trades as suggested by case I.

> *"Now we've embraced that and we have our sub contractor supply chain. The only difficulty we have being XXX construction is that we are. I'm talking now from the UK side of the business. We operate basically throughout the country but it is very difficult to actually have a central supply chain, which satisfies all the geographical spread. ...." Case I*

The reliance on local knowledge was identified, as being important by case K, despite being a national contractor a presence in the geographically defined market was essential.

> *"...we don't rely on key national sub contractors for all of our jobs. So the regional presence is still very important because you are reliant on your regional sub contractors up to a point. Albeit it may well be that it's the lower end of the market. Therefore it's your 20% of your sub contractor base. But its critical, you see, a lot gets. The 80-20 rule people forget that from a performance point of view some of the critical trades are the traditional ones that you were referring to earlier. So your joinery, your brickwork, your ground worker. They are critical to performance on the job. So just because it's not a high value." Case K*

8.3.4.12 Summary of Subcontract Specificity Factors

Large organisations requested quotations from to lower numbers of subcontractors particularly for more specialised trades. The trade is the main influencing independent variable, as suggested by the general linear model within the quantitative analytical phase of the research. Where the client's procurement route required the organisation to develop an interdependent relationship for product development, contracting organisations limited the number of organisations they use to manage the price risk and submit a

reliable price. This reason for limiting numbers did vary with trade and related to design. Small numbers are also used for ground working trades, it was identified that the reason for this was that an organisation had to develop a relationship that had the attributes of temporal specificity i.e. interdependence due to potential hold up rather than product development. The interesting features that emerged from these case studies was that although groundworkers were identified as being critical to project success they were unlikely to return quotations. Often the main contractor carried the price risk for this trade and the subcontractor price was procured at a very late stage in the estimate development. In most cases, a bill of quantities was produced by the main contractor that was used to price the works and also to manage the post contract phase of the subcontract.

This data validated the model, the organisations that had the lowest specificity were those that had low temporal specificity, low interdependence and had a high codification of price data an example being finishes. The estimator was more competent in the assessment of these prices and displayed a greater incentive to learn. The largest organisations were wedded to using competition to gather data due to the market price variances for the key trades and one suggested that it might use a library pricing system for local subcontractors in the future.

> *"... And I've no doubt based on the 80/20 rule that its not unreasonable to say that we will continue to maybe market test the five or six trades that make up the 80% of the value." Case K*

8.3.4.13 Project Environment: Product Complexity

The product complexity for the cases in this category was cited as having an effect on the estimate structure. The main difficulty that was cited was a lack of transparency with the price. It was suggested that this might lead to an element of information asymmetry that meant that if subcontractors could identify potential opportunities at a later stage due to information release they might refrain from being transparent.

> *"Oh very much so, it can take a lot of time, it can take an awful lot of time. And then it's a series of questions and answers isn't it. And almost drawing it down to a bottom line where you end up with a number of figures that you sort of are reasonably happy with that you can compare...."* Case H

The product complexity also required a team approach by the organisation; a commercial report was produced which was then used by the estimating team to manage the identified risks

> *"..., once the [commercial] risks have been identified its usually down to the estimator or the surveyor in the team or both. Because invariably the size of the jobs I'm working with we don't have just one estimator involved and we find that you know bringing in the commercial side that's going to deliver the project at an early stage, that also give you the continuity that you are looking for. So invariably we'll have an estimator and a surveyor working together closely and they between them will most probably put together the commercial risks that go hand in hand with some of those that are on the risk register. " Case K*

The continuity of team involved at estimate stage and post contract stage was not evidenced for the smaller types of organisation, it was not suggested that this has a direct impact upon the estimate structure however appeared to differentiate the approach for intra organisational knowledge transfer.

8.3.4.14 Project Environment: Bilateral Dependence

The identification of the design development risk was cited as being a major area for estimator's management; this validated the findings from the first phase of the study. It was suggested that bilateral dependence helped mitigate the effect of the risks and that the constraint of time in design development during estimate stage was also a critical factor. This concurred with the findings from the open question analysis from question 22 of the phase one survey.

> *"Well the usual way is to do it [control post contract variations] on a lump sum basis so that the Design Development is all part of the sub contractors package. So any changes he's got to have made some provision within his pricing levels to accommodate that. And in some ways that's no different to the way that we compile our final figure at the end of the day. Design Development is most probably the biggest risk to any contractor on a design contract. And there will always be provision for that. You can try and mitigate it as much as you can in the time that's available. And depending on the length of time that you've had to design the solutions will dictate the size of your contingency" Case K*

8.3.4.15 Task Environment: Price risk veracity

The ability to assess the price risks for the lower technology projects was supported by the interviewees in the cases. A familiarity with outputs was suggested as a core skill of the estimator. This validated the findings from the

first phase of the research, the high use of the market place for the use of the finishes subcontract packages was perceived as surprising by Case H. This was considered to be a result of the questionnaire design, which didn't differentiate between the types of finishes.

> *".. any estimator worth his salt can price it anyway. And he may not be bang up to date with the market trends say for example brickwork but he could be pretty close and finishes I'm surprised really if its traditional finishes. Again we probably wouldn't bother, if it was something special then you would, you would send it out. ." Case H*

The future difficulty in ensuring that production outputs were based on reliable historical data was cited by Case K. It was recognised that as the shift towards more reliance on subcontract labour occurred, that the information that was previously available would be now stored further down the supply chain as suggested by the following quotation.

> *"And the biggest danger than I see in all of that is that whilst we were estimators and we were pricing work traditionally We usually had our own workforce ... The danger is we don't have anybody now. So you are totally reliant on market forces because whatever the sub contractor is prepared to do it for is the level of pricing. It doesn't come down to outputs It doesn't come down to labour rates, craftsman rates, it comes down to how much you can get it done for in the market place" Case K*

The difficulty in the assessment of market rates was also illustrated by the quotation below when considering how an organisation would assess the validity of a price.

> *"No again I mean you start to hopefully get together some cost data and you can say well why, why is this building costing X when six months ago a similar building you priced was only Y? Anyway you get some weak answers and you know its hard work." Case H*

The need to ensure that the price risk was off set to other organisations was identified also as a key role the estimator played. It was suggested as buying protection and the only way to achieve this was to gather price information from the market place

> *. ,"you haven't got a crystal ball, the only way you can do it is to take your key trades and go to the market And from my point of view to give you some comfort and its not a fixed price its just you know an interpretation of some drawings at that stage in time as to what they believe the level of pricing would be. But at least you've got a little bit of buying protection from somebody. " Case K*

The information used by the cases to support decision-making was generally market based and the value of historic information as a source of feedback was questioned by one of the interviewees. He identified that the ex post variations and multitude of factors involved in the construction phase of a project, reduced the value of comparisons of production with prediction.

> *"... its always difficult to capture information. ... It's difficult because there are so many variables. Again on site it's not a like for like comparison. Usually, you can't factor in whether its been poorly managed. You can't factor in whether it was a variation. And the way that we record the information on site is such that they can't differentiate between the work that's come about through a change or something that's been done poorly and then has to be corrected. So a lot of the information is unreliable."* Case K

8.3.4.16 Task Environment: Informational Impactedness

When considering the way an estimator views a quotation, the interviewees identified that when the project was procured using anything other than traditional route, that the estimator's role was more interpretative rather than comparative. Consequently the estimator interrogated each design to assess its comprehensiveness, and used a set of questions to ensure that at the adjudication stage that the price risk was covered. This would have required a comprehensive brief as well as an explicit quotation. The estimators intimated that there would be more of a dialogue and higher level of trust between the organisations. When asked to consider the criteria for assessing a price the following quotation from case H was illuminating. The role here was not one of market testing or pricing but more of interpretation of specification information and assessment of its completeness and acceptability. This was an area that many estimators in the quantitative survey felt uncomfortable with, particularly with the mechanical and electrical workpackage.

> *"I think its comparability but not based on comparing one with the other. I think you need to put together your own set of questions and how they have interpreted the answers.... You need to read the specification or the Design Brief or whatever basic information you've got and almost have a series of tick lists as to, ..." Case H*

The social embeddedness of the transaction was also identified by a number of cases that the relationships between the main contractor and subcontractor were an important contextual factor that influenced how the subcontractor's

price was perceived. It was during the adjudication of the estimate that the estimator would give his view as to confidence in the information provided which would translate into the level of contingency to be included within the contractor's price

> *"... when you come to that discussion and adjudication obviously if you have got very good returns off your sub contractor and you've got confidence that they've given it a really good look over been very thorough then obviously in theory you will continue to see the bottom line is going to be a lot smaller than if you've got a load of quotes off people you are not 100% confident with." Case J*

Case J also identified a concern regarding potential opportunism displayed by the subcontractor due to information asymmetry. The estimator's role would be assessment of the compliance with the project specification, and if there were a misalignment, the risk would be the main contractors. The notion of the subcontractors being opportunistic was weakly supported, the estimators considered that the subcontractors were complying with their organisations systems rather than attempting to conceal prices as suggested by the second quote.

> *"Oh certainly, I certainly think they do, I think one maybe two or three years ago that came to the fore was xxxxxxx where you know a spec would call triple, pedestal, panel units but they would then split out off of the main quote . You know you've got to add all those other bits to it to make it compliant with the spec...it so it could end up costing you a lot of money. "Case J*

This suggested that the estimators' role was more one of identifying the completeness of the quotation rather than the market price to ensure that the subcontractor has included for all aspects of the project. This would suggest an incentive to learn about the technology of a project in order to protect against opportunism that originates from project specification information asymmetry rather than market price asymmetry. This was illustrated by the quotation below.

> *"I think some of the previous company, I was with xxxxxx certainly we done a lot of large industrial warehousing and certainly there say the dock leveller/roller shutter people would maybe go down that route as well. You know price for dock levellers when the client actually wants twin ram systems and they are only pricing on a single ram system unless you read through the quotes in great detail your picking these sorts of items up. I think sometimes they maybe get a bad name because they have made you feel they have done a comprehensive quote and your just, and obviously you know*

the whole of the overall picture a lot better than they do and you are hoping to pick up all those you know little sort of not extras but things that should be in there that aren't in there. I mean a great one always comes down to twin steel and the cladding. Who does all the cladding rails? That's always you know a prime one for falling in the middle you know and a people picks it up. And it always falls down to middle you know and again it can cost a lot of money." Case J

8.3.4.17 Task Environment: Competition

The use of competition to gather reliable and valuable price information was at the core of how the estimators perceived themselves, Case H identified a scepticism with the current trend of partnering in that it added costs and the difficulties in its management and Case I suggested that the lowest price criteria was applied, even to supply chain organisations.

"I can see what's going to happen in the market in the next few years. I think its going to be a swing away from it [partnering]. Because the way to police people is very difficult ...the criticism of the costs that have been incurred on that and how it could have been achieved at a much better price, competitively, and at the end of the day as an estimator you need competition to get the best price" Case H

"I think it is always a risk and certainly and there is always the concern are you getting the cheapest price ... .." Case I

8.3.4.20 Task Environment: Estimators Capability

The task environment of estimating has changed radically in the last fifteen years for organisations of this size; the quotation below suggests that a core skill is now supply chain assessment rather than quantification

"Well they are no longer looking for bill bashers. I mean building quantities are very rare anyway. Procurement routes have changed dramatically and so we've had to change with it ... I tell my lads we are supply chain managers...we are not just estimators." Case K

The interviewee in Case K identified that a key attribute of an estimator was the ability to commit to a price based on incomplete information. This suggested better skills at conceptualisation that the skills developed by surveyors for price management based on quantities

"Estimators have always been, they've always been in a position where they've been able to commit to a price, far sooner than perhaps a surveyor. If you ask a surveyor to

price something because he wants everything you know 95% or 100% of the design so he can capture the quantities so he can put a price against it. …." Case K

This aspect of pricing of organisations was considered in more depth in a follow up question considering the opportunity of the supply chain to provide prices in a library style format. The interviewee considered that this may occur in future. The interviewee, similar to other cases, identified the transactional approach to the collection of data was at the heart of its approach to pricing. This was despite the espoused approach of supply chain management.

"I'd like to think we are going to develop closer relationships with the sub contractors so the supply chain management that we are doing at the moment has been really capturing a lot of information. I don't think its really done what my expectation was. Which was to get closer to sub contractors so that we do get the openness and trust that we are looking for..hopefully they will provide on a library pricing basis. , but there's no doubt that we have developed relationships with quite a number of sub contractors. Certainly the key trades who are prepared to give us information as and when we require it. ." Case K

8.4 Summary of Phase Two Case Studies

The use of an analytic strategy to compare the grounded categories of factors with those that were proposed from the first phase allowed for an explication of the theoretical model. The grounded data however yielded evidence of greater complexity than was considered in the a priori approach of the survey in phase one. The categories of factors affecting the transaction between the construction organisation and its supply chain organisation, which were identified to have an affect upon the structure of the project estimate, were external environment, project environment, task environment and organisational relations. These categories were grounded in the data from the case studies; the Nvivo codes are within appendix 11, and were supported by the analysis of the interview data provided by the respondents.

The external environmental factors were found to relate to the relationship with the clients, market and supply chain relationships and are shown in Table 8.2 below.

External environmental factor	Nvivo node ref
Client requirements	14 6
Organisational capability,	14.2
Competitive advantage	14 3
Supply chain relationship	14 4
Market intensity	14 6
Small numbers- market perception	14 5
Small numbers-availability	14 1
Network effect	14 6

Table 8.2 External environmental factors affecting structure of project estimate derived from case studies

The definitions of these factors were drawn from the analysis data and the literature review as suggested by Glaser and Strauss (1967) and are shown in Table 8.3 below. To further explicate the factors, an example for each factor or an axial dimension drawn fro the coding is given

External environment	Definition	Example
Client requirements	The expectation of information type	Early cost advice
Organisational capability,	Ability to gather resources in order to respond to client requests	High flexible--- low,specific
Competitive advantage	An organisations behaviour to s/c in attempting to gain advantage	Clustered sc, managed------- fragmented, loosely managed
Supply chain relationship	Organisation that has a relationship with a main contractor	Mature---Emergent
Market intensity	Trade competition	High----low
Small numbers- market perception	Number of organisations prepared to bid	High---low
Small numbers-availability	Numbers of subcontractors with capability	Low ---High
Network effect	Effect of subcontract intelligence on pricing behaviour.	Extensive, mature-- fragmented

Table 8.3 Definitions of external environmental factors

The project environmental factors were particularly influenced by the complexity of the projects undertaken by organisations. This complexity was considered to affect the governance structure of the main contractor's use of the market place and had an effect upon the specificity of the subcontract

organisation, which was instantiated by examples suggesting price specificity, technical specificity locational specificity and temporal specificity. The factors are shown in Table 8.4 below.

	Project Environment	Nvivo node ref.
1	Temporal specificity	5 4
2	Bi lateral dependency	5 13
3	Client control	5 11
4	Governance structure	5 2
5	Specificity- Price Organisational capability	5 5
6	Specificity- Technology	5 6
7	Product development	5 8
8	Transaction protection	5 9
9	Subcontract capability	5 10
10	Constraints	5 12
11	Small numbers	5 1

Table 8.4 Project environmental factors

The definitions are also given along with examples of the axial scales that were derived from the interview data analysis using the searching feature of the Nvivo software package. Table 8.5 illustrates the definitions and examples drawn from phase two.

Project Environment	Definition	Example
Temporal specificity	Specificity is defined using Williams terms as the ability to replace a resource, temporal specificity relates to hold up.	Low e.g. Finishes...high e.g. steelwork
Bi lateral dependency	Two way dependence between organisations	High interdepence of mc/sc--------Low interdependence mc/sc
Client control	Mechanism adopted to financially control a contractor	High level of performance ambiguity-----Low levels of performance ambiguity
Governance structure	This is defined using Williamson's terms as the control of organisations supplying a good or service	Tight – Information agreement, high levels of defined process----Loose, lump sum
Specificity- Price	Price that is specific to one organisation	High...Low
Specificity- Technology	Project technological requirements	High, specialised--------Low, Human
Product development	The extent the design required development	Extensive complex...Low simple
Transaction protection	Non-release of information to protect price.	High design...Low price details
Subcontract capability	Subcontractor capability pricing	High-steel...Low groundworker
Constraints	Constraints imposed by client procedures	Time—Tight—Loose, Risk—Defined—Undefined
Small numbers	Numbers returned	High...Low

Table 8.5 Definitions of Project environment factors

The task environment of the estimators was found to be similar across the cases. The estimator's role was to manage price risk to arrive at a single deterministic estimate that could then be used as a basis for tendering. The information complexity that was used to support decision making varied with the context of the organisation however the type of information remained constant. The external environment and project environment factors interacted to have an affect on the task environment and this proved to be the most complex to model. The task environment factors are shown in table 8.6 with the Nvivo node reference.

	Task environment	Nvivo node ref
1	Uncertainty	6 3 1
2	Comparability	6 2
3	Client control systems	6 9
4	Completeness	6 6
5	Estimator capability	6 4
6	Price risk veracity	6 10
7	Knowledge of supply org	6 7
8	Ex ante communication	6 8
9	Documentation	6 11
10	Information impactedness	6 3
11	Motivation to learn	6 1

Table 8.6 Task environmental factors

Table 8.7 illustrates the definitions, and example scales drawn from the interview data in phase two.

Task environment	Description	Example
Uncertainty	Estimators assessment of price	Low uncertainty--- High uncertainty
Comparability	The comparability of prices between different trades	Highly comparable--- low comparability
Client control systems	Methods of controlling uncertainty	Well defined systems for uncertainty------- ---Fuzzy definitions of uncertainty
Completeness	Extent of project information at time of adjudication	High completion(full design)—Low
Estimator capability	Ability to assess technological alternatives	High—Low
Price risk Veracity	Ability to assess the veracity of a quotation	High--low
Knowledge of supply org	Personal knowledge of the subcontractor	Extensive-none
Ex ante communication	Extent of clarification communication	Frequent—none
Documentation	Specificity of price required	Extensive—Low
Information impactedness	The informational bounds imposed on the estimator	Tight—loose
Motivation to learn	The incentives/ absorption capacity of the estimator	Big incentives to learn/high absorptive capacity – low incentive/low absorptive capacity

Table 8.7 Definitions of task environment factors

The organisational relationship factors emerged from phase two as a category that had a strong effect on the data gathered and on the estimate structure. The relative strength of these factors varied with the context of the organisation size, which supported the findings from the first phase of the research. These are shown in Table 8.8 below.

	Organisational relationships	Nvivo Node ref
1	Supply capability	9 4
2	Market making	9 9
3	Opportunism	9 10
4	Trust	9 11
5	Power	9 12
6	Repetition	9 13
7	Propensity to price	9 14

Table 8.8 Organisational relationship factors

The definitions and examples of the axial scales of the factors drawn from the data analysis in phase two are shown below in Table 8.9.

Organisational relationships	Definition	Indicative scale
Supply capability	Availability of resources with known capability	High low
Market making	The economic relationship of main contractor to subcontractor	High reliance—low reliance
Opportunism	Seeking advantage through guile or information asymmetry	High---Low
Trust	Trust to interpret requirements	High—low
Power	Power relationship of main contractor over subcontractor	High... Low
Repetition	Frequency of use of subcontractor	High...Low
Propensity to price	The propensity to return a bona fide price	High—Low

Table 8.9 Definitions of organisational relationship factors

The propositional statement can be restated and the case study data was found to support it; as:-

Organisations take a contingent approach to the structuring of the subcontract components of a project's estimate that is affected by the interrelationship between factors that relate to the project environment and external environment and is also affected by factors that relate to the external environment, the project environment and task environment, which exist in the context of an organisations size.

There is an interaction between the project environment and external environment for complex projects that is related to subcontract tendering costs and results in a network effect that influences a subcontractor's propensity to bid. This interaction was labelled organisational relations and formed a factor category

A matrix structure suggested by Miles and Huberman (1983) as being appropriate when display in data was used to illustrate the comparison of the findings between the two phases of the research is developed in chapter nine. The strengths of the qualitative phase of enriching the positivistic model helped identify four high level processes of seeking, gathering, analysing and communicating. The hierarchical model uses these process headings to illustrate when during the estimating process the factors are likely to affect the structuring of the estimate. The richness of the data collected in phase two allowed for a naming of factors and a dimensionalising that required further empirical work that is considered beyond the scope of this study. Chapter nine explores the effect of these factors in more depth.

CHAPTER 9: MODEL STATEMENT

9.1 Introduction

The aim of this chapter is to discuss how the models that were derived from the first phase and second phase were converged, to suggest how the interrelationship of the identified factors affects how organisations of differing sizes structure their estimates and to provide a discussion of the applicability of the study. The approach used was to consider each category of contingency factor in turn, after identification of the factors that there was agreement and disagreement upon an attempt was made to develop some factor dimensions using the theoretic terms suggested in the literature reviewed in chapters 2 and 3. The naming of the high level categories of factors that was used at the end of chapter six followed the conventions suggested by Lansley (1994) when investigating organisations and were external environment, project environment and task environment. A matrix structure suggested by Miles and Huberman (1983) was used to illustrate how the qualitative data collected and analysed in phase two augmented the quantitative data analysis from the first phase. The chapter concludes by suggesting a revised model.

9.2 External Environment

The variables used to measure the respondent's external environment in phase one of the research were related to the organisational characteristics such as organisational size, procurement environment, business sector of client as categorised by the DTI and the tendering procedures used by the respondent's employer's clients. The data analysis did not identify that organisations were differentiated by business sector however it did indicate that smaller organisations carried out a higher proportion of their work using drawings and specifications and that their work was secured mainly through competition. The measuring instrument did not gather information on the type of client and the extent of repeat business and this was considered a shortcoming of its design. The categorisation of organisation by turnover was used as a proxy for project complexity and support for this latent variable was demonstrated by the

approach taken to risk management, the supply chain and the type of strategic linkages the larger organisations had within their external environment.

The data gathered in phase two was gathered using a themed semi structured interview, this style of data gathering was more naturalistic than that employed in phase one and the advantages were that lines of enquiry could be followed up and developed. This lead to awareness that there was greater complexity that had not been considered during the first phase data collection and that couldn't be tested using the statistical measures adopted. This was a strength of the mixed method approach. The naturalistic approach to data gathering through semi-structured interviews however was not strong when attempting to gather data for particular categories. The difficulty of gathering data through interviews was identified in chapter 7 due to the unreflective use of normative terms by the informants and that the conversational nature of an interview constrained attempts to gather deterministic data.

9.2.1 Supply chain relationships

The qualitative data suggested that clients procurement systems were having an impact upon the organisations approach to the gathering of price data by requiring supply chain management approaches to be demonstrated. This was a differentiating factor when comparing the external environment for smaller organisations and those organisations whose turnover exceeded £99m. The imperative for seeking relationships with smaller numbers of subcontract organisations in the contractor's environment was to ensure a mitigation of price risk. The smaller organisations used a smaller number of subcontractors to gather price data, this was found generally from phase one of the research and they tended to maintain close social style relations with them, the medium sized organisations identified that the nature of their environment was such that they required to provide their clients with the lowest possible price. They consequently used the market extensively to gather price data. This finding of a differentiation in the market environment between medium and small and medium and large organisations was validated by the case study data.

Another underlying factor that was uncovered by the qualitative phase was that organisations differentiated their approach to linkages with small numbers of subcontractors for mechanical and electrical works and steelwork when compared with the other trades. The reason for this was to counter a market perception of the main contractor as a bid shopper. This was particularly in evidence for medium sized and large organisations that undertook more complex projects and required the subcontractor to carry out design work. The subcontract market place was different for the mechanical and electrical trade than the steelwork trade in two aspects, respondents identified that the suppliers of components acted as knowledge brokers for the mechanical and electrical subcontractors informing them of the extent of competition within their market. This was not suggested as being a factor for the steelwork subcontractors, who were more isolated and it was suggested would be more responsive to providing a bid. The market intensity was also a factor that influenced the propensity of specialist organisations to provide prices, some cases were market makers for particular trades and consequently used their power judiciously, in one case the geographic position of the contracting organisation created external environmental conditions that encouraged an intensive use of the market.

The difficulty faced in modelling the factors was that there was a complex interrelationship between the factors that lead to contexts and processes that were not capable of being generalised outside of the organisational context. An example of such complexity was identified by case G when considering price risk of a low quotation, a knowledge of the market place, the technology used by the subcontractor, the informal communication process undertaken, the value of the package, the decisions taken on price risk for other aspects of the estimate and the procurement process generally were identified as interrelating factors that influenced the task environment. An attempt at modelling these was taken however were too complex to display, the study delimits these, as the methodology adopted did not support the depth of analysis required to uncover these interrelationships. A grounded indirect phenomological approach was considered to be more appropriate for this as suggested by Eaton and Akbryikli (2005) when assessing risk.

9.3 Project Environment

The factors that were identified from phase one of the research related to risk perception and how it varied between respondents working for organisations of different sizes, the general linear model identified that organisations did differentiate by trade and that procurement was an external variable when considering the mechanical and electrical subcontractors and particularly for the design and build procurement route. The literature on organisational economics identifies this as this asset specificity and phase one attempted to investigate whether espoused subcontract partnering had an effect on send out behaviour.

9.3.1 Product development

The procurement route of design and build was identified in chapter two as forming a larger proportion of the market environment than in the last two decades. This procurement route does not have a recognised explicit structure for the estimate and is unlike the traditional procurement route, which prescribes the common arrangement of work sections and quantified works. The design and build route was used significantly more by clients who employed organisations whose turnover exceeded £99m. The risk perception of estimators working for organisations of this size was significantly higher for risks categorised as design development, design completeness and design complexity and programme than medium sized and small organisations. The design and build procurement route required an element of design development between contractor and subcontractor in order to provide a competitive price, the results from phase one of the research, indicated that competition was used for almost all trades for complete packages of design. The only trade indicated as an exception was the mechanical and electrical subcontract package, the data collected during phase two of the research validated this finding and suggested that the reason for this was due to guarantees required by the market place regarding the placement of contracts. It was identified that the small numbers of subcontractors with the capability to undertake complex design and build projects combined with the costs of

tendering has created conditions whereby the subcontractor can influence their project specificity, this is a particular feature for organisation whose turnover exceeded £99m.

9.3.2 Subcontract specificity

The source of asset specificity was suggested in the literature review as relating to human (specific skills), locational aspects (in a particular geographic area) or temporal attributes (relating to hold up problems). The data gathering in phase one of the research sought to identify if there was a correlation between the existence and length of time of a strategy for closer links with the supply chain and the extent of usage of the market place. The results from chapter 6 indicated that supply chain strategy had no effect upon organisational behaviour towards the market. This was found to be too simplistic a finding when considering the data gathered in phase two. Contractors with a turnover exceeding £99m were found to maintain strategic links with a limited number of national subcontractors, the smaller contractors were found to have more social linkages with local contractors. The cases which were differentiated from these were the medium sized organisations that used competition extensively, however all organisations recognised the benefits of developing a dialog during the estimating process. This dialog is also referred to within the task environment section of this chapter.

The results from phase one suggested that the estimator was central to the decision upon which subcontractor to include within an estimate. This finding was validated by the second phase. As organisations became larger, the decision became more of a team decision, again this confirmed the findings from phase one. The estimator communicated the structure of the estimate to the adjudication team, this team took informed decisions regarding overheads and margin and one case study indicated that the size of the design contingency was influenced by the design completeness and the "confidence" that the subcontractor's designs had included necessary items. The estimator's role consequently was bid 'interrogation' for those elements that contained a large element of design. This is returned to in section 9.4 that considers the estimators skills in this area.

9.3.3 Subcontract specificity: Price

Few organisations indicated that they felt that the strategy for developing closer links with the supply chain that had been developed had yielded economic benefits. This was found when considering the price variability from subcontractors in the first phase. This was a difficult area to develop comparable measures for and was outside the scope of this study. One organisation in the case studies indicated that they would expect a subcontract organisation to include a premium on prices for other contractors, if they were in a bilateral agreement, however agreed that there was little opportunity to verify if this occurred in practice. Phase two indicated that almost all organisations would consider an unsolicited quotation in order to enhance the competitiveness of their estimate, however the decision would be a tendering decision and taken by the adjudication committee. The extent of risk in this practice was recognised and this was given as the reason why a senior person within the organisation would take the decision. The benefits of frequency and inter organisational learning were identified in the literature as being difficult to quantify. There was evidence that estimators "had more confidence" in quotations from sources they knew and they were less likely to include a high contingency for design completeness. Although not possible to directly quantify with the methods adopted for this study they suggested that the benefits of partnering are more likely for design and build projects than traditionally procured ones.

9.3.4 Subcontract specificity: Temporal

Temporal specificity refers to the effect of hold up on asset specificity and was discussed in chapter 3 of this thesis. One of the unexplained findings from phase one of this study was the comparatively high use of the market for finishes prices during the estimating process. This was followed up in phase two and a number of the case studies indicated that subcontractors that were considered to be late in the programme would have a very low specificity. The reasons for this were given as changes to the original tendering specification, programme or pressures on the budget. Consequently, the likelihood of placing

a subcontract with a tendering subcontractor for these trades was low; landscaping contracting was cited as a specific example. The reasons suggested for this high use of the market place are that in order to offset price risk, a contractor requires a finishes price, however as the organisations bidding in the finishes market place were likely to appreciate their low specificity they may decline to return a bona fide price. The measuring instrument in phase one didn't gather information on this, or were subcontractors interviewed during the second phase, both of which can be considered as limitations to this study.

9.4 Task Environment

The task environment was examined to determine the factors that influence the estimator when selecting a subcontract price for inclusion within an estimate and also the extent of communication that was undertaken during the estimate development phase. Phase one of the study, reported in section 6.9.5, identified that the estimator was more likely to be the final decision maker in smaller organisations than in larger organisations. The estimator working for a large organisation tended to be a key decision maker, which reflected the team role that the estimator took in these organisations. The case studies confirmed this categorisation, however the role in the large organisation involved communication to an adjudication group and the case study data indicated that this was influential in the decision-making that was taken during adjudication. This was not identified from the first phase of the research and indicated the methodological benefits of taking a mixed approach to data collection

The results reported in section 6.9.1 identified that of the seven factors identified by the measuring instrument in phase one that the estimators market knowledge was the most significant when selecting a subcontract quotation for use in an estimate. The factors of contract compliance and price variability were also identified as significant factors. This indicated that the use of competition to gather data was central to the estimating function and that the estimator required skills in assessment of the market place and assessment of the quotation. The ex post factors of governance of price variation and claims governance were of the least importance. This was also identified in phase two

of the study as being a feature of current estimating practice. A number of estimators working for the medium and small organisations indicated that their role was to win work, the achievement of profitability was considered to be unimportant as a different group with a different culture carried it out. This aspect of organisational culture difference is considered later in this chapter. The selection of subcontractors that could adequately perform was an important feature identified by decision makers in phase one, phase two confirmed that this was a factor however suggested that the screening and selection of the bidding subcontractors had already been carried out by others (buyers and supply network managers). Knowledge of the subcontractors approach was a relatively low scoring factor, which would suggest that each price was considered in its own right and that estimator's personal preference was not a factor. It was also implied that the frequency of bid did not influence the selection of the subcontractor.

The assessment of subcontract price information was a central feature and whilst the estimator's knowledge of the subcontractor was not identified as the influential factor when selecting a price for inclusion within an estimate, it was an important contextual communication when considering the price information received. An analysis of the factors that influenced the estimator's ability to assess the received price information indicated that those that related to information comparability were highest such as comparative price information and the quality of information provided with the quote. This suggested that the estimator's frame of reference when deciding upon the price veracity was within a project context and that there was little internal organisational information to assess whether the prices received were valid. It is suggested that estimators use other quotations to triangulate to arrive at the most appropriate price and that their judgement was based on comparators rather than inherent pricing knowledge. The variance of the comparator was identified as being an area that caused difficulty. The central problem in this aspect of assessment of price was found that the key trades such as steelwork and mechanical and electrical were found to have high levels of price variability and there were correspondingly low levels of ability to assess the prices received. The ability to assess the compliance of the quotation with the contract due to poor quality of information provided with low levels of codification was an important factor in

phase one that was validated by phase two. This was differentiated by trade and is discussed in more detail below.

The factor analysis from phase one that suggested that there were two high level factors called technical knowledge and information impactedness and were considered to be validated by the data collected and analysed in phase two. Technical knowledge which had components of lack of company in-house expertise, lack of communication with subcontractor and time since reviewing a similar quotation loaded on to it, and information impactedness which had components of comparative price information, price variation and quality of information with quotation loaded in order of importance.

The informational impactedness was developed in phase one using a series of factor analyses to identify how the trade would influence the quality and format of the price information, the ability of the estimator to assess the received information for contract compliance and the ability of the estimator to assess whether the subcontractor was being opportunistic in suggesting price savings due to specification changes. The aim of this data gathering and analysis was to investigate the compliance with industry protocols and to assess the extent of bilateral dependence that occurred through information exchange. When considering the ability of estimators to assess subcontract market prices, two high level orthogonal factors emerged from the data analysis in phase one these were non-quantifiable price veracity and quantifiable price veracity. The non-quantifiable price veracity, which included the mechanical and electrical prices, steel frame and roofing and cladding which were all trades that were found to give little price breakdowns and tended to communicate lump sums.

The other factor was labelled quantifiable price veracity and the subcontract components that loaded onto this from phase one were brickwork and finishes, groundworks was slightly lower and floor finishes the lowest. These trades either gave full detailed quantities with their quotations or were perceived as trades that the estimator had little difficulty in price assessment. A number of the larger organisations identified these as low risk due to estimator's knowledge and also temporal specificity and larger numbers within the market place were other factors indicated. The case study data in phase two validated

both these factors and indicated that subcontractors protected their designs in order to stop them being appropriated and used by the main contractor. This transaction protection may also be a feature of the quantity and quality of price information provided. A number of cases suggested that they would have little requirement to capture this information at a resource level due to the difficulties in its interpretation however the larger organisations had developed the capability to capture and analyse the data to provide early cost advice to clients. This capability was embodied in a new function called supply chain manager or category manager.

When considering the estimators ability to assess the specification alternatives from the different trades, two orthogonal factors called non comparable and comparable transparent were identified. The mechanical and electrical trade loaded highest on the opaque factor possibly indicating difficulty in gathering meaningful price information and the difficulty in its assessment. The factors were confirmed as being appropriate by the case studies however the effect of specification price opacity was differentiated by organisations of differing sizes. The organisations that were in the category £25-49m identified that they felt that their subcontractors would not act opportunistically by trying to maximise returns however the larger organisations indicated that the subcontractors they used were particularly commercial and that they employed consultants or in house resources to provide a check. This indicated different approaches to subcontractors, which may relate to project complexity. It also suggested that there was an extent of bilateral strategic dependence of the smaller sized contractors with there high technology subcontractors that was not in place for the larger contractors or the mid range contractors. This interesting emerging contextual area would form a useful further study.

When considering the factor analysis of the performance of the specification, a similar pattern was found; opaque performance assessment and transparent performance assessment were identified as high-level factors. This suggested that the competitiveness of the main contractors tender was dependent on incentivising the subcontractor to forgo organisational opportunism (which would increase the bid price) and to look to develop the optimum design price. This interaction of subcontract specificity factors and procurement product

development factors was found by the case studies to occur mainly for the large organisations. This interaction explained the finding of the high level of project specificity for the mechanical and electrical contractor found in phase one. These subcontractors required a guarantee that they would be awarded the contract if it were eventually won. A similar interaction was expected for the steelwork subcontractors however it was identified that the costs of design of this element were low in comparison, consequently contractors used competition to gather price data. The ability of subcontractors to influence their project specificity was not found in any other instance.

9.4.1 Decision Support Systems

The data gathered in phase one identified that the estimating IT systems were very good at supporting the traditional function of unit rate pricing, retrieval of information from past estimates and subcontract rate analysis. This concurred with the results of previous surveys investigating estimating software. The case studies also identified that quantifying and pricing low technology work was reasonably straightforward and that the estimator had a reasonable knowledge of the unit rates to apply. The earlier work reported in the literature review by Green (1989) that suggested that estimators worked in a quasi-closed environment were not replicated by the results from phase one. The estimator's task environment had feedback from project performance, in the form of the cost value reconciliation data, buying reports and cost reports, all of which were considered to be influential to their decision-making. The case study data suggested that the feedback was of low quality and subject to bias. The main area of difficulty the estimator had was in the use of data from past projects as comparators due to the technological and market variances in projects. The low extent of pricing using in house labour was reflected by the low usage of bonus records. The case study data supported this and extended the analysis to suggest that whilst the information was available it had little impact upon the decision. This dichotomy was difficult to explain, it may relate to the overriding need by the estimator to provide "market cover" or "buying protection" irrespective as to where it came from.

The involvement of the estimator in providing early cost advice to clients was highlighted by the larger organisations as a developing role. The two-stage design and build tender procurement approach was identified as the principal driver for this. Few organisations (26%) rated their design cost planning systems as very good or excellent and this emerged during the case study interviews as an area of low organisational capability. The larger organisations relied upon strategic links with selected subcontract organisations to provide early cost advice based on sketch designs, they indicated that their clients required guaranteed maximum prices based upon these supply chain prices. This would suggest that early design cost advice is being given by subcontracting organisations and may influence their specificity. An assessment of the subcontractor's capability and approach were considered to be outside the scope of this study however as the drive for early involvement of the supply chain in projects, the ability to cost plan designs may become a source of strategic competitive advantage for subcontractors.

9.5 Convergence of the Models

The aim of the two-phase methodological approach was to identify the factors that affect the structure of the estimate and these are suggested at the end of the chapter. A detailed examination of the effect of the factors is outside the scope of this chapter however the quality of the data collected in phase two and the use of a matrix allowed for the effects to be tentatively modelled. Silverman (1997) suggests that qualitative data analysis should only be used to assess what is within the data, however Denzin and Lincoln (2003) suggest that this robs the paradigm of its interpretative strength. The approach taken by this study has been predominantly empirical; consequently the factor effects are based on interpretation by the researcher by reading between the lines of the narratives and by reflecting upon the literature reviewed during the earlier phases. The approach to converge the case studies and the first phase was to use a factor framework categorised by the high level factors. Miles and Huberman (1983) suggested the use of a matrix was an appropriate means of comparison.

9.5.1 External Environment

The data implies that organisations have an optimum project size range that is correlated with turnover. The smaller organisations with low overheads also have limited capability to undertake the larger projects, this capability relates to access to clients, funding and subcontractors. The relationships that the contracting organisations had with its subcontractors were differentiated by the size of the organisation and the subcontracting trade. Some organisations were considered as market makers for groundworkers. An investigation into the social and economic linkages that exist between contracting organisations and their subcontractors was outside the scope of this study but would provide a rich environment to provide much needed light on the structure of the construction industry. There was little evidence of these types of linkages for the larger organisations, as one estimator commented when considering groundworkers "*..but they never seem to last, that's the strange thing about them, they never seem to last..*" The availability of particular trades, entry and exit barriers and the churn of subcontractor by main contractors were areas that emerged from the data analysis in phase two. There were few reported empirical studies found that considered the structure of the industry and empirical work in this area would provide extremely valuable contextual information for researchers. The work by Williamson (1981) identified that small numbers would have an effect upon the governance structures adopted by contractors. This could be refined in the context of the external environment of construction to reflect the propensity to provide a price.

The small numbers provided an impetus for partnering as did the market intensity found particularly in urban areas where high demand was exhibited. The data collected in phase one was assessed for geographical effect however none was found. The case study data did however suggest that it did, case study E dominated a market and used its power to maintain a commercial price based environment with its subcontractors. Case study F of a similar size was in a more urban environment and had different relationships with its subcontractors. The effect of these contextual factors upon the explicit structure of the estimate were considered to be negligible however the implicit structure of the estimate which included the provenance of the figures, the extent of

competition that existed to gather the price data and the potential specificity of the subcontractor are likely to be significantly affected.

Table 9.1 summarises the external environment variables for each of the cases and places them into high level process categories of seeking, gathering, analysing and communicating present within phase one and phase two of the study.

	Procurement	Organisational capability	Market intensity	Small number	Client relationship	Competition	Supply chain relationship	Small numbers market	Small numbers availability	Network effect
Quantitative model	P	P		P		P	P			
Case study A	S	A	P	S	P	S	G	S		
Case study B	A	A	P			A	G	S		
Case study C	P	P	P	P		A	G	P	P	
Case study D	P	P	P	S		A	A	S	G	
Case study E	P					A				G
Case study F	P					A		P		
Case study G	P				S	G				
Case study H	S			S	S	A	A	G	G	G
Case study I	S	P		S	P	A	G	G	G	G
Case study J	S			S	S	A	G	G	G	G
Case study K		P			P					

S -Seeking P - Present A-Analysing

G- Gathering C-Communicating

Table 9.1 Cross case analysis and comparison of phase one and phase two results for external environment factors

9.5.2 Project environment

The project is undertaken within an external environment, which will influence such factors as the specificity of the subcontractor. Where there are high levels

of specificity it would be expected that there would be a corresponding high level of performance. The small number factor considered in the first phase was enriched to include the small numbers available to provide a price, and also the small numbers prepared to provide a price. The network effect influenced how these two factors interrelated. The price data exchanged between the main contractor and subcontractor was influenced by the procurement environment, when the project was procured using the traditional form the quantified work sections were sent out and returned, when design and build was used mainly lump sum prices were returned. The exception to this was the groundworks trades, which were quantified and sent to subcontractors, the difficulty expressed by the small cases studies was getting prices from these trades. The inference was drawn from the study that the estimators role of structuring work sections by quantifying them added value to the estimating process by reducing uncertainty, this was found for low technology work packages such as groundworks and drainage, finishes and painting. The ex post implications of this quantification is that a detailed framework for assessment of variations and misalignments was available. In contrast the higher technology work packages were more opaque, the estimator was not involved in information generation and the details available for ex post control were minimal. The study found that an alignment between subcontractor and contractor occurred, referred to as "back to back". The implications for this were that the responsibility for costs control of misalignment was transferred to the client. The financial control of any misalignment that occurred between main contractor and subcontractor was based upon information exchange ex ante. The quality and quantity of this information were found to be limited and differentiated by trade. The use of industry wide protocols for information exchange was not found to be supported, a standard form of measurement, coding systems and concordance with recognised good practice was found to be limited.

The ex post relationship between the subcontractors and main contractor was also a factor uncovered, this was not explicitly referred to by all the case studies however a number referred to a quasi integration of groundworkers into the project team. The groundwork trade and labour only subcontractors were used more flexibly than other trade contractors and the information for ex post

control was more extensive. The existence of a causal link was inferred but not strong.

Table 9.2 identifies the project environment contingency factors within the case studies categorised by high-level process of seeking, gathering, analysing and communicating present within phase one and phase two of the research.

	Temporal specificity	Bilateral dependency	Client requirement	Governance	Price specificity	Technology Specificity	Product development	Transaction protection	Subcontract capability	Small numbers	Constraints
Quantitative model		P		P		P	P				
Case study A	P	P		P						S	
Case study B		S		S		P				S	P
Case study C			P							S	
Case study D	S			P	G	P			P	S	P
Case study E				C		G	P		P		
Case study F	A	A				G	A		P	P	P
Case study G	P	G				G	C	A	A		
Case study H	P	G	S	C	S	G	A		C		P
Case study I	P	G	P		S	G	C	A	C		P
Case study J	A	C	S	P	S	G	C		P		
Case study K											

S -Seeking G- Gathering P - Present C-Communicating A-Analysing

Table 9.2 Cross case analysis and comparison of phase one and phase two results for project environment factors.

9.5.3 Task environment

The informational environment of the estimator was found to be greatly affected by the project procurement context. Phase one of the study identified that the

quality of information provided by clients and their representatives had reduced over the last ten years. The study identified that a key task was one of interpretation of project requirements, communication to subcontract and then analysis and communication of the returned price data. Almost all organisations in the case studies identified that the ability to assess price was poor and that comparable prices were required in order to validate the subcontract price. This required that a transactional approach using competition was required. The informational basis for this competition varied as suggested in the previous section and related to the procurement approach and the information returned by the subcontractor. The phase one data analysis which identified that the ex post use of this data to financially control the subcontractors was of little interest to the estimator was validated by the case study. This suggested that the feedback regarding performance was limited and Bindslev's (1995) aspiration to have informational models that developed standards for monitoring and control is not met.

The motivation to learn was a factor that emerged from phase two of the study that was not considered in the first phase. Estimators showed little propensity to address their low abilities to assess market prices, technology prices and technology performance standards. The case study data identified that the organisations size was an independent variable and that the job function, organisational alignment, reliance on the market and constraints of time were contributing factors that affected this propensity to learn. Boisot's (1995) suggestion of information diffusion could consequently be extended to differentiate the trades, the case studies identified that a high level of codification was used for low technology and low price trades that was easily diffused within the organisation however the higher level trades such as steelwork and mechanical and electrical low levels of codification occurred (possibly due to the performance nature of these trades) and consequently low levels of diffusion took place. The model could be developed to consider the absorption capacity of the estimator for the different trades and how organisational size influenced this however this was considered to be outside the scope of this study.

Table 9.3 summarises the task environment contingency factors for the cases categorised by high level process present within phase one and phase two of this study.

	Org Capability	Comparability	Price risk veracity	Governance	Completeness	Estimator capability	Price risk	Know. Of S/C	Ex ante comm.	Documentation	Information impactness	Motivation to learn
Quantitative model	P	P	P	P	P	P	P	P		P	P	
Case study A	P	S	S			A		A	P			
Case study B	G					A		A	P		P	
Case study C	G	A	A	S		P		A		P	P	S
Case study D				S	A		A	A		P		S
Case study E	G	A					A	P	P		P	S
Case study F		A		S	P		P	P		P		
Case study G		S	A		A	A	A		G	P	P	S
Case study H	P	C	A	S	A	C	A	P	G	P	P	S
Case study I	C	C	A	S	A	P	A	P	G	P	P	S
Case study J	C	A	A	S	A	C	C			P	P	
Case study K		P	C		C	C			C			C

S -Seeking P - Present A-Analysing

G- Gathering C-Communicating

Table 9.3 Cross case analysis and comparison of phase one and phase two results for task environment factors

9.5.4 Organisational relations

Phase one of the study gathered and analysed information on the use of the market for the different trades and the effect of a subcontract strategy upon the benefits to the estimator. The results indicated in section 9.2 and 9.4 above indicated that there was an interaction, however a category induced from the case study data suggested that organisational relations were a key contextual component affecting the estimate structure. The method for data collection in

the second phase used a semi structured interview technique that was necessarily focused upon the propositional statements, however the data collected supported this category of factors. The factors are not supported by saturated codes from the grounded data. They are presented as influencing variables and their effects upon the estimate structure require further study. Figure 9.4 identifies the cases and organisational relations identified within the study, which emerged during, phase two of the research.

Table 9.4 Cross case analysis and comparison of phase one and phase two results for organisational relations

	S/C Capability	Market making	Opportunism	Trust	Power	Repetition	Propensity to price
Quantitative model							
Case study A	P		P	A		S	P
Case study B	G		P	A		S	
Case study C	G		P	A		S	
Case study D	P	G	P				S
Case study E	S	G					
Case study F	S		G		P		
Case study G	P				P	P	
Case study H			P		P	S	S
Case study I			P	P			S
Case study J							S
Case study K				P			

S -Seeking	**P - Present**	**A-Analysing**
G- Gathering	**C-Communicating**	

A summary of the categories of factors is identified in Figure 9.1. They are categorised by high level processes as well as the level they were found at.

The levels used were Moore's (2002) taxonomy of environmental level of macro, meso and micro.

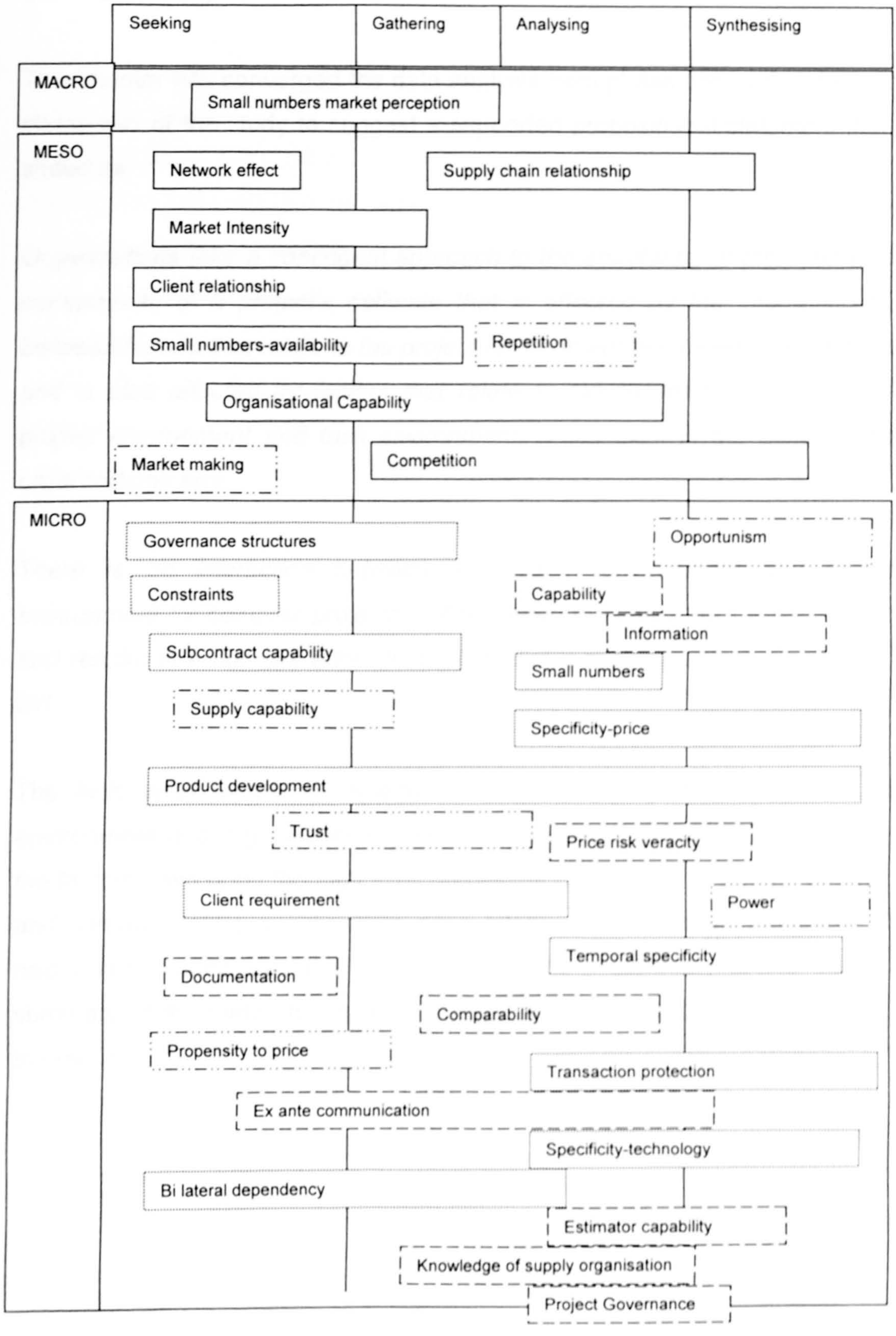


Figure 9.1 Factor model differentiated by process and level

9.6 Summary

This chapter has converged the data analysis from phase one of the study and phase two of the study to suggest a supported propositional statement that is stated as:

Organisations take a contingent approach to the structuring of the subcontract components of a project's estimate that is affected by the interrelationship between factors that relate to the project environment and external environment and is also affected by factors that relate to the external environment, the project environment and task environment, which exist in the context of an organisations size.

There is an interaction between the project environment and external environment for complex projects that is related to subcontract tendering costs and results in a network effect that influences a subcontractor's propensity to bid.

The high level factors of external environment, project environment, task environment and organisational relations have been discussed and the effect the factors have upon the high level processes of seeking, gathering, analysing and communicating supply chain price information has been modelled. The next chapter concludes the study by providing a summary of the thesis, a summary of the methodology and findings, and discusses the triangulation of the results.

CHAPTER 10: SUMMARY AND CONCLUSIONS

10.1 Introduction

The overall aim of this thesis was to contribute to the theoretical development and understanding of the factors that influence the formation of construction project organisation teams. To achieve this aim the research examined contractors' organisational behaviour during the estimating process, in seeking, gathering and analysing price data from its supply chain. It was suggested that the factors would have an effect on the contingent structure of the estimate, and would be grounded in the environmental context of the organisation. These contexts were suggested to relate to the external environment, project environment, task environment, and organisational relations. This chapter concludes the thesis by recapping on the thesis structure and the research questions, and identifies the contribution to knowledge and limitations of the approach taken. It summarises by identifying a future research agenda.

Chapter one of this thesis outlined the broad field of study of construction procurement, and how the changing structure of the UK construction industry had brought about conditions in the external environment of contracting organisation that required modification of behaviour when responding to requests from their clients for prices. Chapter two and chapter three aimed to build the theoretical foundations of the research, by reviewing the extant literature in construction management. The review encompassed construction procurement, and identified that the procurement routes used by clients had changed from a sequential design bid build approach to a more integrated approach of design and bid, then build. Chapter two also identified a number of strategic initiatives that had been taken by the UK government over a ten year period, to develop a more integrated means of developing and delivering construction projects, by involving the supplying subcontracting organisations earlier in projects. The normative communication protocols suggested by Bindslev (1995) and Karlen (1995) were reviewed, to provide a background to the approaches available to the gathering and synthesis of supply chain price information into an estimate. The final review in chapter two considered the existing academic research on construction estimating, and concluded that little

empirical work had been undertaken to identify the factors that affected how contractors structured their estimates that considered the supply chain. Chapter two concluded with a framework for the investigation that integrated construction procurement and estimating processes. Chapter three placed the research into the context of the parent theoretical discipline of transaction economics and reviewed work by Williamson (1981; 1996), Dow (1994; 1987), Dietrich (1994) and Hodgson (1993), which provided an economic theoretical grounding to the work. This chapter identified that organisations adopt governance approaches to their resources that are influenced by the context of the business, the transaction costs of integrating resources within the firm and the informational uncertainty that existed between organisations. A central aspect of the work of Williamson (1981) related to asset specificity of the supplying organisation to the buying organisation that restated the earlier work of Coase (1937), which was that the transaction should be the central unit of analysis in organisational economics. The theoretical transaction economics work, in a construction context, of Winch (1989; 2001), Reve & Levitt (1984), Turner and Simister (2001), Turner (2004) and Chang and Ive (2002) were used to assist in the operationalisation of the constructs of asset specificity, informational impactedness, and how organisational price exchange may be influenced by ex ante processes. The conclusion of chapter three was that there was a gap in current understanding of the construction estimating process, and that this gap was due to the lack of a theoretical underpinning in construction transaction economics and the adoption of limited empirical methods. Chapter three concluded by identifying a set of indicative hypotheses that aimed to guide the work.

Chapter four justified the research strategy used to collect the data in order to answer the hypotheses. It commenced with a review of the current epistemological positions in construction management research, and considered the strengths and weaknesses of the positivist and phenomological paradigms, and used this as a basis for the selection of the methodology. The chapter suggested that the adoption of a mixed method approach was appropriate for the research question. The unit of analysis was the organisations behaviour in seeking, gathering, analysing and synthesising supply chain price data into an estimate, that was then used as a basis for

tendering, and the chapter concluded by identifying that the philosophical paradigm was post positivistic and the dominant method for collection of data for the study was quantitative. The rationale for this essentially positivist approach was due to the limitation of data available to aid the identification of a representative case for study. The chapter concluded by identifying that a survey method would be the optimum means of collecting data for phase one and would provide an empirical framework that required validation and explication via methodological and data triangulation.

Chapter five considered the design and development of a measuring instrument that was adapted and extended measures used previously and the development of new measures based upon the operationalised constructs from the literature review. The identification, description and measurement of independent and dependent variables was an important aspect of this chapter and was used to measure the hypothesised relationships between the organisational, procurement, trade and task environment variables. The procedures for piloting and administration of the measuring instrument to ensure the measures had internal and external validity were identified. The distribution of the questionnaire to the 760 estimators who made up the population sample was discussed, and the effectiveness of the follow up procedures in obtaining a 41% return rate was also considered. Chapter five concluded by discussing the data analysis techniques available and justified the use of a factor analysis approach, the discussion necessarily covered Bartlett's tests of sphericity, treatment of data and methods of rotation. Chapter five concluded that a general linear model with a 3 x 6 factorial design was appropriate to apply to organisational data for three procurement conditions and six trades. It also suggested that non-parametric procedures should be used to validate parametric models when applied to data that may be non-parametric.

Chapter six reported on the results of the first phase of the study. The results were organised to commence with an analysis of the demographics of the populations, from which the data had been collected, and provided data on organisational and personal data. This concluded that the data were drawn from a sample that could be considered to be 'representative' of the UK's

construction industry estimators, who were authoritative and had a good knowledge of their organisations procedures and processes. The analysis identified that the resources available to gather and analyse data in order to provide an estimate were differentiated by organisational size. The risk perceptions also varied with large organisations, more concerned with design development, design completeness, and price risk inflation, than the smaller organisations. The analysis of the supply chain data indicated that organisations used different governance approaches that were affected by the procurement route generally, and that the trade variable was significant for large organisations. Chapter six considered the task environment of the estimator, and concluded that informational impactedness upon the estimator's judgement could be considered to be present. The chapter concluded by identifying a model of contingency factors that affect the estimate structure. The model required validation, and as suggested in chapter four, methodological and data triangulation using a case study approach was considered appropriate.

Chapter seven discussed the second phase procedures for explication of the model. This was a multi case study method that investigated and refined a series of propositional statements. The selection of the cases, the case study protocols, and the analytic strategy were considered. The procedures used for the data collection and the development of questions that explored theoretical propositions were considered. The procedures for coding the data and the use of a computer aided qualitative data analysis package were also justified. The chapter concluded by suggesting a procedure for testing and identifying limitations.

Chapter eight commenced with a discussion on how multiple cases can be used for theory development, and then reported upon the case study data analysis in the four categories of cases selected. In order for clarity and brevity concerning the qualitative data generated, selective use of quotations was used to illustrate support for the propositions. The approach to the reporting of the case study analysis was necessarily lengthy as it reported rich case study data. The chapter concluded by an explication and extension of the phase one model that formed the basis for the discussion in chapter nine.

Chapter nine converged the two phases of data collection and analysis to form a generalisable model of factors affecting the structure of contractors' economic organisation of projects. The approach adopted was a matrix approach, and it sought to extend the model to consider the effects the factors may have.

10.2 Conclusions: Research question

The central research proposition to this study was, that organisations, when responding to price risks within their environment, develop a contingent approach to the collection and structuring of their project economic information that is influenced by identifiable and measurable factors. This was developed after reviewing the literature in chapters two and chapter three and was expressed by a series of indicative hypotheses, which addressed specific issues of external environmental variables relating to procurement and supply chain technologies, inter organisational relations and the task environment of the estimator. The operationalisation of these variables and the dependent variables was developed through the review of the extant literature in construction.

The primary hypothesis that related to the external environment was that:

Organisations will exhibit different behaviour towards the supply chain for different procurement routes and supply chain technology will have a significant effect.

Supporting this primary hypothesis were two hypotheses relating to the task environment of the estimator. These were that;

A statistically significant correlation was expected between supply chain technology and estimators ability to assess market price, technology price and influence of technological change on price.

If the estimators informational environment were similar for organisations of differing sizes that similar sized samples would be drawn and combined to form

one sample. This would support the development of primary factors as the first step to the production of a general model of informational environment. Statistically significant and positive correlations were expected amongst these primary factors.

The estimating literature reviewed in chapter three did not consider any differentiation when considering different procurement routes and the supply chain. This criticism should be placed in context, as most empirical work in this field was carried out in the early 1980's and later in the early 1990's, the recent surveys by Akintoye and Fitzgerald (2000) and Akintoye et al (2000) have focused upon factors causing inaccuracy that relate to the task environment and did not consider the external environment. Akintoye et al's (2000) later survey regarding the supply chain, excluded the contextual variables of procurement and trade.

The data collected in the first phase of the study indicated that the larger main contracting organisations were developing closer relationships with their supply chain. The majority of respondents indicated that their organisations were still in the early stages of developing closer relationships. The hypothesis was supported, as the data analysis reported from the 3 x 6 factorial design general linear model was that the main factor influencing contractors subcontract price procurement behaviour was the procurement arrangement adopted by clients. A non-parametric procedure was used to validate this model. The trades of groundwork and brickwork were indicated by this model as having the lowest number of enquiries sent for all organisational groups. The number of missing values for groundworks for lower sized organisations indicated that they tended to employ their own resources to carry out this work, which was an important finding. The steel frame trade was found to have consistently the highest level of enquiries sent for all organisation sizes, which was a surprising result given the extent of design required, this peaked for organisations that fell into the category of £50-99m, and roofing and cladding followed a similar trend. The finishes trade was consistently placed as the third lowest in number of send outs by all organisations. The mechanical and electrical send out numbers varied across the range of organisation sizes. Smaller organisations of <£5m and £5-24m sent out a similar number of enquiries to the mechanical and

electrical trade as other trades. This approach changed as organisations turnover exceeded £25m, which indicated that organisational size was having a significant effect. Organisations with a turnover >£99m sent out the least number of enquiries to the mechanical and electrical trade than any other trade or any other organisation category.

The conclusions drawn from the support of this hypothesis were, as the relational approaches to procurement by client organisations are allied with the use of the design and build approach and as the supply chain strategies start to mature, that more technological interdependency will occur in future. This would support richer data passing between the parties, and a consequent opportunity exists for the partial un-entanglement of price and cost data. Contractors were found to make less use of the market place when gathering subcontract price information for the design and build and drawings and specification procurement approach than when the main contract was quantified, a procurement approach that only contributed an average of 25% of respondents organisations turnover. The project specificity of the subcontractor for these approaches could therefore be considered as being consequently higher, and related to the higher levels of dependency of the contractor on the subcontractors ex ante involvement in the development of the tender. This contention was supported by data analysis of the benefits identified by the estimators, which related to improved communication. The benefits derived by the estimator from the closer relationships were considered as relating to the dependence on the subcontractor to provide information that enhanced the competitive position of the contractor. These identified benefits were associated with the development of alternative designs and specifications, benefits that would only be realised where the product was incompletely specified and capable of development. The results from phase one however, did not provide any evidence of the sharing of resource cost data. This may be considered as a transaction asset that may be used ex post, to provide an economic power differential between the parties, or may be appropriated by the contractor for use in other relationships, which will influence ex ante communication. Design information and attendant cost information could be considered as a transaction asset that will only be released when more formal ex post governance structures are in place to compensate for the investment made by

the subcontractor. The information provided at the estimate stage can also be considered as being influenced by the subsequent use of the information during the negotiation stage in entering into a contract, and also the ex post control of the subcontract. The communicative behaviour at the early stage relies upon the trust established between the parties; the data collected in the survey would suggest that even where organisations have mature relationships with the supply chain parties, there was a limit to the provision of information that could be considered as private to the selling organisation.

A statistically significant correlation was expected between supply chain technology and estimators ability to assess market price, technology price and influence of technological change on price.

To investigate the relationship between the supply chain technology and estimators ability to assess market price, technology price and the influence of technological change on price, a Likert scale was used whereby estimators assessed their own competence. A principal component factor analysis using varimax rotation of the resultant data reported in section 6.9 identified the areas where the estimator required a comparative price in order to assess the veracity of the price risk to the main contractor. The primary component factors, that were supported by the factor analysis and had reliability measured by Cronbach's Alpha, were technical knowledge, informational impactedness, non-quantifiable price veracity and quantifiable price veracity, opaque and transparent specification assessment and opaque and transparent performance assessment. The higher order factor model was developed under a category identified as the task environment.

The data collected and analysed on risk perception and analysis, indicated that estimators working for larger organisations perceived the risks of design completeness, design complexity and inflation higher than those working for smaller sized organisations. This suggested a differentiation by organisational size (a proxy for project complexity) and supported further factor analysis, which suggested that estimator's uncertainty over price risk veracity, informational asymmetry between the supply chain and main contracting

organisation and the project specificity of the supplying organisation were interacting.

The factor model formed the converging aspect of phase one of the study and the hypothesis stated at the commencement of the thesis, suggested that the higher order factor structures would be distinctive and the anticipated differences between the external environment, project environment and task elements for organisations of different sizes was supported.

To explicate and validate the findings of phase one, methodological triangulation was undertaken, using an approach that reflected the ontological perspective of the estimators. The eleven cases were selected purposively in order to examine the theoretic and literal predictability of the model from phase one. The data were gathered using a series of semi-structured interviews, the questions within which where designed to investigate a number of propositional statements drawn from phase one. The interview data was transcribed and coded using a grounded style approach, as suggested by Strauss and Corbin (1967), the codes were entered as nodes within Nvivo, a computer aided qualitative data analysis package. Nvivo assisted in the analysis of the data by allowing rapid comparison of transcripts from the interviewees and allowed the researcher the ability to 'flip flop' between the organisation in the external environment and the estimators task environment. The nodes were iteratively examined, interpreted and redefined as the analysis of the cases took place. The final model was expanded upon to include the contextual factors that considered the social context of the economic exchange between the subcontractor and contractor, this social embeddedness of the transaction (Granovetter, 1985) was found to be a complex construct, and an analysis of the data indicated that it was a factor that influenced the estimate structure and was termed organisational relations. The factors identified in this part of the model were suggested tentatively due to the practical limitations of the gathering of sufficient data to allow for analysis and possible saturation of these emergent categories.

The proposition that was supported by the data was that:

Organisations take a contingent approach to the structuring of the subcontract components of a project's estimate that is affected by the interrelationship between factors that relate to the project environment and external environment and is also affected by factors that relate to the external environment, the project environment and task environment, which exist in the context of an organisations size.

There is an interaction between the project environment and external environment for complex projects that is related to subcontract tendering costs and results in a network effect that influences a subcontractor's propensity to bid.

The factors were identified and defined and were:

External environment;
Procurement
Organisational capability
Market intensity
Small number

Project Environment;
Subcontractor specificity
Subcontractor specialisation
Product development
Subcontractor capability
Price specificity
Bilateral dependence
Interdependence
Constraints

Task Environment;
Price risk veracity
Estimator's capability- price & technology performance
Information impactedness
Need for competition

10.3 Conclusions: Research Problem

The research problem was to investigate the underlying structures of contractor's estimates and to uncover and identify the factors that affected the contractors ex ante behaviour when gathering price information from

subcontractors. The research problem originated from reviewing the extant literature in the fields of construction procurement and the role information played in the communication of price commitments. The field of study of construction procurement is a relatively young one, the CIB W92 working commission was established in 1989, and the early work in the field was carried out by construction economists whose philosophical stance was primarily positivistic, for example by establishing utility models for procurement selection. These approaches adopted a naive approach to the complexity of projects by attempting to develop criteria that where then valued and weighted and then compared against how the procurement routes available matched these criteria. This is not to be too critical of this work, as it identified key criteria for management attention during the early stages of a project. A central weakness of these approaches and more recent approaches at procurement modelling has been that the focus has been upon the contractor/client interface and has only considered the contractors governance structures implicitly. The model developed by this study, extends the line of visibility beyond the contractor client interface and down into the supply chain. It has identified factors that can be influenced by client and contractor procurement approaches that are inclusive of the supply chain, which could be used for the development of a new procurement selection methodology that is grounded in real data. It used an innovative methodology of using a 3 x 6 factorial general linear model and principal component analysis to investigate how organisations used the market to gather supply chain price data

The factors identified from the phase one PCA have been developed from the most extensive survey of construction estimators undertaken to date in the UK and the procedures for the internal reliability and external validity of the measures used were rigorously followed. The procedures adopted for validation of the model were also followed rigidly however the factors developed by the grounded style of data collection and analysis do require further data to be collected before they can be stated as being generalisable.

The validation of the thesis's orientation hypotheses was undertaken by combining the strengths of the different paradigms in a complementary manner. The quantitative phase was a necessary stage in the research, as little

empirical research was uncovered on the interaction between contractors and subcontractors during the estimating process. The constructs adopted in this phase were measured by quantitative scales and gathered data on organisational behaviour, attitudes and values. This data was analysed using descriptive statistics and the thesis adhered to the positivistic criteria of reliability, and validity when reporting the results in chapter six. The statistical analysis adopted for the factorial general linear model and its non-parametric validation were complemented by the more 'interpretive' factor analysis approach. The factor analysis of the estimator's attitudes towards assessment of subcontract financial data and risk allowed for the factors to emerge from the survey dataset. Tabachnick and Fidell (2001) suggested that in order for a factor analysis to be applied meaningfully to data that the minimum number of cases should be 300, this study met this criterion and is one of the few uncovered in construction research that did. The limitations of the research strategy adopted relate to the generalisability of the factor model developed from the data. The labelling of the factors in phase one are based on an interpretation of the nature of the components that load upon the factor which are in turn based upon the researchers interpretation of the research literature. The method for the models validation was also interpretative seeking confirmation and explication from different data sources using different methods to gather the data and using methodological triangulation in order to support the findings. The resources available to the researcher limited the number of cases that were used during this stage and also access to the records available within the cases was restricted. Ideally the case studies require more than one data source to triangulate the case data however the commercial nature of the estimate and the lack of historical records meant that only one source of data within each case was used. The approach taken during the interviews used for the data collection was to develop a rapport and gather 'true' data. This data appeared to be a true account however a check was not possible. The iterative approaches towards coding, critical reflection by the researcher and the negotiation of meaning developed during phase two of the work supported the labelling of the nodes.

A further limitation to the study was that the population sample were members of a professional body, and in this context, may not represent a typical

respondent within the industry and that in responding to the survey, they necessarily were in effect a self-selecting group. An attempt was made to overcome the first limitation by contacting one other professional body in the UK, the RICS. The RICS categorised its members by faculty, which embraced a wide range of disciplines and could not be used to overcome the limitation of one group. The strengths of using an approach that gathered data from experienced practitioners however, was considered to outweigh the limitations of inclusiveness.

10.4 Limitations

The limitations of the methodology for this study have been discussed in chapter five and seven and are restated below. The approaches of rigorously implementing the methods available have sought to ensure the findings are robust.

The primary limitation imposed by the first phase related to construct measurement and the population sample used. The constructs were derived from the literature search, which was limited primarily to the area of construction management. Some of the constructs used in the first phase e.g. risk perception can be considered to be related to cognition which is outside of the investigation. All questionnaire surveys have limitations in that the language used for the questions can be open to misinterpreation n=by the respondent, rigourous piloting was used to overcome this limitation however it is impossible to reove it totally. The sample used was derived from the CIOB's database of estimators, these were chosen as an authoritative sample however it was recognised that they may not be representative of the UK construction industry estimators. The RICS member database did not capture information in sufficient detail to allow a comparable sample to be drawn. The sample used for the first phase included few subcontract organisations and the number of estimators responding who were employed by £50-98m were low in number consequently care should be taken when generalising the findings of the research to this group. The limitations of the data analysis of this phase relate to the factorability of the correlation matrices for the principal component analysis as well as the naming of the resultant factors. These limitations were

controlled using the data analysis techniques identified in chapter 5 however the factors should be interpreted in this context.

The primary limitation of the second phase was quantity of case studies from which data could be collected and the analysis of language that used normative terms in an unreflective manner by the interviewees. The resources available limited the number of case studies to 11 and didn't allow the search and analysis in detail of deviant cases. Additional cases would have strengthened the validation of the phase one model. The triangulation that took place between the two phases strengthened the study and sought to mitigate these limitations. The structure of a country's construction industry and extent of use of subcontractors is unique to a particular country and the data used to develop the model has been collected from estimators working for UK contractors. The contingency factor model is therefore based on UK practice of procurement and construction industry structure and is subject to this geographic limitation.

10.5 Implications for Theory

The main contribution of this thesis is the identification and definition of contingency factors that can influence organisation's behaviour to the seeking, gathering, analysis and synthesis of supply chain price data, in order to structure an estimate for a construction project. The identification of these factors is important to allow for the design of procurement systems based on theory, and the development of a better understanding of the ex ante processes that lead to the formation of project organisations. The methodology for procurement system design that could be based upon this model is outside the scope of this thesis, however this is identified as an area for further research.

The exchange of product and process information early in the design stage is an essential pre requisite for the benefits of concurrent engineering as reported by Anumba et al (2002). The standards for exchange of financial information were developed to support the traditional sequential design bid construct process adopted by the traditional procurement route. This study has found that the integrated procurement routes such as design and build has increased the involvement of specialists during the early stages of projects however the use

of competition by contractors during these stages to procure subcontractors with the lowest price constrains the extent of design and price information exchange. The subcontractors that are particularly affected by these barriers to effective transmission of data are those that tender for projects undertaken by medium sized organisations. The thesis identified that in order to increase their project specificity that they withhold design and cost information to protect their design cost investment consequently this constrains optimisation of the design development process. The specialist mechanical and electrical organisations working for large organisations using the design and build procurement route were found to influence their project specificity by requiring guarantees that they would be contracted to construct the work if the main contract was let. The case study data from these large organisations identified that the estimator was central to the cost planning of the design and build project however had little knowledge of the cost implications of alternative designs offered by the subcontractor. The thesis identified this was due to two main reasons, firstly that the codification of the communicated price information was low and consequently the opportunity to store, analyse and learn from the economics of past projects was low. The second reason was that estimators had little motivation to learn about these costs, as the approach by the large organisations, was to accept the subcontract price and include a "back to back" arrangement that transferred the risks for misalignment to the client. The cost modelling that was undertaken by the steelwork subcontractors was done in isolation to the other specialist organisations, as large and medium sized contractors made extensive use of the market to gather specialist prices. The use of competition for this trade was perceived as the best means of enhancing the contractor's prices. The number of steelwork contractors within the market, and the relative low cost of design of steelwork were identified as the factors behind the differentiation of this trade with the mechanical and electrical trade.

There is a clear need for design cost information process protocols for the key trades to allow for the costs of the designs to be modelled, and the cost implications of the interdependent elements identified at early stages. In order for subcontract organisations to adopt these protocols, there is a concurrent need for procurement routes to recognise their need for project specificity from the outset. To ensure that clients have confidence that these organisational

teams are not being opportunistic due to information asymmetry, a transparent financial information system that recognises the costs of design and the costs of production is required. The standards for the codification of this information are already developed however, to facilitate their adoption, the procurement framework within which transactions between organisations take place requires further development. The thesis identified a paradox in the quantity of information and the value of the workpackage. Contracting organisations quantified in detail what were considered low value workpackages such as groundworks and drainage and brickwork however were content to manage the large value workpackages on the basis of lump sums. The ability to price a workpackage had a negative correlation with the specificity of the subcontractor.

The strategic issues in construction procurement are the subject of a body of research and form the published work of the commission CIB W92. A key aspect that reoccurs throughout the literature reviewed, and the plethora of strategic industry reports, is the need to develop interdependent organisation structures for the design and the construction processes. The search for contingency factors that affect the efficacy of the procurement routes have been reported by Rowlinson (1999). This is the first study that has considered the ex ante economic contingency factors. The approaches reviewed in chapter three have largely ignored the socio-economic factors that exist that affect the contractor's price structure, which in turn influences the contingent structure of the project team. Researchers who have not differentiated by trade have previously ignored the external environmental factors of small numbers availability and propensity to price. The relative specificity of the subcontract trades and the impact of the market structures of the main contractors upon this specificity expanded upon in chapter nine suggested that one size of procurement approach does not fit all. The thesis identified that more real world research was required outside of the arena of partnering which had become so saturated with rhetoric, as to make it virtually impossible to gather meaningful data. The thesis also identified the need for more empirical work to investigate the structure of markets and the frequency of use, specificity of trades and the extent of networks and their effect.

The thesis contributed to the area of transaction economics by extending the work of Williamson (1996) and suggesting that organisational relations of market making factors had an effect of specificity. It extended the work to suggest that information impactedness could be a result of not only ex ante processes but also the use that information is put to the control and coordination of parties that are quasi integrated into the project team.

10.6 Implications for Policy and Practice

The following are some areas that policy and practice can be developed from the findings of the thesis. The implications of the move away from standardised approaches to procurement of construction projects means that there is currently a fertile environment to consider new ideas for procurement system design, the areas of tendering, procurement systems and client control systems are identified as some key areas.

10.6.1 Tendering

There is a need for tendering procedures used by clients that maximise the opportunities to innovate by including the supply chain. This requires development, not just for large clients but also for the small occasional client, as the culture of networks and unsolicited subcontract bids, endemic competition as a process for selection of the subcontractor are all militating against development of an environment that encourages concurrent engineering. The pre-qualification criteria used by clients may request information using a similar approach to this study in order to gather data on the main contractors approach to the supply chain and seek to place contracts with organisations that can empirically demonstrate a commitment to high project specificity of supply chain organisations.

10.6.2 Procurement systems

The recent development of two stage procurement systems that increased the project specificity of contractors could be deepened to consider increasing the specificity of subcontractors. The consequential development of criteria that are

based not on price alone are required for subcontract selection. These need to be established in the context of the subcontract trade and capability and be made more transparent to the construction client. These are both areas where there is a dearth of empirical research. The increasing use of ICT on projects has not yielded the benefits of cost modelling expected, one of the barriers to this development is access to meaningful data. Procurement approaches that yield price data that can transcend the main contractor/subcontractor barrier could be stored in national databases such as the Building Cost Information Service (BCIS) as a means of reducing performance ambiguity of the specialist contractors and the consequential potential for their opportunistic behaviour. A system of standardised rates for common processes such as groundworks may assist the procurement of subcontract trades without the transaction costs of quantifying.

Procurement has been identified as a key driver for organisational learning, however there is the need for more protocols for communication of design cost plans during the design development process that can be adopted by design and build contractors. This may provide a prescriptive framework for the key trades to work within and develop capability that helps develop the industry strategically.

10.6.3 Client control systems

The BCIS could augment its systems to capture information on availability of trades in particular areas of specialism and geographic areas. The study found that propensity to price was a key factor in a specialist trade/contractor relationship. If the capacity and intensity of the markets was known, it may help with the timing of client projects in order to smooth the effect of market intensity on small numbers. Clients also require systems that develop their capability to manage the implications of misalignment when the risk is placed on them for financial control.

10.7 Implications for Future Research

Further research into the field of study of construction procurement is essential for development of a more effective construction industry. It has only relatively recently been considered as a driver for change and has been recognised as having a central role in innovation and learning. It is also a field that is relatively young in theoretical terms and requires a lot more development in order to understand how procurement routes affects the organisations and the socio economic processes of design and construction. Whilst this thesis has developed the theoretical contingency factors that affect the structure of the estimate, there is considerable work to be done to develop practical systems from this model. This thesis has indicated the influence that client procurement systems have on the members of the supply chain. The more integrated procurement approaches require these organisations to develop capability in terms of technology, process and expertise in predicting, planning and controlling their resources. The education of current and future estimators working in these organisations needs to include cost information management and cost modelling in order to allow the industry to continue innovating. The specialist trade contractor will play an important role in the innovation of the industry and the future procurement research agenda should place the need to gather more information about the structures of their industries and how increased interdependency can be facilitated by taking account of the contingency factors identified in this thesis.

The following recommendations for further work are suggested after taking account of the findings of this study and its limitations:

The study found that the context within which temporary multi organisational teams formed differed with market sectors. There was little empirical work carried out in the identification of how these sectors used procurement systems and the constraints imposed upon construction organisations by the resources available to them. Further empirical work gathering data on these constraints would help inform future research.

The factors that influence the specificity of the specialist trade contractors at an organisational and project level have been identified within this study, the limitations of the data collection suggest that further research by carried out to explore this aspect in more detail. This would assist in the design of procurement systems that facilitate increased frequency of use of specific subcontractors and consequently encourage inter organisational learning at organisational level and project level.

Further study is required of the current practice of cost modelling in the specialist trade organisations to identify gaps that need to be addressed in developing capability which may be through education, development of technology or organisational processes for better information capture.

A methodology is urgently required to allow for clients advisors to design procurement routes that take account of the reality of practice in the construction industry and its supply chains. This thesis has identified the factors that affect the gathering of supply chain price data, procurement routes that increase the specificity of organisations and information may assist in the development of approaches that encourage trust between the parties and a more innovative environment for product development.

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APPENDIX 1

Questionnaire Pilot Feedback

Construction Estimating practice pilot survey 2003

Please answer the following questions after you have completed the pilot survey questionnaire. Your feedback on the pilot is critical to the success of the main survey and consequently please be critical in your analysis.

1. How long did it take you to complete the questionnaire?

   .....Mins.

2. If there were any questions that were ambiguous in their wording, please could you indicate the number of the question below and if possible the reasons why this was the case.

3. If any of questions requested information that you were uncomfortable to please could you indicate the number of the question below and if possible the reasons why this was the case.

4. If any questions appeared irrelevant to you or you organisation please could you indicate the number of the question below and if possible the reasons why this was the case.

5. If there were any categories of response that you felt didn't match the question posed, please could you indicate the number of the question below and if possible the reasons why this was the case A.

6. If you have any suggestions for improvement please include them on the reverse of this sheet.

   Thank you once again for your valuable assistance; please return this sheet and the completed questionnaire to me by 14 November using the self-addressed envelope.

APPENDIX 2

Notes on

Questionnaire Design

Appendix Two : Notes on questionnaire design

Questionnaire development

The measuring instrument was designed to measure qualitative and quantitative variables. The following levels of measurement were utilised;

1.0 Nominal level: To measure qualitative data at nominal level, the establishment of categories is required, this establishment is developed in such a way that the informant can only answer the question in one category.

1 Which of the following best describes your organisations field of operation? (Please tick)	
General contracting: Building	
General contracting: Civil Engineering	
General contracting: Civil and Building Engineering	
Specialist Trade Contractor	
Other. Please indicate _____	

Figure 1: Format of question 1 of the measuring instrument indicating the measurement at nominal level of an organisations field of operation.

Figure 1 above indicates the level of measurement of an organisations field of operation. These nominal categories are drawn from those recognised within the annual construction industry statistics published by the DTI 2001. This measurement was used to identify the respondents employing organisation and allow cross industry comparisons to be measured. Good practice in survey design suggests that the categories must be exhaustive and mutually exclusive.

Table 1 below indicates the variables measured at nominal level within the survey, measuring instrument was carefully design to increase the response rate. It has been found that if a questionnaire is perceived to be short the response rate will be higher than that perceived to be lengthy. To ensure that respondents were not put off by the amount of data requested, the numbering of the questions was carefully considered. Questions numbered only 1- 21 however data was collected on 165 variables at nominal, ordinal and scale measurement.

Tables 1- 3 indicate the question number within the measuring instrument, the construct under investigation and the variable name. The categories, numerical scale or codes for response are also given.

Question number in measuring instrument		Variable	Categories used
1	Organisations field of operation	Industry sector	General contracting: Building General contracting: Civil Engineering General contracting: Civil and Building Engineering Specialist Trade Contractor Other. Please indicate
3	Organisational capability	Procurement arrangement tender enquiry	Firm Bills of quantity Drawings and Specification Design and Build Prime Contracting Cost Reimbursement Management Contracting Construction Management Measurement- Civils Other
4	Client sector	Market sector	New housing Industrial Warehouses Schools & Colleges Universities Healthcare Offices Leisure Retail Infrastructure
5	Partnering experience	Tender arrangements	Competition Competition with partnering agreement Negotiation Negotiation with partnering agreement
6	Functional role	Risk Identification and Analysis responsibility	**Contractual Risks** Inflation provisions Dispute resolution Contract complexity Variation/claim expectation **Project Risks** Programme Site characteristics Resource productivity Design complexity Design completeness Health and safety ***Supply chain procurement risks*** Subcontract quotation selection Supplier quotation assessment **Organisational risk** Design team Project management team Client organisation
9	Risk identification technique	List of techniques drawn from literature review	Experience Prompt lists Use of past project records Use of sub-contractor/supply meetings Don't rely on a system

			Other (Please indicate)
10	Risk analysis technique for a taxonomy of risks.	List of techniques drawn from lit review	Judgement Risk registers Statistical analysis Sensitivity analysis Decision tree Other
12	Supply chain strategy	Strategy in place	Yes No
13	Price information format	Categorised work packages; Groundwork- Finishes	All in unit rates Mainly lump sums Method related charges Resource costs
19	Estimators role in subcontract price inclusion	Decision making role	Final decision maker Key decision maker Key influencer No input
21	Informant title	Status of informant	Junior Estimator Estimator Senior Estimator Estimating director Other
21	Qualifications	Academic/Prof qualifications	HND BSc Prof Body MSc Other

Table 1: Variables measured at nominal level in the measuring instrument to investigate estimating practice December 2003.

2.0 Ordinal level: To measure quantitative or qualitative variables at ordinal level, the establishment of ranked or ordered categories is required. As with the nominal level variable measurement, the categories should be exhaustive and mutually exclusive.

12 Does your organisation have a strategy to develop closer links with selected specialist trade contractors?

Yes ☐ No ☐ ***If no, please go to question 12***

How long has this strategy been implemented? ….. Years

Please give your opinion on the assistance, if any, the strategy gives the estimator by ranking the following: **1 = Greatest Benefit**

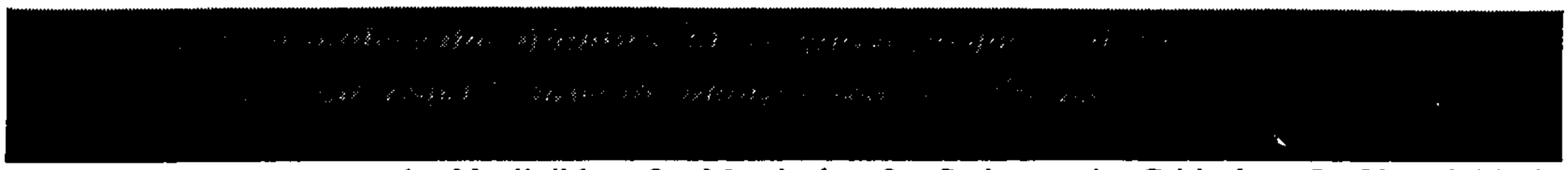
	Please Rank
Less of a requirement to send out enquiries eg Provision of standard unit rates that can be used for estimate development on a number of projects	
Guaranteed response to requests for quotations	
Improvement in sharing of knowledge about construction techniques	
Improvement in the communication of cost information and implications of alternative construction approaches	
Improved communication of cost information and implications of alternative design approaches	

Improvement in the sharing of alternative specification cost information	
Sharing of resource cost information	
Improvement in the processes for the management of risk	
Other	

Figure 2: The use of ordinal level scaling to gather data on the benefits of a strategy to develop closer links with the supply chain

Figure two above illustrates how a question can be structured to gather data at a range of levels; measured at the nominal level i.e. does the organisation have a strategy to develop closer links yes/no, measured at ratio scale level i.e. how long has this strategy been in place and also ordinal level where the informant was asked to rank the top five benefits.

Likert scales were also used to gather attitudinal data at the ordinal level, this method of measurement allowed the informant to rank responses to questions that sought their opinion. There was no numerical difference between the categories identified and figure 3 below gives an example of the format used.



1 = Negligible 2 = Marginal 3 = Serious 4 = Critical 5 = Very Critical

Contractual Risks					
Inflation provisions	1	2	3	4	5
Dispute resolution	1	2	3	4	5
Contract complexity	1	2	3	4	5
Variation/claim expectation	1	2	3	4	5

Figure 3; Format of a section of question 11 indicating the use of a Likert scale to investigate estimator's opinion on the significance of contractual risks

Table 2 indicates a list of the quantitative and qualitative variables measured at ordinal level.

Question number in measuring instrument		Variable	Categories used
11	Risk significance for a taxonomy of risks	Risk significance	Negligible Marginal Serious Critical Very critical
12	Benefits derived to estimator from supply chain strategy	List of benefits drawn from literature, inclusion of	Rank top 5, 1=highest benefit, 5=lowest.

		other	
14	Tender decision making	Estimators knowledge of market	Essential Important Of some importance Not important
14	Tender decision making	Estimators knowledge of subcontractor pricing approach	Essential Important Of some importance Not important
14	Tender decision making	Price variability	Essential Important Of some importance Not important
14	Tender decision making	Price Qualification	Essential Important Of some importance Not important
14	Tender decision making	Post contract variation control	Essential Important Of some importance Not important
14	Tender decision making	Post contract claim control	Essential Important Of some importance Not important
14	Tender decision making	SCon workload	Essential Important Of some importance Not important
15	Quotation assessment	Areas of difficulty	Ranking 1=most difficult 6=Least difficult
16	Price assessment categorised into work packages	Good ability to assess accuracy of prices	1= Strongly agree 2=Agree 3=Neither agree or disagree 4=Disagree 5=Strongly disagree
16	Knowledge of cost of alternatives-categorised into work packages	Good ability to assess cost of alternative specifications	1= Strongly agree 2=Agree 3=Neither agree or disagree 4=Disagree 5=Strongly disagree
16	Knowledge of performance of alternatives-categorised into work packages	Good ability to assess acceptability of alternatives	1= Strongly agree 2=Agree 3=Neither agree or disagree 4=Disagree 5=Strongly disagree
16	Ability to assess the risks associated with	Good ability to assess the risks	1= Strongly agree 2=Agree

	each work package	associated with a work package.	3=Neither agree or disagree 4=Disagree 5=Strongly disagree
17	Supply chain capability	Early budget cost information	1=Excellent 2=V.good 3=Neither good nor poor 4=Poor 5=V. Poor
17	Supply chain capability	Input into risk management practice	1=Excellent 2=V.good 3=Neither good nor poor 4=Poor 5=V. Poor
17	Supply chain capability	Input into value management	1=Excellent 2=V.good 3=Neither good nor poor 4=Poor 5=V. Poor
17	Supply chain capability	Provide accurate info on resource costs	1=Excellent 2=V.good 3=Neither good nor poor 4=Poor 5=V. Poor
17	Supply chain capability	Provide sound advice on alternatives	1=Excellent 2=V.good 3=Neither good nor poor 4=Poor 5=V. Poor
18	IT system capability	Unit rate estimating	1=Excellent 2=V.good 3=Neither good nor poor 4=Poor 5=V. Poor
18	IT system capability	Contractors design cost planning	1=Excellent 2=V.good 3=Neither good nor poor 4=Poor 5=V. Poor
18	IT system capability	Sub contract quote analysis	1=Excellent 2=V.good 3=Neither good nor poor 4=Poor 5=V. Poor
18	IT system capability	Risk management	1=Excellent 2=V.good 3=Neither good nor poor 4=Poor 5=V. Poor
18	IT system capability	Previous info retrieval	1=Excellent 2=V.good

			3=Neither good nor poor 4=Poor 5=V. Poor
20	Feedback type and influence	Cost value reconciliation	Very Influential Influential Slightly influential Not Influential
20	Feedback type and influence	Buying report	Very Influential Influential Slightly influential Not Influential
20	Feedback type and influence	Cost reports	Very Influential Influential Slightly influential Not Influential
20	Feedback type and influence	Bonus records	Very Influential Influential Slightly influential Not Influential
21	Age	Age in years	Age in interval scales; 20-30 31-40 41-50 51-60 >60
21	Tenure with current employer	Tenure in years	<1 1-5 5-10 10-15 >15

Table 2: Variable measured at ordinal level in the measuring instrument to investigate estimating practice December 2003.

3.0 Numerical scale: The measuring instrument sought quantitative data of variables measured by a numerical scale. The numerical data sought on organisation size utilised an interval scale illustrated by figure x below.

2 What was your organisations turnover in the last financial year? (Please tick)

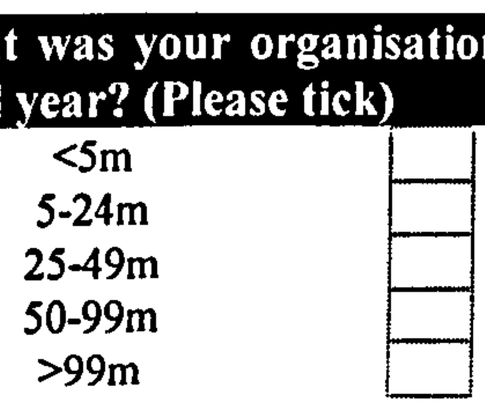


Figure 3: Format of question 2 of the measuring instrument indicating the quantitative measurement using a numerical scale of an organisations size. The indicator used to

measure the size of the organisation was turnover and the categories are as shown. The organisations size ranges from very small <5m to large >99m.

Table 3 below indicates a list of the quantitative variables measured at numerical scale level.

Question number in measuring instrument		Variable	Categories used
2	Organisations size	£ M	<5m 5-24m 25-49m 50-99m >99m
3	Organisational capability	% Enquiries prices	*Firm Bills of quantity* Drawings and Specification Design and Build Prime Contracting Cost Reimbursement Management Contracting Construction Management Measurement- Civils Other
4	Client sector specialism	Annual turnover	Numerical percentage for the below; New housing Industrial Warehouses Schools & Colleges Universities Healthcare Offices Leisure Retail Infrastructure
5	Partnering experience	Tendering experience	Numerical percentage for the below; Competition Competition with partnering agreement Negotiation Negotiation with partnering agreement
7	In house work	Subcontracted work	Interval scale measurement <20% 20-40% 40-60% 60-80% >80%

8	Subcontract competition-categorised into work packages	Numbers invited to bid-Divided into procurement approaches	Number Groundworks and Drainage Steel Frame Mechanical and Electrical Roofing and Cladding Brickwork Finishes
12	Length of time supply chain strategy in place	Implementation period	In years
13	Market price variability	Range of competitive prices for a list of work packages	Measured as a percentage, informant free to insert figure.
21	Experience	Years	Interval scale <5 5-10 10-15 15-20 >20

Table 3: Variables measured at the numerical scale level within the measuring instrument to investigate estimating practice December 2003.

At the end of the questionnaire an open question was included to allow the respondents to indicate how they believed the estimating practice to be changing, if at all.

APPENDIX 3

Covering Letter

Fields from CIOB database

Date as postmark

Dear

Construction Estimating practice survey 2003

I am writing to invite you to take part in a national UK survey of construction estimating practice that I am undertaking as a research project with the support of the Chartered Institute of Building. The aim of the research is to collect information on how estimators' request and use price data provided by subcontractors in the development of project estimates. The results of the survey will be reported to the CIOB and also used in the second phase of the work.

You have been selected as a practicing estimator who may be able to provide valuable information on current practice. The survey is confidential and your response will not be identifiable from the analysed data.

I do hope that you can find the time to complete the questionnaire enclosed and return it to me in the self-addressed envelope by ..... December, as your response is crucial to the success of the research.

If you have any queries regarding any aspect of this research please contact me on 0151 231 3281 or email a.d.ross@livjm.ac.uk

Thank you once again

Yours faithfully,

Andrew Ross, MCIOB

APPENDIX 4

Measuring Instrument

Construction Estimating Practice Survey 2003/4

This survey aims at investigating your current practice of estimating for construction projects. If any questions request information that you feel uncomfortable with releasing, please skip on to the next question.

Thank you in anticipation.

Your responses are critical to the success of the research and if you have any queries, please contact Mr Andrew Ross on 0151-231-3281 or email a.d.ross@livjm.ac.uk.

Section One – (Organisational Information)

1 Which of the following best describes your organisations field of operation? (Please tick)

- General contracting: Building ☐
- General contracting: Civil Engineering ☐
- General contracting: Civil and Building Engineering ☐
- Specialist Trade Contractor ☐
- Other. Please indicate _____

2 What was your organisations turnover in the last financial year? (Please tick)

- <5m ☐
- 5-24m ☐
- 25-49m ☐
- 50-99m ☐
- >99m ☐

3 Please indicate below the appropriate percentage (by value) of tender enquiries your department has priced over the last 12 months

Procurement approach	*% Enquiries priced*
Firm Bills of quantity	
Drawings and Specification	
Design and Build	
Prime Contracting	
Cost Reimbursement	
Management Contracting	
Construction Management	
Measurement- Civils	
Other	

4 Please indicate the areas of your organisation's main business by indicating the % turnover for each of the sectors given. (Please tick all that apply)

Market sector	*% Annual turnover*					
	<10 %	11-30%	30-50%	50-70%	70-90%	>90%
New housing						
Industrial						
Warehouses						
Schools & Colleges						
Universities						
Healthcare						
Offices						
Leisure						
Retail						
Infrastructure						

5 What percentage of your work is secured by? %

Competition	
Competition with partnering agreement	
Negotiation	
Negotiation with partnering agreement	

Section Two – Risk Management

6 Please indicate who usually identifies and analyses the following risks during the project estimating stage. (Please tick all that apply)

	Estimator	*Buyer*	*Planning Engineer*	*Contract Manager*	*Director*	*Team*
Contractual Risks						
Inflation provisions						
Dispute resolution						
Contract complexity						
Variation/claim expectation						
Project Risks						
Programme						
Site characteristics						
Resource productivity						
Design complexity						
Design completeness						
Health and safety						
Supply chain procurement risks						
Subcontract quotation selection						
Supplier quotation assessment						
Organisational risk						
Design team						
Project management team						
Client organisation						

7 Please indicate the percentage of work you usually subcontract. (Please Ring)

<20%	*20-40%*	*40-60%*	*60-80%*	*>80%*

8 Please indicate the number of subcontractors usually invited to submit bids for the three procurement approaches indicated.

Work Package	Design and Build	Drawing and specification	Firm BQ
Groundworks and Drainage			
Steel Frame			
Mechanical and Electrical			
Roofing and Cladding			
Brickwork			
Finishes			

9 Please indicate the systems you usually use for risk identification. (Please tick all that apply)

- Experience ☐
- Prompt lists ☐
- Use of past project records ☐
- Use of sub-contractor/supply meetings ☐
- Don't rely on a system ☐
- Other (Please indicate) _____

10 Please indicate the techniques you mainly use to assess the risks you highlighted in question 6 (Please tick all that apply)

	Use of Judgement	Risk Registers	Statistical Analysis	Sensitivity Analysis	Decision Trees	Other
Contractual Risks						
Inflation provisions						
Dispute resolution						
Contract complexity						
Variation/claim expectation						
Project Risks						
Programme						
Site characteristics						
Resource productivity						
Design complexity						
Design completeness						
Health and safety						
Supply chain procurement risks						
Subcontract quotation selection						
Supplier quotation assessment						
Organisational risk						
Design team						
Project management team						

11 Please indicate your opinion, for a typical project, on the significance of each risk that you usually have to identify/assess. (Please circle all that apply)

	1 = Negligible	2 = Marginal	3 = Serious	4 = Critical	5 = Very Critical
Contractual Risks					
Inflation provisions	1	2	3	4	5
Dispute resolution	1	2	3	4	5
Contract complexity	1	2	3	4	5
Variation/claim expectation	1	2	3	4	5
Project Risks					
Programme	1	2	3	4	5
Site characteristics	1	2	3	4	5
Resource productivity	1	2	3	4	5
Design complexity	1	2	3	4	5
Design completeness	1	2	3	4	5
Health and safety	1	2	3	4	5
Supply chain procurement risks					
Subcontract quotation selection	1	2	3	4	5
Supplier quotation assessment	1	2	3	4	5
Organisational risk					
Design team	1	2	3	4	5
Project management team	1	2	3	4	5

12 Does your organisation have a strategy to develop closer links with selected specialist trade contractors/suppliers?

Yes ☐ No ☐ **If no, please go to question 13**

How long has this strategy been implemented? ....Years

Please give your opinion on the assistance, if any, the strategy gives the estimator by ranking the top five of the following benefits:- **1=Highest, 5=lowest**

	Please Rank
Less of a requirement to send out enquiries eg Provision of standard unit rates that can be used for estimate development on a number of projects	
Guaranteed response to requests for quotations	
Improvement in sharing of knowledge about construction techniques	
Improvement in the communication of cost information and implications of alternative construction approaches	
Improved communication of cost information and implications of alternative design approaches	
Improvement in the sharing of alternative specification cost information	
Sharing of resource cost information	
Improvement in the processes for the management of risk	
Other	

13 Please indicate the format of the price information that is usually returned from the following specialist trade contractors. (Please tick all that apply)					Please indicate below the approx % range of prices received from each trade when obtained competitively eg. +/-10%
Work Package	All in unit rates for quantified items	Mainly lump sums for major items	Method Related Charges	Resource Costs	
Groundworks and Drainage					
Steel Frame					
Mechanical and Electrical					
Roofing and Cladding					
Brickwork					
Finishes					

14 How important are the following considerations upon the decision to use a particular subcontractor in a tender? (Please tick)				
	An essential consideration	An important consideration	Of some importance	Not important
Estimators' knowledge of the current market for the trade				
Estimators' knowledge of a particular subcontractors pricing approach				
The variability in the prices received				
The extent of qualifications to the price				
The quality of information to manage the costs of post contract variations				
The availability of information to manage the costs of programme related claims				
The consequence on the workload of the selected subcontractor if successful				

15 Please rank the following factors that cause you most difficulty when assessing specialist quotations.	
	Please Rank **1 = Most Difficult 6 = Least Difficult**
A lack of comparative price information	
A lack of personal knowledge of specialist technology	
The variations in the prices received	
The time elapsed since reviewing a similar trade quotation	
The quality of the information provided with the quotation	
A lack of in-house Company expertise to whom you can refer	
A lack of communication with sub-contractor during estimate development	
Other	

16 When assessing the quotations received from the following trades, please indicate your agreement or disagreement with the statement by ringing the appropriate number.

1=strongly agree, 2=agree, 3=Neither agree or disagree, 4=disagree, 5=strongly disagree

Work Package	I have good ability in assessing the **accuracy of prices quoted**	I have good ability in assessing the **cost of alternative specifications suggested**	I have good ability in assessing the **acceptability of alternative specifications**	I have good ability in assessing the **risks associated with the work package**
Groundworks and Drainage	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Steel Frame	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Roofing & Cladding	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Mechanical and Electrical	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Flooring Contractors	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Brickwork	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Finishes	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

17 How would you rate your sub-contractor/suppliers in their ability to:-? (Please ring all that apply)					
	1 = Excellent	2 = Very Good	3 = Neither Good Nor Poor	4 = Poor	5 = Very Poor
Provide reliable early design budget cost information	1	2	3	4	5
Input into the risk management process	1	2	3	4	5
Input into value management	1	2	3	4	5
Provide accurate information on their resource costs	1	2	3	4	5
Provide sound advice on alternatives	1	2	3	4	5

18 How would you assess your IT systems for the following functions? (Please ring all that apply)					
	1 = Excellent	2 = Very Good	3 = Neither Good Nor Poor	4 = Poor	5 = Very Poor
Unit rate estimating	1	2	3	4	5
Contractors design cost planning	1	2	3	4	5
Sub-contract quote analysis	1	2	3	4	5
Risk management	1	2	3	4	5
Retrieval of information from previous estimates	1	2	3	4	5

19 What role to you play in making the decision on the inclusion of a sub-contractor price in a tender? (Please ring)			
Final decision maker	Key decision maker	Key influencer	No input

20 Please indicate the influence of feedback from previous estimates on your decision making. (Please tick all that apply)				
	Very Influential	Influential	Slightly Influential	Not Influential
Cost value reconciliations				
Buying reports				
Cost reports				
Bonus records				
Other				
Other				

21 Personal Details. (Please ring)					
How many years experience do you have as an estimator?	<5	5-10	10-15	15-20	>20
Which of the following titles best describes the role you undertake?	Junior Estimator	Estimator	Senior Estimator	Estimator Director	Other
What qualifications do you have?	HND/C	BSc	Prof. Body	MSc	Other
Please indicate your age	20 - 30	31 - 40	41 - 50	51 - 60	> 60
How long have you worked for your current employer?	< 1 yr	1 – 5 yrs	5 – 10 yrs	10 – 15 yrs	> 15 yrs

If you would like to take part in a short telephone interview, which investigates the estimators' use of supply chain price information during the estimate development, please either include your business card or write your phone number. Alternatively you can email me: a.d.ross@livjm.ac.uk.

Thank you for assisting us with this important project. Please return the questionnaire in the pre-paid envelope provided by 20 January 2004

If you would like a copy of the results of this survey, please tick this box ☐

Please use the rest of this space to indicate how you believe the estimating process is changing, if at all.

APPENDIX 5

Follow-Up Letter

Date as postmark

Dear

Estimating practice survey

I have had some feedback highlighting the fact that the timing of the above survey coincided with a busy run up to Christmas and that some estimators may have found it difficult to find the time to complete the questionnaire. I am writing to invite you once more to take part; the closing date for the survey has been extended to 20 January 2004.

The research aims to gather as much data as possible across all sectors of the industry from practicing estimators therefore your response is highly valued. I enclose a further copy of the survey and envelope for return in case you have misplaced the original and would be most grateful if you could spare the time to complete the survey and return it to me by 20 January 2004.

If you have already returned the questionnaire, it may be caught up in the New Year post and consequently please ignore this reminder.

Many thanks once more in anticipation of your help and best wishes for the New Year.

Yours sincerely,

Andrew Ross

Andrew Ross, Head of Construction Studies, MCIOB
School of the Built Environment, Liverpool John Moores University
Clarence Street, Liverpool L3 5UG Telephone 0151-231 3281 Facsimile 0151-709 4957

APPENDIX 6

Non Parametric Validation of the General Linear Model

A KS test for normality was applied to all the distributions that related to the supply chain which indicated that some of the supply chain data were not normally distributed consequently appropriate non-parametric tests were applied. In order to determine the most appropriate statistical technique for the assessment of the data, the type of sample had to be considered. This differed as either a between subjects comparison or within subjects comparison, the non-parametric statistical test used was dependent on this distinction.

A derived criterion variable, which was the mean number of subcontract enquiries (SE) for each procurement approach (PA) for each organisation, was computed. The descriptive results of the analysis indicated that there was differences between the mean numbers of send outs for the different procurement routes identified. The highest mean number of SE was the traditional procurement route, ($x_{(228)}$ = 3.79, sd 1.19), followed by drawings and specification, ($x_{(248)}$ =3.09,sd=1.05) and design and build ($x_{(217)}$ =3.12, 1.15).In order to examine whether the means were significantly different a paired t test was carried out between the overall means for each procurement approach for the sample. The paired variables of subcontract average enquiries for drawings and specification and design and build was $t_{(203)}$ = 1.121, p>0.05, design and build and traditional $t_{(194)=}$-9.531, p<0.001and drawings and specification and traditional $t_{(222)}$ =10.711, p<0.001. This indicated that there was a significant difference between the drawings and specification and design and build approach and traditional but not between design and build and drawings and specification.

1.Inter organisational analysis.

The assumption was made that the data came from an unrelated sample and the aim of testing the series of hypotheses was to focus upon the practice of different organisations, categorised by size, type, approach to subcontracting and experience of partnering. The appropriate statistical test was *an uncorrelated or independent* non-parametric test.

Ho: The combined means of subcontract trades (*u*) send outs for a given client procurement route vary between organisations.

Ha: $u_1 \neq u_2 \neq u_3$

Where *u*=combined mean of a subcontract sends out for a given procurement route.

To test the above hypothesis the independent variable was stated as organisation categorised nominally by size. The criterion variables were a derived from the average of responses for groundworks and drainage, steel frame, mechanical and electrical, roofing and cladding, brickwork and finishes for three procurement routes of design and build, drawings and specifications and firm bills of quantities.

In order to establish whether the differences found were significant for different organisation sizes, a Kruskal Wallis test was used. The chi square value for the Design and build procurement route was x^2=19.495, df, 4, p<0.001, Drawings and specification x^2= 46.498, df 4, p<0.001 and the traditional route x^2=62.668, df,4, p<0.001. It was established that the differences were significant and the null hypothesis was rejected.

A post hoc scheffe test was used to identify where the significant differences (p=0.05)were within the groups and it was established that the smallest organisations indicated that they sent out the lowest average number of enquiries than any other organisation size. The lowest numbers were sent out for the drawings and specification procurement approach, the traditional approach lead to higher numbers being sent out. The approach adopted by these organisations was significantly different from organisations of larger size for the drawings and specification procurement approach and for organisations of sizes, 25-49, 50-99 and >99 for the traditional approach who tended to send out more enquiries. Organisations with a turnover of 5-24m had a similar approach to organisations of <5m for the establishment of subcontract prices for the design and build and drawings and specification procurement approach. They tended to send out more subcontract enquiries when tendering using the traditional approach than the other two. The approach adopted by these organisations was not significantly different to that or organisation sizes of 25-

49 or >99m for the drawings and specification route but they sent out to a significantly lower number than organisation of sizes <5 and 50-99. They also sent out a lower number of enquiries for the traditional procurement which was significantly different to organisations with turnovers of 50-99 and >99 m. Organisations with a turnover of 25-49m had a different approach for design and build and drawings and specification, this was not identified in the paired t test above and is considered in the intra organisational analysis. The larger organisations, 50-99 and >99m, tended to send out more enquires than the smaller organisations, organisations with a turnover of 50-99m displayed the largest average number of enquiries for the traditional procurement route than any of the other groups. The trend for significantly lower numbers of sends outs for the design and build and the drawings and specification arrangement than the traditional approach was maintained across both organisation sizes.

The following were established.

The null hypothesis was rejected and it was found from the data gathered that significant differences were found for the mean number of subcontract enquiries sent out by organisations between the three procurement approaches.

The null hypothesis was not rejected for organisations of different sizes when measured by turnover and the organisational size can be stated as having a moderating effect.

7.32 Inter organisational comparison of subcontract enquiries analysed by subcontract trade.

In order to investigate what the effect subcontract trade had on the number of send outs, a derived criterion variable, which was the mean number of subcontract enquiries for each trade (SEt) for each organisation, was computed. The data were not normally distributed consequently a non-parametric test approach was used to establish whether there was a significant difference between organisations of different sizes, the sample was assumed to be uncorrelated and independent. The test used was the KW test.

Generally

The descriptive results of the analysis indicated that lowest number of enquiries were sent to brickwork subcontractors ($x_{(224)}$ =2.86, sd=1.358), followed by groundwork and drainage ($x_{(233)}$ =2.933, sd=1.29), M and E ($x_{(257)}$ =3.51, sd=1.14), roofing and cladding ($x_{(251)}$ =3.45, sd=1.21), finishes ($x_{(243)}$ =3.45, sd=1.17, steel frame ($x_{(250)}$ =3.49, sd=1.16). A KW test established that a difference existed for the means of the different trades between organisations of differing sizes. Groundworks x^2=44.017, df,4, p<0.001, Mechanical and Electrical x^2=26.367, df,4, p<0.001Roofing and Cladding x^2=50.902, df,4, p<0.001 Finishes x^2=57.510, df,4, p<0.001Steel frame x^2=50.531, df,4, p<0.001brickwork x^2=42.790, df,4, p<0.001.

A more detailed investigation involving a hypothesis test was carried out.

The hypothesis to be tested for each trade was Ho: that a significant difference would exist for the average number of trade subcontract enquiry sends outs between organisations of different sizes.

Ha: $u_1 \neq u_2 \neq u_3$

Where U= the average number of send outs for a subcontract trade for an organisation of a given size.

A post hoc scheffe test for ANOVA (p<0.05)was carried out which indicated the following that the mean number of send outs for trades for finishes, roofing and cladding, steel frame and Mechanical and electrical was significantly higher than those of groundworks and brickwork for organisations up to 24m turnover. Organisations with a turnover that exceeded this displayed a lower difference in mean number of send outs between these two groups. Steel frame send outs were found to be significantly higher for almost all organisations with the exception of organisations whose turnover was less than £24M where the mechanical and electrical trades were indicated as being higher. The relative mean number of send outs to M and E subcontractors fell as organisations

turnover increased, organisations with the >£99m turnover indicated that they sent out the lowest average number of enquiries to this trade. The highest average was that of organisations of turnover £50-99m, however the results in the previous section indicated that organisations that fell within this group tended to send out more enquiries. The finishes trades also tended to have a significantly higher number of send outs than other trades for all categories of organisational turnover.

It was resolved to further test a series of hypotheses that contrasted the approaches that were taken by differing organisations. The main aim of the tests was to establish whether procurement approach, traditional and organisation turnover had intervening effects as established by the GLM.

Ho: The means of given subcontract trades (*u*) send outs for a given client procurement route do not vary between organisations.
Ha: $u_1=u_2=u_3$

Where *u*=mean of a given subcontract send out for a given procurement route.

To test the above hypothesis the independent variable was stated as organisation, categorised nominally by type, size, subcontract strategy and partnering experience. The last nominal variable wasn't considered within the GLM. The criterion variable was a given trade for a given procurement route

Organisation independent variables were categorised as follow;

a. Organisational size, five nominal categories
b. Subcontract strategy, four nominal categories
c. Partnering approach, two nominal categories

The Kruskal Wallis test was used for testing the hypothesis for a, b, and c.

A. Organisational size and procurement approach

It was established for the following trades and procurement routes that there was a significant difference between organisations of different size,

Table app.6.1 KW test for differences for trade for three procurement approaches

Trade	Design and build		Traditional		Drawings and spec.	
	x^2	p	x^2	p	x^2	P
Groundworks and drainage	19.27	p<0.001	52.15	p<0.001	28.485	P<0.001
Steel frame	22.467	p<0.001	42.003	p<0.001	35.060	P<0.001
Mechanical and electrical	13.708	p=0.05	24.936	p=0.001	15.802	P=0.001
Roofing and cladding	18.716	p<0.001	45.358	p<0.001	42.246	P<0.001
Brickwork,	11.497	P<0.05	42.819	p=0.001	25.682	P=0.0012
Finishes	22.885	p<0.001	56.846	p<0.001	38.864	P<0.001

The null hypothesis was consequently rejected, and Ha was accepted that there were significant differences found of the means for the trade subcontract send outs for the design and build, traditional and drawings and specification client procurement routes between organisations with different annual turnovers. This supported the findings within the general linear model identified above. A non-parametric intra organisation analysis was also required, as a method of non-parametric analysis of between subject and within subject independent variables was not found.

The assumption was made that the data originated from a related sample and the aim of testing the series of hypotheses was to focus on the practices of the different organisation sizes for a range of subcontract trades and client procurement routes. The derived criterion data were calculated at interval level. In order to test whether the means are significantly different, the data were filtered within SPSS to give a data set that facilitated within subject design. If there is little difference between the samples their mean ranks should be similar. The table below 6.05 indicated that there was a significant difference found between the average numbers of sends outs for the three procurement routes within each group. A Wilcoxon signed ranks test indicated that a significant difference (z=-2.204, p<0.05) was evidenced for organisation with a

turnover of 24-49m for the design and build and drawings and specification route.

Table app 6.2 Friedman test identifying differences between organisation size for three procurement routes

Procurement route	<5	5-24	24-49	50-99	>99
	Mean rank	Mean rank	Mean rank	Mean rank	Mean rank
Design and Build	1.83	1.77	1.52	1.75	1.62
Drawings and spec	1.79	1.84	1.84	1.66	1.74
Traditional	2.38	2.39	2.64	2.59	2.64
$x^2(2)$	9.39	26.00	30.52	17.32	51.13
P	<0.05	<0.01	<0.01	<0.01	<0.01
N	24	61	28	22	57

A similar approach was used to establish the effect that subcontracts trade had on the approach adopted by organisations and is displayed in table 6.06 below.

Generally -Between subcontract trades

Table app 6.3 Friedman test for six trades and five turnover groups. The data are shown below for each of the organisation sized groups

Trade	<5	5-24	25-49	50-99	>99
Groundworks	3.29	2.61	2.70	3.00	3.48
Steel frame	4.03	4.01	4.09	4.50	3.88
M and E	4.0	4.20	3.23	3.00	2.63
Roofing and cladding	3.84	3.77	4.04	4.05	3.96
Brickwork	2.51	2.71	2.88	2.50	3.13
Finishes	3.33	3.70	4.07	3.95	3.92
x^2 (df 5)	31.35	70.48	28.41	27.133	42.71
n	38	64	28	20	63

P<0.001

The data analysis indicated that organisations whose turnover exceeded >£99m only differentiated for M and E and brickwork by sending out fewer enquiries to these two groups. Organisations with a turnover between 50-99 sent out more enquiries to steel frame subcontractors and roofing and cladding,

significantly lower numbers were sent to brickwork subcontractors. Organisations with a turnover of 25-49 grouped groundworks and brickwork together, they sent significantly lower numbers of enquiries to these contractors than steel frame, roofing and cladding and finishes. 5-24 steel frame and M and E are grouped as the highest, roofing and cladding and finishes grouped as the middle and the lowest number sent to brickwork and groundworks. For organisations with a turnover of less than <5m the lowest number of enquiries were to brickwork and finishes, the highest number to steel frame and M and E.

Between procurement routes

Table app 6.4 Friedman tests results for within subjects analysis for differing organisational turnover between three procurement routes

	<5(n=38)	5-24(n=64)	25-49(n=28)	50-99(n=20)	>99 (n=63)
Design and Build	1.83	1.77	1.52	1.75	1.62
Drawing and specification	1.79	1.84	1.84	1.66	1.74
Traditional	2.38	2.39	2.64	2.59	2.64
x^2 (df 2)	9.38	26.00	30.522	17.32	51.13

P<0.05

The data analysis displayed in table app 6.4 indicated that organisations took a different approach to the design and build approach and drawings and specification. This was confirmed the between subjects analysis.

Between procurement routes and trades within subject analysis

To establish whether a significant difference existed in the mean number of send out for the same trade between the ranges of procurement routes for the same organisation. This can be considered as a *related* sample or a "within subject" design. The criterion data was collected at interval level. In order to test whether the means are significantly different, as there were three comparison groups (Design and Build, Traditional Procurement and Drawings and Specification) the appropriate test was the Friedman two-way analysis of variance test. The data were filtered within SPSS to give a data set that facilitated within subject design for the range of organisation sizes. If there is little difference between the samples their mean ranks should be similar.

Trade	<5(n=38)			5-24(n=64)			25-49 (n=28)			50-99(n=20)			>99(n=63)		
	D&S	D&B	T	D&S	D&B	T	D&S	D&B	T	D&S	D&B	T	D&S	D&B	T
Groundworks	3.09	3.22	3.35	2.63	2.67	2.92	2.72	2.86	2.90	2.91	3.09	3.44	3.46	3.43	3.60
Steel frame	4.00	3.95	3.96	3.81	4.05	4.00	4.06	4.00	3.92	4.44	4.62	4.03	3.61	3.85	3.65
M and E	3.97	3.75	3.92	4.20	3.94	4.18	3.52	2.90	3.87	3.03	3.09	3.47	3.14	2.74	2.96
Roofing and cladding	3.82	3.80	4.00	3.84	3.84	3.63	3.98	4.12	3.77	3.88	4.15	3.64	3.94	3.77	3.73
Brickwork	2.67	2.75	2.33	2.74	2.83	2.49	2.70	3.00	2.85	2.69	2.32	2.78	3.08	3.28	3.13
Finishes	3.45	3.53	3.44	3.78	3.67	3.78	4.02	4.12	3.69	4.06	3.74	3.64	3.76	3.93	3.93
x^2 (df 5)	25.67**	12.99*	34.31**	63.12**	44.09**	76.81**	32.98**	26.54**	21.43**	22.83**	31.52**	10.18	19.10*	33.75**	24.07**

*=p<0.05

**=p<0.001

Table8.08 Friedman test for five organisation sizes, three procurement arrangements and six subcontract trades

The data can be considered to have originated from a "within subject" or related sample, there are more than two criterion variables measured at interval level and the appropriate non parametric test in this instance was the Friedman two way analysis of variance test. The Friedman test indicated in table 6.08 displayed that organisations did differentiate in their send out behaviour for the three procurement approaches and for different trades. The lowest send outs were to the design and build procurement route followed by drawings and specification and then the traditional approach. An assessment of the number of enquiries sent out for each trade was carried out, this indicated significant differences were found within the subjects for differing trades.

This series of non-parametric tests supported the findings of the GLM in that the design and build procurement approach led to the lowest number of send outs and that the number of enquiries sent to mechanical and electrical subcontractors for organisations with a turnover in excess of £99m was significantly lower than those sent to other trades by other organisation sizes.

APPENDIX 7

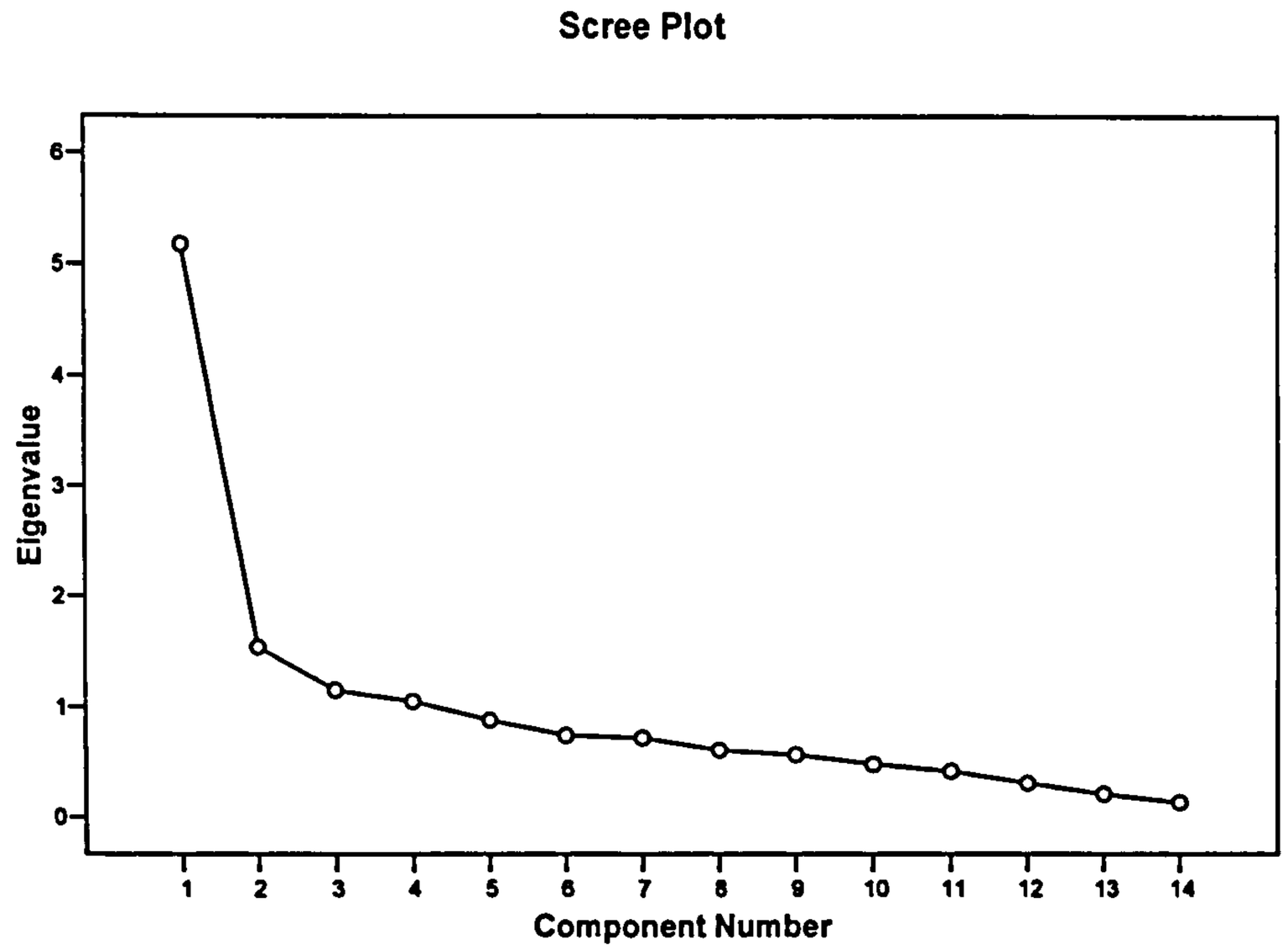
Factor Analysis Data

Factor analysis of risk perception- Section 6.7

Communalities

	Initial
Inflation-p	1.000
Disputes-p	1.000
Contract Comp-p	1.000
Variation ass-p	1.000
Programme-p	1.000
Site Char-p	1.000
Res Productivity-p	1.000
Design Complexity-	1.000
Design completenes	1.000
Health and Safety-p	1.000
Subcontract quotat	1.000
Supplier quotation-	1.000
Design team-p	1.000
Project managemer team-p	1.000

Extraction Method: Principal Componen



KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.815
Bartlett's Test of Sphericity	Approx. Chi-Square	1421.399
	df	91
	Sig.	.000

Anti-image Matrices

		Inf	Dis	CC	Var ass	Prog p	Site	R prod	D comp x	D comp l	H and S	Sc	Sup	D Tea m	PM team
Anti-image Covariance	Inflation-p	.741	-.248	.011	-.002	-.101	-.036	.006	-.037	-.017	.136	-.036	-.002	.035	.038
	Disputes-p	-.248	.583	-.113	-.244	.153	-.035	.086	.000	.000	.008	-.022	.015	-.074	-.008
	Contract Comp-p	.011	-.113	.466	.089	-.179	.029	.092	-.055	-.052	-.158	-.121	.054	.115	-.119
	Variation ass-p	-.002	-.244	.089	.695	-.152	.131	-.063	.046	-.083	.002	.039	-.047	.122	-.103
	Programme-p	-.101	.153	-.179	-.152	.556	-.137	-.160	-.051	.043	-.002	-.027	.043	-.087	.057
	Site Char-p	-.036	-.035	.029	.131	-.137	.723	-.031	-.036	-.015	-.121	.018	-.063	.093	-.086
	Res Productivity-p	.006	.086	.092	-.063	-.160	-.031	.628	-.084	-.062	-.071	-.037	-.038	-.002	-.020
	Design Complexity-p	-.037	.000	-.055	.046	-.051	-.036	-.084	.418	-.244	.127	-.032	.051	.023	-.087
	Design completeness-p	-.017	.000	-.052	-.083	.043	-.015	-.062	-.244	.458	-.138	.124	-.101	-.095	.102
	Health and Safety-p	.136	.008	-.158	.002	-.002	-.121	-.071	.127	-.138	.651	.042	-.062	.002	-.014
	Subcontract quotation-p	-.036	-.022	-.121	.039	-.027	.018	-.037	-.032	.124	.042	.324	-.245	-.109	.085
	Supplier quotation-p	-.002	.015	.054	-.047	.043	-.063	-.038	.051	-.101	-.062	-.245	.354	.075	-.085
	Design team-p	.035	-.074	.115	.122	-.087	.093	-.002	.023	-.095	.002	-.109	.075	.289	-.199
	Project management team-p	.038	-.008	-.119	-.103	.057	-.086	-.020	-.087	.102	-.014	.085	-.085	-.199	.242
Anti-image Correlation	Inflation-p	.532[a]	-.377	.019	-.002	-.157	-.050	.009	-.066	-.028	.196	-.073	-.004	.076	.089
	Disputes-p	-.377	.557[a]	-.216	-.383	.269	-.053	.142	.000	.000	.014	-.051	.034	-.181	-.023
	Contract Comp-p	.019	-.216	.663[a]	.157	-.351	.050	.169	-.125	-.113	-.287	-.313	.133	.313	-.355
	Variation ass-p	-.002	-.383	.157	.415[a]	-.244	.185	-.096	.085	-.147	.004	.082	-.095	.272	-.250
	Programme-p	-.157	.269	-.351	-.244	.675[a]	-.217	-.271	-.107	.085	-.003	-.063	.098	-.218	.155
	Site Char-p	-.050	-.053	.050	.185	-.217	.754[a]	-.046	-.066	-.026	-.177	.036	-.124	.202	-.206
	Res Productivity-p	.009	.142	.169	-.096	-.271	-.046	.833[a]	-.164	-.116	-.111	-.083	-.082	-.005	-.052
	Design Complexity-p	-.066	.000	-.125	.085	-.107	-.066	-.164	.727[a]	-.559	.243	-.087	.132	.065	-.274
	Design completeness-p	-.028	.000	-.113	-.147	.085	-.026	-.116	-.559	.568[a]	-.252	.322	-.251	-.262	.305
	Health and Safety-p	.196	.014	-.287	.004	-.003	-.177	-.111	.243	-.252	.685[a]	.091	-.129	.004	-.035
	Subcontract quotation-p	-.073	-.051	-.313	.082	-.063	.036	-.083	-.087	.322	.091	.535[a]	-.725	-.357	.303
	Supplier quotation-p	-.004	.034	.133	-.095	.098	-.124	-.082	.132	-.251	-.129	-.725	.602[a]	.234	-.290
	Design team-p	.076	-.181	.313	.272	-.218	.202	-.005	.065	-.262	.004	-.357	.234	.544[a]	-.752
	Project management team-p	.089	-.023	-.355	-.250	.155	-.206	-.052	-.274	.305	-.035	.303	-.290	-.752	.597[a]

a Measures of Sampling Adequacy(MSA)

Rotated Component Matrix [a]

	Component			
	1	2	3	4
Inflation-p				.91
Disputes-p			.835	
Contract Comp-p	.435			.36
Variation ass-p			.765	
Programme-p	.622			
Site Char-p	.650			
Res Productivity-p	.639			
Design Complexity-p	.798			
Design completeness-p	.781			
Health and Safety-p	.399			
Subcontract quotation-p		.890		
Supplier quotation-p		.874		
Design team-p	.474	.446	.488	
Project management team-p	.470	.412	.527	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

Anti-image Matrices

		CPI	PV	Time	Qual	In h e	Com
Anti-image Covariance	Comparative price information	.808	-.317	-.051	-.094	-.002	-.043
	Price variation	-.317	.821	-.040	-.065	-.003	-.006
	Time since reviewing a similar quotation	-.051	-.040	.861	-.037	-.133	-.197
	Quality of information provided with quotation	-.094	-.065	-.037	.917	-.124	-.068
	Lack of company in house expertise	-.002	-.003	-.133	-.124	.829	-.230
	Lack of communication with Subcontractor	-.043	-.006	-.197	-.068	-.230	.808
Anti-image Correlation	Comparative price information	.587[a]	-.389	-.062	-.110	-.002	-.054
	Price variation	-.389	.576[a]	-.048	-.075	-.003	-.008
	Time since reviewing a similar quotation	-.062	-.048	.714[a]	-.041	-.157	-.236
	Quality of information provided with quotation	-.110	-.075	-.041	.758[a]	-.142	-.079
	Lack of company in house expertise	-.002	-.003	-.157	-.142	.670[a]	-.281
	Lack of communication with Subcontractor	-.054	-.008	-.236	-.079	-.281	.663[a]

a. Measures of Sampling Adequacy(MSA)

Total Variance Explained

	Initial Eigenvalues			raction Sums of Squared Loaditation Sums of Squared Loadin					
Compone	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.940	32.325	32.325	1.940	32.325	32.325	1.715	28.577	28.577
2	1.258	20.966	53.291	1.258	20.966	53.291	1.483	24.713	53.291
3	.872	14.525	67.816						
4	.716	11.939	79.755						
5	.632	10.531	90.287						
6	.583	9.713	100.000						

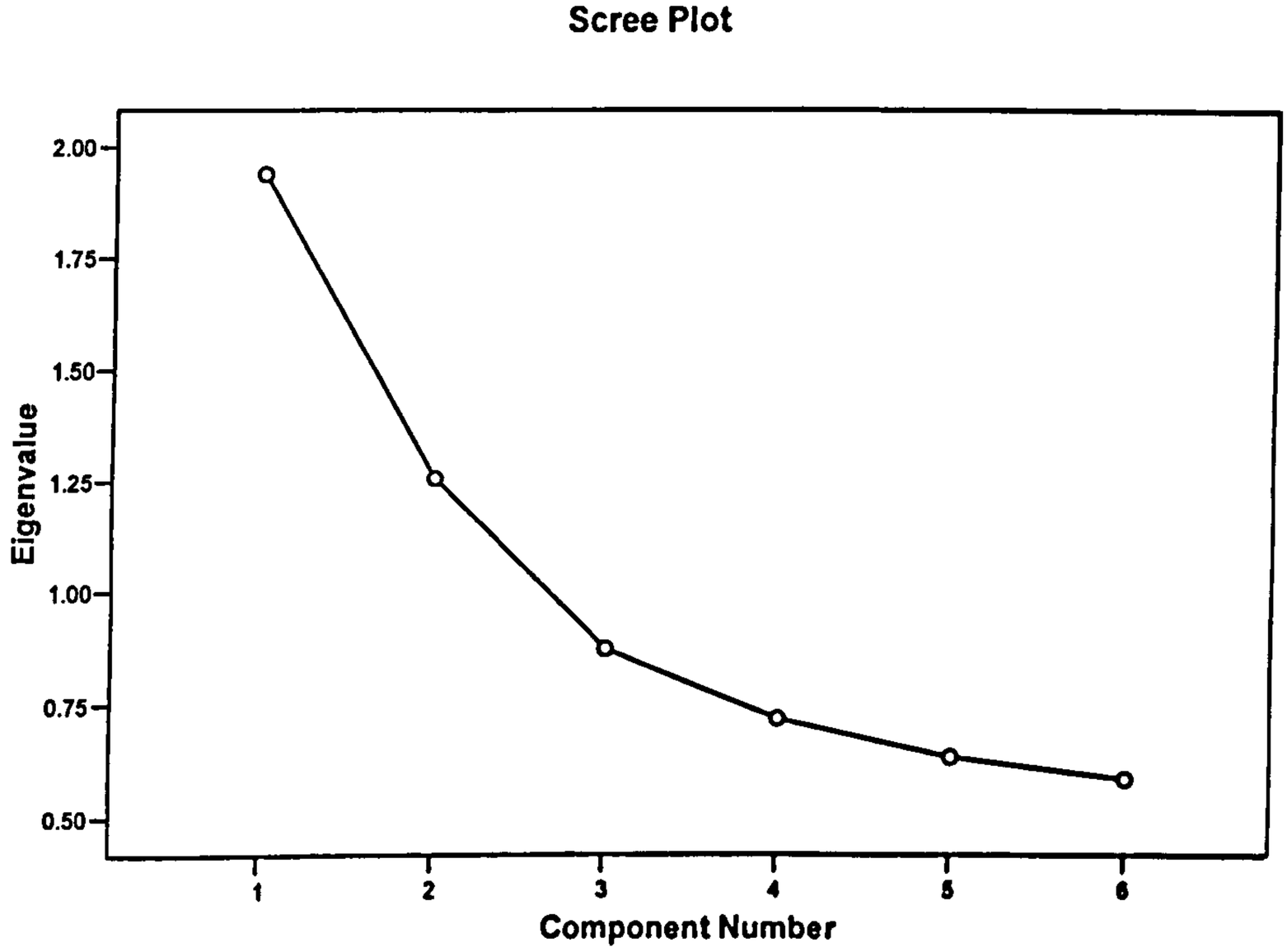
Extraction Method: Principal Component Analysis.

Rotated Component Matrix [a]

	Component	
	1	2
Comparative price information	.082	.834
Price variation	.019	.812
Time since reviewing a similar quotation	.681	.108
Quality of information provided with quotation	.390	.792
Lack of company in house expertise	.782	-.003
Lack of communication with Subcontractor	.746	.046

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.



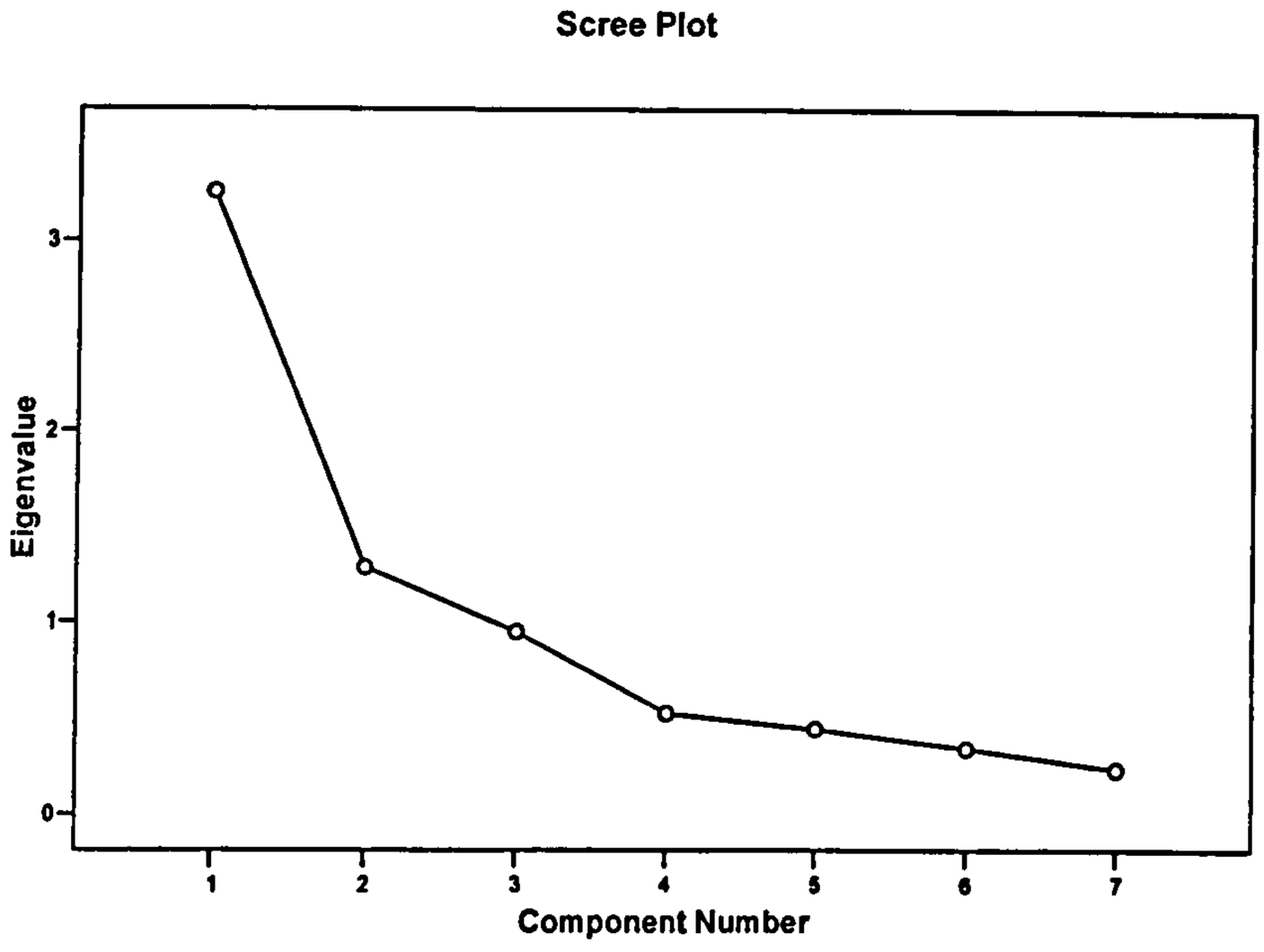
Anti-image Matrices

		GW	SF	RC	ME	F	Bk	Fin
Anti-image Covariance	Groundworks Market price assessment	.562	-.144	-.025	.076	-.083	-.231	.061
	Steel frame Market price assessment	-.144	.564	-.253	-.055	-.025	-.011	.055
	Roofing and cladding Market price assessment	-.025	-.253	.494	-.190	-.052	-.007	-.054
	M and E Market price assessment	.076	-.055	-.190	.746	-.088	.046	-.017
	Flooring Market price assessment	-.083	-.025	-.052	-.088	.500	.029	-.229
	Bkwk Market price assessment	-.231	-.011	-.007	.046	.029	.435	-.214
	Finishes Market price assessment	.061	.055	-.054	-.017	-.229	-.214	.397
Anti-image Correlation	Groundworks Market price assessment	.723[a]	-.256	-.048	.118	-.157	-.467	.129
	Steel frame Market price assessment	-.256	.729[a]	-.479	-.085	-.047	-.022	.117
	Roofing and cladding Market price assessment	-.048	-.479	.760[a]	-.313	-.105	-.014	-.122
	M and E Market price assessment	.118	-.085	-.313	.753[a]	-.144	.080	-.032
	Flooring Market price assessment	-.157	-.047	-.105	-.144	.777[a]	.063	-.514
	Bkwk Market price assessment	-.467	-.022	-.014	.080	.063	.695[a]	-.515
	Finishes Market price assessment	.129	.117	-.122	-.032	-.514	-.515	.674[a]

a. Measures of Sampling Adequacy(MSA)

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.726
Bartlett's Test of Sphericity	Approx. Chi-Square	617.225
	df	21
	Sig.	.000



Rotated Component Matrix[a]

	Component	
	1	2
Groundworks Market price assessment	.712	
Steel frame Market price assessment		.720
Roofing and cladding Market price assessment		.801
M and E Market price assessment		.794
Flooring Market price assessment	.672	.365
Bkwk Market price assessment	.879	
Finishes Market price assessment	.807	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Anti-image Matrices

		GW	SF	RC	ME	FL	Bk	Fin
Anti-image Covariance	Estimators opinion of ability to assess alt spec costs- Groundwork	.551	-.147	-.029	.057	-.066	-.190	.049
	Estimators opinion of ability to assess alt spec costs- steel frame	-.147	.567	-.178	-.150	.033	.014	-.034
	Estimators opinion of ability to assess alt spec costs- roofing and cladding	-.029	-.178	.466	-.165	-.125	-.045	-.010
	Estimators opinion of ability to assess alt spec cost- M and E	.057	-.150	-.165	.642	-.114	.088	.010
	Estimators opinion of ability to assess alternative spec costs- Flooring	-.066	.033	-.125	-.114	.495	.017	-.172
	Estimators opinion of ability to assess alt spec costs- Bkwk	-.190	.014	-.045	.088	.017	.353	-.211
	Estimators opinion of ability to assess alt spec costs- Finishes	.049	-.034	-.010	.010	-.172	-.211	.364
Anti-image Correlation	Estimators opinion of ability to assess alt spec costs- Groundwork	.783[a]	-.262	-.058	.095	-.126	-.431	.109
	Estimators opinion of ability to assess alt spec costs- steel frame	-.262	.803[a]	-.347	-.248	.062	.032	-.076
	Estimators opinion of ability to assess alt spec costs- roofing and cladding	-.058	-.347	.826[a]	-.301	-.260	-.112	-.024
	Estimators opinion of ability to assess alt spec cost- M and E	.095	-.248	-.301	.706[a]	-.202	.185	.021
	Estimators opinion of ability to assess alternative spec costs- Flooring	-.126	.062	-.260	-.202	.817[a]	.040	-.405
	Estimators opinion of ability to assess alt spec costs- Bkwk	-.431	.032	-.112	.185	.040	.698[a]	-.588
	Estimators opinion of ability to assess alt spec costs- Finishes	.109	-.076	-.024	.021	-.405	-.588	.730[a]

a. Measures of Sampling Adequacy(MSA)

KMO and Bartlett's Test

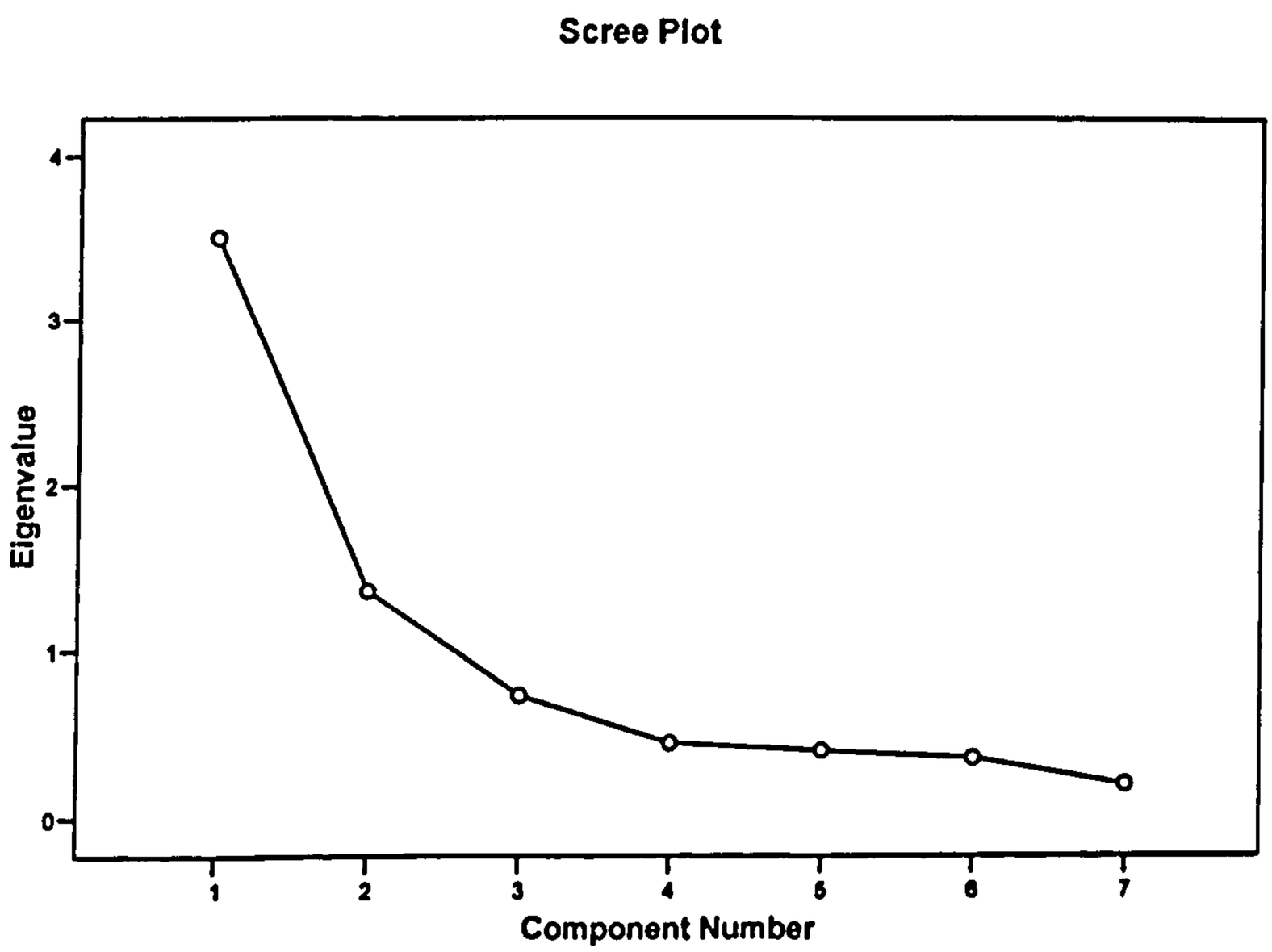
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.766
Bartlett's Test of Sphericity	Approx. Chi-Square	700.709
	df	21
	Sig.	.000

Rotated Component Matrix [a]

	Component	
	1	2
Estimators opinion of ability to assess alt spec costs- Groundwork	.740	
Estimators opinion of ability to assess alt spec costs- steel frame		.712
Estimators opinion of ability to assess alt spec costs- roofing and cladding	.399	.754
Estimators opinion of ability to assess alt spec cost- M and E		.875
Estimators opinion of ability to assess alternative spec costs- Flooring	.580	.512
Estimators opinion of ability to assess alt spec costs- Bkwk	.911	
Estimators opinion of ability to assess alt spec costs- Finishes	.833	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

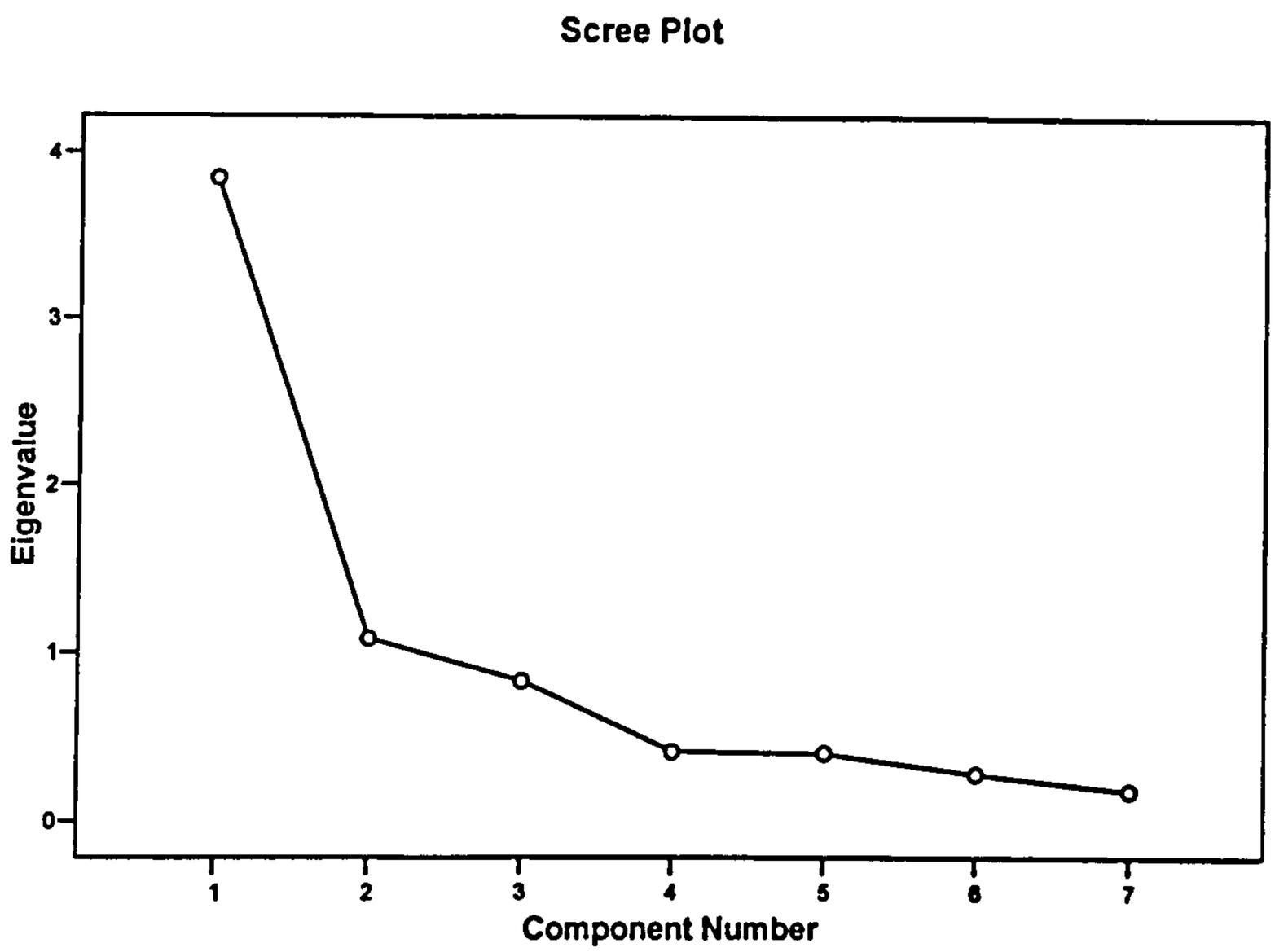


Factor analysis of assessment of specification- 7.17

Anti-image Matrices

		GW	SF	RC	ME	Fl	Bk	Fin
Anti-image Covariance	Estimators opinion of ability to assess alt spec acceptability- Groundwork	.424	-.128	-.053	.055	-.044	-.186	.035
	Estimators opinion of ability to assess risks- steel frame	-.128	.747	-.165	-.093	.004	.041	.017
	Estimators opinion of ability to assess alt spec acceptability- roofing and cladding	-.053	-.165	.486	-.144	-.064	-.028	-.052
	Estimators opinion of ability to assess alt spec acceptability- M and E	.055	-.093	-.144	.643	-.167	.049	-.002
	Estimators opinion of ability to assess alt spec acceptability- Flooring	-.044	.004	-.064	-.167	.360	-.025	-.140
	Estimators opinion of ability to assess alt spec acceptability- Bkwk	-.186	.041	-.028	.049	-.025	.284	-.148
	Estimators opinion of ability to assess alt spec acceptability- Finishes	.035	.017	-.052	-.002	-.140	-.148	.315
Anti-image Correlation	Estimators opinion of ability to assess alt spec acceptability- Groundwork	.795[a]	-.227	-.116	.105	-.112	-.536	.095
	Estimators opinion of ability to assess risks- steel frame	-.227	.799[a]	-.274	-.134	.008	.089	.035
	Estimators opinion of ability to assess alt spec acceptability- roofing and cladding	-.116	-.274	.889[a]	-.257	-.152	-.075	-.132
	Estimators opinion of ability to assess alt spec acceptability- M and E	.105	-.134	-.257	.771[a]	-.346	.115	-.004
	Estimators opinion of ability to assess alt spec acceptability- Flooring	-.112	.008	-.152	-.346	.849[a]	-.079	-.416
	Estimators opinion of ability to assess alt spec acceptability- Bkwk	-.536	.089	-.075	.115	-.079	.765[a]	-.495
	Estimators opinion of ability to assess alt spec acceptability- Finishes	.095	.035	-.132	-.004	-.416	-.495	.807[a]

a. Measures of Sampling Adequacy(MSA)



Rotated Component Matrix [a]

	Component	
	1	2
Estimators opinion of ability to assess alt spec acceptability- Groundwork	.811	
Estimators opinion of ability to assess risks- steel frame		.693
Estimators opinion of ability to assess alt spec acceptability- roofing and cladding	.527	.641
Estimators opinion of ability to assess alt spec acceptability- M and E		.835
Estimators opinion of ability to assess alt spec acceptability- Flooring	.695	.482
Estimators opinion of ability to assess alt spec acceptability- Bkwk	.926	
Estimators opinion of ability to assess alt spec acceptability- Finishes	.837	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

APPENDIX 8

Case Study

Interview Protocols

Concepts for exploration for interviews 1-3

Interview protocol

Introduction to confirm some aspect of the general analysis and seek some further information about the relationships that exist between organisations and their subcontractors and how this influences the process of estimate development. The aim is to develop a richer picture of current practice and identify good practice.

Introduce the interview three sections

1. Organisational relationships with subcontractors.
2. Perspectives on subcontract price selection
3. A scenario, design and build.

Remember the unit of analysis is the transaction between subcontractors and main contractor and the social processes that make up the communication of the prices.

Need to gather demographic information relating to the case that information is being gathered from, need to start to develop the concepts of transparency(information asymmetry) , organisation relations/ approach to supply chain, how the asset specificity is instantiated within organisations and how this influences project estimating etc

Introduction

SECTION ONE

Organisational

Developing relationships with subcontractors

Do you feel that there is a movement towards more stable relationships between main contractors and subcontractors, which is evidenced by sending out fewer enquiries to a smaller pool of selected organisations?

How may this vary with workpackage trade?

Is it evidenced by any changes in your organisations approach to developing estimates?

(only to be asked if +ve answer earlier) How do you balance the need for competition and a reduced pool of organisations prepared to provide a price?

The survey data analysis indicated that organisations took a different approach to sending out enquiries to steel frame manufacturers and M and E, they both have an element of design, is this the Case In your organisation ?.

Organisations appear to have differing approaches to send out behaviour when dealing with different procurement arrangements, if the works are quantified a full BQ they tend to send out more, is this solely because they are more likely to get prices returned?.

Section two-Subcontract price selection

Do you feel some subcontractors take advantage of the lack of knowledge of pricing levels/specification details that exist within main contracting organisations.

How often will you use an unsolicited bid within a competitive tender?

Bearing in mind the limited numbers of some trades, how do you know that one of your key subbies isn't pricing a proposal for another contractor?

Seems to be a move away from estimating unit rates based on outputs and a move towards more market oriented pricing

Section Three -Scenario

Further information

The following questions are based on a scenario, a project that is approximately £5m, steel frame distribution warehouse, green field site for a know client. Tendering procedure: Competitive, design and build, geographically located within operating region, six weeks to complete the tender. Commence on site four weeks after tender submission.

Please could you explain the general processes that the organisation goes through to obtain a prices and particularly for the steel frame workpackage and the M and E workpackage?

(this relates to organisational behaviour, up to the receipt of a quote and be useful to identify processes, characteristics and dimensions)

Does the organisation have a policy of offering incentives to workpackage subcontractors as the estimate develops, ie if the job is won the package is guaranteed. Are these incentives offered to all trades or just certain ones?

How does the estimator assess the competitiveness of the prices received particularly if the workpackage is complex and the competitiveness of the bid is dependent on a keen price?

What are the principal benefits to the estimator that accrue from long term relationships with subcontractors, does this vary with trade?

Concepts for exploration for interviews 4 & 5

Interview protocol

Introduction member of staff completing some research on estimating to confirm some aspect of the general analysis and seek some further information about the relationships that exist between organisations and their subcontractors and how this influences the process of estimate development. The aim is to develop a better understanding of current practice and identify good practice.

Discussion will take about thirty minutes

Introduce the interview three sections

4. Organisational relationships with subcontractors.
5. Perspectives on subcontract price selection
6. A scenario, design and build.

Remember the unit of analysis is the transaction between subcontractors and main contractor and the social processes that make up the communication of the prices.

Need to gather demographic information relating to the case that information is being gathered from, need to start to develop the concepts of transparency(information asymmetry) , organisation relations/ approach to supply chain, how the asset specificity is instantiated within organisations and how this influences project estimating

Introduction

Section One

Organisational

Developing relationships with subcontractors

Would you agree that the selection of the right subcontractors to bid is central to an estimates competitiveness, Would you say that your organisation has changed in its relationships with its subcontractors, if so how?

How may this vary with workpackage trade as some trades appear to be more critical to a bids success than others?

The role of the estimator includes bid assessment do you think that the more established links that exist changes your assessment of subcontract estimates, would it be possible to give examples?

(only to be asked if +ve answer earlier) How do you balance the need for competition and a reduced pool of organisations prepared to provide a price?

The survey data analysis indicated that organisations took a different approach to sending out enquiries to steel frame manufacturers and M and E, they both have an element of design, is this the Case In your organisation?.

Organisations appear to have differing approaches to send out behaviour when dealing with different procurement arrangements, if the works are quantified a full BQ they tend to send out more, is this solely because they are more likely to get prices returned?.

SECTION TWO - SUBCONTRACT PRICE SELECTION

The survey indicated that estimators have a better ability to assess works that have been quantified; Do you feel some subcontractors take advantage of the lack of knowledge of pricing levels/specification details that exist within main contracting organisations?

Would you say that you are limited by the small numbers of certain trades and bearing in mind the limited numbers of some trades, how do you know that one of your key subbies isn't pricing a proposal for another contractor?

Seems to be a move away from estimating unit rates based on outputs and a move towards more market oriented pricing

SECTION THREE - SCENARIO

Further information

The following questions are based on a scenario, a project that is approximately £5m, steel frame distribution warehouse, green field site for a know client. Tendering procedure: Competitive, design and build, geographically located within operating region, six weeks to complete the tender. Commence on site four weeks after tender submission.

Please could you explain the general processes that the organisation goes through to obtain a prices and particularly for the steel frame workpackage and the M and E workpackage?

(this relates to organisational behaviour, up to the receipt of a quote and be useful to identify processes, characteristics and dimensions)

What processes are used to cost plan the design during estimate development?, Does the need for competitive sc bids get in the way of developing a dialog ?

Does the organisation have a policy of offering incentives to workpackage subcontractors as the estimate develops, ie if the job is won the package is guaranteed. Are these incentives offered to all trades or just certain ones?

How does the estimator assess the competitiveness of the prices received particularly if the workpackage is complex and the competitiveness of the bid is dependent on a keen price?

What are the principal benefits to the estimator that accrue from long term relationships with subcontractors, does this vary with trade?

Do you feel that any subcontractors limit the information that's passed to you at tender stage in order to be commercial/opportunistic post contract ?

Do you have any systems that might pick this up?

Concepts for exploration for interviews 6-11

Interview protocol

Introduction member of staff completing some research on estimating to confirm some aspect of the general analysis and seek some further information about the relationships that exist between organisations and their subcontractors and how this influences the process of estimate development.

The aim is to check on the results of the survey and seek some further information that the survey couldn't pick up

Discussion will take about thirty minutes

Introduce the interview three sections

7. Organisational relationships with subcontractors.
8. Perspectives on subcontract price selection
9. A scenario, design and build.

Remember the unit of analysis is the transaction between subcontractors and main contractor and the social processes that make up the communication of the prices.

Need to gather **demographic information** relating to the case that information is being gathered from, need to start to develop the concepts of transparency(information asymmetry) , organisation relations/ approach to supply chain, how the asset specificity is instantiated within organisations and how this influences project estimating

1.0 Introduction

Your organisation: turnover
Background of interviwee

SECTION ONE

Organisational

Developing relationships with subcontractors

2.0 Would you agree that the selection of the right subcontractors to bid is central to an estimates competitiveness, Would you say that your organisation has changed in its relationships with its subcontractors, if so how?

2.1 How may this vary with workpackage trade as some trades appear to be more critical to a bids success than others?

2.2 The role of the estimator includes bid assessment do you think that the more established links that exist changes your assessment of subcontract estimates, would it be possible to give examples?

(only to be asked if +ve answer earlier). How do you balance the need for competition and a reduced pool of organisations prepared to provide a price?

2.3 The survey indicated that certain trades of subcontractor will only provide a price if they feel that they are not in too large a competitive market, I wonder if you could shed any light on whether subcontractors who price a job for one m/c pass their quote to another mc in order to get a return on the costs of developing the estimate.

2.4 Do you feel that subcontractors assess the likelihood of an organisation winning a project before agreeing to provide a price for that organisation?

2.5 The survey data analysis indicated that organisations took a different approach to sending out enquiries to steel frame manufacturers and M and E, they both have an element of design, is this the Case In your organisation?.

2.6 Organisations appear to have differing approaches to send outing out for quotes behaviour when dealing with different procurement arrangements, if the works are quantified a full BQ they tend to send out more, is this solely because they are more likely to get prices returned?.

2.7 Would you say that you are limited by the small numbers of certain trades and bearing in mind the limited numbers of some trades, how do you know that one of your key subbies isn't pricing a proposal for another contractor?

SECTION THREE - SUBCONTRACT PRICE SELECTION

3.1 The survey indicated that estimators have a better ability to assess works that have been quantified; Do you feel some subcontractors take advantage of the lack of knowledge of pricing levels/specification details that exist within main contracting organisations?

Prompt: There seems to be a move away from estimating unit rates based on outputs and a move towards more market oriented pricing

3.2 How does the estimator assess the competitiveness of the prices received particularly if the workpackage is complex and the competitiveness of the bid is dependent on a keen price?

3.3 Do you feel that any subcontractors limit the information that's passed to you at tender stage in order to be commercial/opportunistic post contract ?

Do you have any systems that might pick this up?

SECTION FOUR - SCENARIO

Further information

The following questions are based on a scenario, a project that is approximately £5m, steel frame distribution warehouse, green field site for a know client. Tendering procedure: Competitive, design and build, geographically located within operating region, six weeks to complete the tender. Commence on site four weeks after tender submission.

4.1 Please could you explain the general processes that the organisation goes through to obtain a prices and particularly for the steel frame workpackage and the M and E workpackage?

(this relates to organisational behaviour, up to the receipt of a quote and be useful to identify processes, characteristics and dimensions)

4.2 What processes are used to cost plan the design during estimate development?, Does the need for competitive sc bids get in the way of developing a dialog ?

4.3 Does the organisation have a policy of offering incentives to workpackage subcontractors as the estimate develops, ie if the job is won the package is guaranteed. Are these incentives offered to all trades or just certain ones?

4.4 What would you say are the principal benefits to the estimator that accrue from long term relationships with subcontractors, does this vary with trade?

And finally the last question relates to the benefits from D and B,

4.5 The benefits to the client appear to relate to more about the m/c post contract processes of managing the risks between design s/c's rather than the opportunity to develop cost effective design pre contract, is this an accurate perception.

Thank and offer to send a copy of the completed research which will be completed early in the new year.

APPENDIX 9

Estimating Practice Survey 2003/4

Open Question Answers

Respondent no.	Organisation size	
2	<5	The quality of information is reducing and contains lack of clarity, conflicts of information, quite often additional information such as M and E packages/structural design comes after the initial enquiry.
13	<5	Far more reliance on schedules of rates/comparisons rather than 5 line pricing to basic build ups.
18	<5	Computerised systems are operating a new work, but traditional taking off and pricing are still in demand for alterations, extensions, refurbishments and specials.
21	25-49	Total reliance on subcontractors
22	5-24	Less Bills of quantities, more spec and drawings, fewer real design and build. More development from budgets/cost plans through to full estimate. Estimating software still in the BOQ era, fewer systems with more and more features but not easier to use and not addressing the problems.
24	5-24	Poor information from Architects/surveyors, less time to tender, increasing risk on contractor/ good support for IT.
27	5-24	Greater reliance on computers, less reliance on experience. More tendency to use lump sums for grouped items as opposed to detailed build up of unit rates.
34	>99	More work sublet Computer data used Alternatives explored more
39	25-49	Lack of good tradesmen to use, lack of time allowed by client for tender lack of bills of quantity, the client seems to think he is saving money by going for the spec and drawings. Wrong!

Respondent no.	Organisation size	
45	25-49	As a maintentance contractor we carry out all trades with our in house staff. Subcontractors are only used to iron out the peaks. We currently have 400 multi skilled operatives on the road.
64	>99	Quality of bidding documentation is declining, as a result of IT developments late changes are now the norm. Employers are not willing to enter into high front end engineering thus passing the burden of risk to the contractor.
71	5-24	There is a general move from bills of quantities to drawings and spec and design and build
89	25-49	Computer Estimating systems now help provide consistency of pricing, before the commercial consideration applied. Computers also provide far more analytical detail. The gut feeling however is still one of the best decision makers. There is a danger of estimating becoming too analytical and losing its human touch. Competitive tendering and BQ tendering has reduced the latter more than the former. Estimators are required to produce their own BQ. Negotiation is on the increase.
115	<5	Bills of quantities being supplied for estimates is now rare; Drawings and specifications is now the norm.
116	5-24	V comprehensive comments see questionnaire.

Respondent no.	Organisation size	
117	25-49	Too many tender packages are poorly prepared, inadequately researched by consultants/professionals that do not understand the basics of building construction taught as a fundamental in the 60's. H and S and CDM too often placed in the contractors court and the client and the consultant ignore their responsibility. The estimator spends more and more time correcting bad documentation or ignores it and prices for a claim.
120	5-24	Becoming increasingly harder(and more frustrating) due to poor drawings, specifications, bills of quantities. Also given less time in which to prepare tenders. Subcontractors do not return quotations on time.
132	<5	The estimating process is now a team activity, involving planners, QS's, contracts managers, H ans S IT
134	<5	Increasing use of PPC2000 leads to supply chain management,use of subcontractors.
135	5-24	Continuing use of clients use of specification and drawings in lieu of BQ's. Apparent decline of estimators with ability/experience in building up unit rates from first principles.
142	5-24	Information provided is getting poorer, so many other influences (health and safety- contract conditions) Computer technology makes the number crunching easier and information availability better.

Respondent no.	Organisation size	
143	>99	My function is preparing target cost estimates under ECC contract cost reimbursement. Our contract is with Welsh Water and is a framework partnering contract with tier 1 and tier 2 supply chain partners for materials and sub contract works, we undertake direct works also we are committed to Cl. I have not prepared formal tenders for 3.5 years but still use software spreadsheets and cost feedback.
146	<5	Now using computer system (conquest 3rd system tried)
159	50-99	Very detailed remarks see quest for more detail., excellent points made.
160	Not indicated	Role seems to be reducing in spec housebuilding. – Appears to be relying on obtaining ....tender and using it in forecast. The days of a complete detailed estimate which is used as the start of the forecast total cost to which actual costs are compared to is rapidly disappearing.
164	<5	Shorter documentation, more responsibilities, v.much more stressful, zero job satisfaction
170	>99	The emphasis is moving to bid management and a broader approach to the tender process including risk analysis.
177	<5	Same system used for 20 years consistent results. Site visits needed to check labours against aging workforce!
188	>99	The use of the conquest estimating system and email have changed the software and replaced spreadsheets and the use of comp operators. The main problems that lie ahead are training a new generation of estimators. Who will replace the existing, old, grey and experienced lads?

Respondent no.	Organisation size	
192	5-24	Far fewer bills of quanity, detail in BQ a lot less, specification without a schedule of rates increasing, more decision making needed by estimator, subcontractors role far more important, subcontractors more capable in their submissions.
205	<5	Estimating is much more of a team activity than a function fulfilled by one individual. The sue of computers, health and safety issues, the management of risk and the sheer volume of some tender enquiries have all had a profound effect on the estimating process. There are times when I find there is little to recommend it but much depends upon the contractor.
208	50-99	I am an old school estimator with many years computer estimating experience. I ow basically work for a groundworker/RC fram contractor who employs direct labour. I left main contracting because I could no longer use my skills as an estimator. Many estimators lost out in the last recession- I do not know what is going to happen in the industry when my age group retires. Main contractors just assemble quotes.
215	>99	Cost planning is only carried out by the estimator final cost estimates/tender produced by the site team during preferred bidder stage.
220	>99	Experience is essential duo to poor information at tender stage and the difference procurement routes now available for a client to chooso from.
232	<5	More selective on pricing of works. Negotiation on one to one basics formulated on a budget.

Respondent no.	Organisation size	
236	<5	Over the years the estimating process has not changed greatly although the documentation available at the tender stage has. More emphasis in now placed on safety which is correct. When it comes to the actual bills are now rare, the quality of specifications is reducing with less emphasis on detail. Performance specifications are becoming more common resulting in more work and responsibility for the estimator. This can lead to significant variations in the tenders that are submitted.
239	>99	Closer ties with subcontractors have led to more confidence in tenders rather than the old days when we fired out to many enquiries to get the lowest(often too low) prices in the market. Large design and build tenders require a bid manager as well as an estimator to cope with the large amount of information aked for in the submission document.
241	50-99	The use of two stage tender process is becoming more and more common. As such the role of the estimator is moving to more to that of procurement.
243	<5	Partnering and management style contracts reduce the need for traditional estimators except that subcontractors now need to employ estimators due to the type of packages they are asked to price.

Respondent no.	Organisation size	
249	25-49	The quality of the information is declining With D and B contracts the specification is poor and the drawings little more than sketch details. Subcontractors are more interested in pricing bills of quantities only Response from subcontractors are becoming more difficult. Tendering is becoming shorter than ever.
254	5-24	More design and build contracts with not enough time for the design element.
255	5-24	Estimating is no longer a science but an art We rely more on knowledge and quotes than building up unit rates The quantity of most tender documentation is very poor, this leads to ore risk put upon the builder. The estimators role is therefore mainly assessing risks Straightforward enquiries with bills are be3coming rare as are most drawings and spec. This all leads to the post tender evaluation process becoming more complicated and drawn out.
258	5-24	For too long prices/profits/etc have been cut by own competitiveness and client attitude. It used to be price first now its safety first and quality is also more important. There has been too much waste of estimating, tendering energies instead of team working managing risk and reducing waste. There has been a lack of trust .

Respondent no.	Organisation size	
261	5-24	The information at tender stage is becoming poorer and poorer.
264	5-24	Rapidly transforming into IT format but key decision making should be manually handled by the estimator.
267	25-49	Fax helps quick quote return now email is adding to this IT helps through quick communication and is getting better IT computerised methods is not as quick as the old manual method but is now universal Project collaboration eh internet posting drawings to a software server is not very good Tesco and waitrose do this but my experience is not frequent but what I have experienced is not satisfactory.
282	>99	Analytical(unit rate) estimating has a lesser role. Two stage tendering and frameworks using open book procurement is becoming common practice. PFI bids and presentation techniques are as important as traditional estimating skills. Main contractors no longer employ direct labour, relying on subcontract packages but the ability to build up unit rates and establish net costs is vital. Tender periods and bid periods are inadequate increasing risk and pressure.
283	25-49 Specialist trade contractor	Subcontractors now provide "all in lump sum" total price It is difficult to understand how they built up these figures to achieve the total lump sum. Only repeat business develops close links.

Respondent no.	Organisation size	
284	50-99	Currently a larger number of tenders are two stage, when you tender on prelims and overheads, then get involved in 2nd stage with client to develop cost and consult.
292	25-49	The quality of the documentation provided by the so called professional bodies is getting progressively worse. More guesswork= higher tenders. The ability of professional bodies to respond to tender stage queries is also deteriorating. Failure to respond to queries= higher tenders.
293	5-24	The estimating process is changing as more clients are providing less information therefore more risk to contractor an at tender stage this means more pressure on estimator.
301	>99	Bidding process is becoming too protracted.
307	25-49	Competitive tendering disappearing, collaborative partnering taking over. Cost planning role now most important (ie balanced view of costs rather than assessment of the most competitive costs.)
308	>99	Less Bills of quantities, more spec and drawings, more PFI . Much more risk put on contractors and subsequently subcontractors. S/c becoming more self sufficient in terms of prelims. Clients becoming more involved with design. Life cycle costs becoming more influential – cheapest is no longer best.

Respondent no.	Organisation size	
314	<5	Not received a bill of quantities in last four years. Subcontractors don't understand cost planning. Universities avoid the teaching of estimating- could use visiting lecturers to plug the gap.
322	5-24	More reliance on specialist subcontracting to resolve shortcomings of clients engineers. Greater input to resolve architect/Qs shortcomings. Less analytical estimating being carried out/less ability for estimators to do analytical estimating- lack of time to train analytically. Greater reliance on subcontractors to quote at tender stage.
332	25-49	The percentage of traditional BQ and plan and spec enquiries has dramatically reduced. Design and Build enquiries with the estimating function growing towards bid manager/design build coordinator per contract.
341	50-99	Tender periods becoming shorter due to designs not being progressed quickly enough and client end dates still being required. Estimators making more assumptions on specifications as designers are not completing them at tender stage. Overall effect is that the client doesn't get an apples for apples view of his price therefore the cheapest then get their feet under the clients table.
351	<5	Use of BoQ's by clients almost non existent- always spec and drawings and they usually include errors and many unclear items requiring further investigation by us.

Respondent no.	Organisation size	
359	<5	Having to identify additional work and alterations through poor information provided by architects etc. Vague specifications provided for specialist goods.
362	5-24	Analytical estimating is no longer the main process many so called estimators obtaining sub contract quotes on a labour, plant and material basis is their short cut to a tender figure.
366	5-24	Computerised estimating is becoming more common as software becomes more user friendly. Computers speed up the pricing process allowing last minute changes to rates which instantaneously amend final tender figures. Previously priced projects can be recalled for comparison with current tenders. Tender periods are being reduced due to improvements in communications; quotations from subcontractors and suppliers can be received next day by fax.
368	50-99	Main contractors are attempting to offload risk onto subcontractors.
378	5-24	Less involvement with the whole process to include preparing the quantities or checking them. Too much reliance on subcontract packages as indicated by the survey as there is no mention of how or comment on building up rates from first principles but mainly on subcontractor risk assessment.

Respondent no.	Organisation size	
401	5-24	Computerisation of the estimating process allows for more rapid tender development, instant cost changes, more detailed analysis of information upon which better decision making can be made.
406	<5	Computer software packages are getting better and quicker and therefore they will become an ever increasing tool in the future. Estimating packages can be used to cost variations giving an edge over the pqs who do not generally have estimating packages.
409	25-49	Movement to more design and build contracts with contractor accepting responsibility and risk of design. Worsening of tender documents received from consultants, clients do not seem to want to pay for lot of preparation of full and accurate design and quantities prior to going out to tender. Lot more work is passed onto tendering contractors with no reimbursement or increase in tender period.
412	>99	We are experiencing significant changes in procurement methods in that more and more tenders are using two stage processes and quality criteria in the selection of contractors.
416	50-99	The estimators role has changed by the use of IT packages used to price BoQ's, form unit rates and store historical information. Role has become far more demanding (many tenders to price) with fewer good sub contractors to use and assist with the estimate.

Respondent no.	Organisation size	
418	<5	The estimating process has not changed. What has changed is that project information at tender stage is becoming poorer with the contractor having to qualify more in his submission. There seems to be more of a "catch the contractor out" ethos by clients and their team.
426	>99	Resource costs: now based upon supply/demand of skills rather than calculated output. Eg bricklayers can charge a lot more than you expect based on standards alone. Advent of poor documentation. We have to more vigilant when communicating with the the project team who do not seem to always give best service to the client. Shortage of skills: Generally poor response from specialists on short notice jobs involves complicated negotiations. Interviews/meetings Have to attend a lot, which keeps one away from the estimating function.
449	5-24	Hopefully computer technology will improve the standard of estimating practice which in my experience is sadly lacking.
451	5-24	I find as time goes on I am becoming more involved during contract and post contract stages.

Respondent no.	Organisation size	
453	>99	The quality of information and documentation is generally poor. The trend is to issue any poor documentation, force the contractor into preparing his own BQ(at his cost)- and impose unacceptable terms and conditions that do not help the tender process. There is a change back to traditional BQ and traditional tenders by LA (away from management and D and B).
454	>99	The estimating process has changed radically over the past years to accommodate the procurement routes demanded by clients. The changes have been from the traditional BOQ standard system to the design and build process in its various formats from competitive tender to two stage tendering to preferred contractor status with risk transfer from client to contractor.
459	>99	Over the last five years construction organisations have made their estimating function more and more efficient, ironing out the troughs in workload. This trend is continuing where construction companies are shedding their estimating staff, retaining one senior staff member to manage the process through the use of freelance estimators. In this respect relationships matter. I have personally seen 3 companies change to working this way during the last three years.

Respondent no.	Organisation size	
472	5-24	Traditional procurement are often "bastardised" to switch the risk to the contractor. The quality of information provided by the QS/Employers agent seems to be deteriorating with each project. You should consider a box above for assessing the risk of information not provided with tender package.
473	<5	Bills of quantities becoming rarer. Plan and spec tender documents declining in quality Design teams expertise declining, QS becoming rarer. Code of procedure for tendering generally quoted but ignored regarding tender periods, notifying results and examination of prices.
474	5-24	With the assistance of Conquest and an excellent all round team tendering/analysis/risk is not a problem. One key area of assistance is partnering both suppliers and subcontractors.
482	>99	Supply chain management is putting pressure on commercial decision making/bidding tactics.
485	50-99	The requirements for producing estimates have become more urgent in its process this being due to information technology, email etc. People's expectations are that much greater because of this thus increasing the pressure on estimators to produce the goods.

Respondent no.	Organisation size	
491	5-24	Unfortunately the estimating process is being restricted by unrealistic tender periods. This in return results in main contractors carrying too much risk which leads to claims orientated contractors and unhappy clients.
503	50-99 Specialist trade	Electronic tendering Other electronic system eg a site, bias, drawings being sent by email. Information overload eg tender packages for trade contractors being sent with information not relevant to there trade. Less time to complete estimates.
507	>99	It should be noted that I work on a PFI healthcare project, we have recently been awarded PB, with FC Project value is £800m. Our SPV is made up of a number of companies and the D and C JV is 50/50 Building contractor/ specialist services constructor. We are keen to integrate specialist contractors into the supply chain/design process early to eliminate potential cost problems at a later date.
508	>99	Moving towards partnering/negotiated two-stage tender process, less emphasis on lowest price, more on best value.
509	50-99	More design and build, more drawings and specification –less bills of quantity More tenders to price every year More concentration on risk but very little knowledge of statistical considerations which is where it should come from More disenchantment with partnering.

Respondent no.	Organisation size	
518	<5	Estimating at our end of the market is hardly changing IT is the future but seems a long way off at this time.
519	5-24	Less time and lack of detailed information, more emphasis being placed on contracting skills and knowledge, less on input form professional team. Quality of tender documentation is deteriorating.
521	>99	Pfi Procurement- More cost planning rather than detailed estimates.
523	5-24	Analytical estimating is disappearing as construction training has deteriorated. Estimators are becoming quotation managers this incresse risk areas as the reliance on subcontractors increases. The use of "data base" estimating systems will add to the reduction of quality estimators.
525	5-24	From my own experience and the observations within the firm that I have recently joined I would say that over the last fifteen years there has been very little change. The essential discipline remains the same ie experience, accuracy and reliance on good historical data.
537	>99	In my opinion we appear to have lost our way a little with regards to first principle estimating, it is great to press a key and print reports etc but building up a rate from basics could be a problem for some people.

Respondent no.	Organisation size	
538	5-24	More use of subcontractors pricing over analytical pricing methods which is leading to all in rates and erosion ot traditional methods, coupled with computerised estimating schedules is slowly leading to estimating by proxy.
550	25-49	I believe the estimating role has become far more complex with regard D and B contracts. The Estimator is now fulfilling the role of pqs, design coordinator as well as estimator. There seems to be little recognition of this or the pressure involved in producing quality bids eliminating risk. It would be interesting to know of the age profile it seems to be a function in decline.
554	<5	Improvement in IT Restriction on sc availability due to workloads Shorter tender periods, effect upon final costing to detriment to all parties.
555	>99	Less B.Q's produced by client. Greater requirement to develop an initial price and then work with the client as a preferred contractor in finalising the lump sum contract before any contract is awarded.
559	>99	Partnering supply chain agreements, increase size of contracts, increase in risk taken by contractors. Lack of feedback on bid results.
562	5-24	Not changed significantly in the last 10 yrs.

Respondent no.	Organisation size	
563	<5	In 1961 when I entered the building trade estimating was done mainly by people who had practical experience on sites with natural progression they achieved positions of responsibility in estimating , nowadays estimators come form university with little site experience This provides more articulate assured estimators who may be very good or very bad. Young estimators who move from job to job should be avoided.
584	<5	The quality of design and project information provided at tender stage by clients appears to be getting worse. The time in which to prepare tenders diminishes and the overall risk as a contractor increases as a result.
591	5-24	Too many clients are taking the easy way out of the tendering process and putting the risks back to the contractor thus costing more for the estimating process, together with trying to stitch up contractors by changing standard forms of contract unnecessarily.
604	5-24	Closer use of smaller list of specialist sc is v.impt. Client/prof time scales for tenders will never improve. All steps have to be taken to maximise efficiency in tender pricing. We have agreed pricing rates with merchants format common materials for the same reasons and saving in post contract buying time.

Respondent no.	Organisation size	
625	5-24	Tender process is becoming unreasonably shorter. Info/drawing at tender stage is becoming less and of poorer quality- more onus on the estimator to provide cost on his own designs for elements which are not completely designed or lacking information. Lack of information leads to an increase in spread of tender values since individual perceptions of each estimator is different ie not all pricing is like for like any more.
631	>99	The estimating process is changing due to the move towards partnering contracts. This has resulted in looking for best value rather than always going for the lowest price. This in itself poses problems as best value is harder to ascertain.
639	5-24	As the industry moves towards totally sub letting works packages to subcontractors, the estimators role has changed from pricing 40-45% of the main trades in a bill of quantities to becoming a bid manager where far greater emphasis is placed on analysing subcontract bids.
640	5-24	The advent of design and build has changed the role from being key individual to a team member.
643	5-24	There is more risk analysis involved due to poor documentation, less cost in preparation of tender documentation by design team means more work in assessing where to pitch tender and far greater variance in tender pricing levels.

Respondent no.	Organisation size	
666	>99	I believe the estimating process is becoming more risk lead than price lead. It is also becoming more selective. Although I believe that professional bodies are becoming less responsible for their designs. Although CDM regs should be making them more responsible.
674	5-24	Quality of information provided in general by clients representatives is poor but tender periods are shorter then ever.
669	5-24	I believe that the role of the estimator is changing in that no longer do I have to necessarily build up rates for work. Generally employers look to nullify risks by ensuring subcontractors rates are inserted into the bill. The estimator has become a risk manager rather than a skilled estimator building up rates from first principles.
700	>99	Management selecting future estimating IT software on its ability to provide management/accountancy tools with less regard to its ability to produce estimates quickly and flexibly.
701	25-49	IT seems to be playing a greater role not only in production of the base estimates but also in sharing of information with project consultants and in house departments. There also seems a shift in risk apportioned to the contractor through an increase in D and B tenders. There is no increase in tender periods despite the shift in procurement methods.

Respondent no.	Organisation size	
702	5-24	The design team seems to be doing less work on projects due to competitiveness of their fees. The majority of tenders now come out as spec and drawings but should be on BoQ. This puts more pressure on estimators in terms of risk and work load.
704	25-49	Pricing is becoming far more cut throat which is making us all competitive which in turn is damaging the supply chain- All of this is being driven by the design team....lowest price wins 98% of our tender process...and with online downward bidding . What is happening to the Egan/Latham principles. Great idea for contractors not being adoped and pushed by commercial clients and their design teams?
708	25-49	It has diversified into numerous procurement routes, which suit individual or groups of businesses. Although many businesses publicly claim that certain routes are "the way forward" such as partnering, in reality there is room and a need within the construction industry (and it is wanted by clients /end users) for all procurement routes, competitive tendering, negotiated
720	>99	Some young dinosaurs will never change, some old hip guys embrace the technology in the belief that they will keep up to date but basically there is still no trust between the clients and construction companies. Henco D and b, plan and spec and bespoke methods of measurement.

Respondent no.	Organisation size	
728	50-99	I am involved in heading up the estimating department . 90% of our work is partnered and rest negotiated and 1-2 tenders per year. We are providing the role of cost consultant rather than estimator. Role is changing to encompass cost planning at key stages, feasibility, cost plan
730	5-24	Much greater reliance on IT. More reliance on multi tasking ie some qs work. Time frames even shorter, greater involvement in the design process/coordination.
734	5-24	When I started estimating over 25 years ago you put 5% recovery/profit onto a job. If you were keen to win you would knock 2 % off. If not leave it or even put between 3 and 5% on top and still stand a good chance of winning. Who ever thought of email tendering wants f***ing shooting.
735	50-99	Estimating is moving away from factual rate build up based on real time costs across whatever it takes to win the job. Factual information on productivity is disappearing. Nobody in any company I have worked for knows how long it takes a man to dig a whole (sic). This is due to more partnering and negotiated contracts with clients having a budget and a director making the decision- can we do this for the money?

Respondent no.	Organisation size	
740	5-24	Tender periods get shorter but information transfer improvements compensate for this. We now play an ever increasing role in working with and influencing the design team pre contract. Profit is no longer seen as a dirty word by the employer when selecting a contractor.
742	>99	The submission documentation that clients require at tender stage has increased. The client used to be content with a completed form of tender and/or BQ. Nowadays submission documentation entails pricing formulation plus programmes, method statements and management structure charts, CV's etc. Such is the additional information required that additional staff are required increasing overheads.
753	>99	I run the tender department for a major civil engineering national contractor. There is a growing pressure from public sector clients to demonstrate continuous improvement from an incentivised supply chain. Additionally the traditional view of cheapest at tender is thankfully giving way to an ethos of assessing best value through sustainable accounting and whole life costs. Happy to help with your research.

Respondent no.	Organisation size	
757	25-49	The role of the estimator has changed dramatically from when I started about 10 years ago. Estimators are now much more at the forefront including involvement in design issues. We now have a much bigger input pre contract since the introduction of partnering contracts. We have a greater relationship with consultants. Cost planning is becoming much more widespread and also 2 stage tendering.

APPENDIX 10

Propositional Framework

Specificity: Specificity is defined using Williams terms as the ability to replace a resource
Governance: This is defined using Williamson's terms as the control of organisations supplying a good or service
Opportunism: seeking advantage through guile or information asymmetry
Small no's: Availability of resources with capability
SC Partner: Organisation that has a relationship with a main contractor
Competitive advantage: An organisations behaviour in attempting to gain advantage
Supply chain technology: The specialist technology supplied by the supply chain
SC Market: The market existing in a particular technology
SC Governance; The mechanism for financial control of supply chain organisation
Procurement: Systems used by client to procure a project
Ex ante process: Estimating processes to compile a price for a client
Client Governance: Mechanism adopted to financially control a contractor
Technology: Project technological requirements
Constraints: Project constraints, subcategorised into time, risk
Bounded rationality: The scope of the estimator to make rational decisions
Motivation to learn: The incentives/ absorption capacity of the estimator
Information impactedness: The information environment that estimating decisions are made in

Propositional statements

P1: *The specificity of the resource has an effect on the governance mechanisms adopted by the main contractor.*

P2: *The specificity of the resource is considered by main contractors to give competitive advantage.*

P3: *Small numbers of specialist subcontractors cause conditions that have an effect upon the specificity of such resources.*

P4, P26: *The supply chain technology has an effect upon the governance mechanisms adopted by contractors.*

P5: *The asset specificity had an effect upon the project procurement processes adopted by main contractors, this includes the extent of use of the market as well as ex ante processes.*

P7: *Asset specificity had an effect on the project financial management mechanisms constraints*

P9: *An individuals motivation to learn about resource costs is indirectly influence by the governance mechanisms adopted and their role, where there is alignment the learning relates to the process of alignment, where there is no alignment the motivation is to learn about resource costs.*

Specificity: Low ie use of spot markets----High integration of resources---Attributes Human, Locational, technological
Governance: Tight – Information agreement, high levels of defined process-----Loose, lump sum
Opportunism: High –advantage gained by sc----------Low- Little opportunity
Small no's: Availability of resources with capability
SC Partner: Strategic, exclusive-----Project, limited
Competitive advantage: Clustered sc, managed--------fragmented, loosely managed
Supply chain technology: High, specialised----------Low, Human
SC Market: Competitive----------non competitive
SC Governance; Aligned to client---------Aligned to contractor
Procurement: Well defined systems for uncertainty----------Fuzzy definitions of uncertainty
Ex ante process: High interdepence of mc/sc---------Low interdependence mc/sc
Client Governance: High level of performance ambiguity--------Low levels of performance ambiguity
Technology: Complex technology----------Simple technology
Constraints: Time—Tight---Loose, Risk---Defined---Undefined
Bounded rationality: Low uncertainty---High uncertainty
Motivation to learn: Big incentives to learn/high absorptive capacity – low incentive/low absorptive capacity
Information impactedness: High quality reliable information----Low quality unreliable information

P10: Related to P9, the governance mechanism adopted had an effect on the information impactedness of the decision maker.

P11: Asset specificity has an effect on an organisations propensity to share information which has an effect on the informational environment of the estimator

P12& P13: Small numbers in the market place have an effect upon organisations partnering behaviour and consequent ex ante estimating processes.

P15: Subcontract partnering has an effect upon main contractors competitive advantage.

P16: Subcontract partnering has an effect on the governance mechanisms adopted by main contracting organisations.

P17: Subcontract partnering has an effect upon the ex ante processes adopted by main contractors.

P19: Subcontract partnering has an effect upon the informational impactedness of estimators decision-making.

P20: An organisation competitive advantage has an effect upon the governance mechanisms adopted which has a corresponding effect upon the ex ante processes.

P21: An organisations intention to gain competitive advantage has an effect upon its subcontract partnering behaviour.

P22: An organisation gains competitive advantage by coordinating its ex ante processes with its supply chain partners.

P24: An organisation maintains its competitive advantage by developing information systems that reduce the information impactedness of the estimator decision making.

P25: Access to supply chain technologies causes asset specificity to those organisations that have such access.

P26: Supply technologies have a specific culture of governance that is accepted by parties.

P27: Supply technology has an influence on the number and type of relationships that main contractors develop with the supply chain.

P28: Access to supply chain technologies causes organisation conditions that lead to competitive advantage.

P29: Supply technology has an effect on the governance mechanisms adopted by main contracting organisations, ex post. Cf P26 which relates to the market place.

P30: Supply chain technology has an effect upon the information impactedness[1] of the estimator's environment. (This environment is mainly focused on ex ante information as the ex post governance is not a big feature of estimators perspectives-see quant model.)

P31&P32: The market that subcontractors are engaged within has an effect on their asset specificity as measured by the main contracting organisation. (This is related to their workload, propensity to bid/engage with mc as the network effect can cause them to decide to pull out of projects)

P33: The market environment for subcontractor technologies has an effect on main contractor ex ante processes.

P34: The mechanisms adopted by main contractors for subcontractor governance (which are sometimes directed by the sc) have an effect upon the extent and type of ex post opportunism[2] that can develop.

P35. The acceptable subcontractor financial governance mechanisms have an effect upon the effectiveness of the deployment of project controls.

P36: The acceptable subcontractor financial governance mechanisms have an effect upon the motivation for the firm to develop adaptive learning.

P36a: Project procurement arrangements (in the methods used to control cost, time and quality) have an effect on the asset specificity of an organisation.

P37: Project procurement arrangements (in the methods used to control cost, time and quality) have explicit governance mechanisms, which have a consequential effect upon the governance of a transaction.

P38: Project procurement arrangements (in the methods used to control cost, time and quality) have an effect on the behaviour of main contracting organisational behaviour of partnering subcontractors.

P39: Project procurement arrangements (in the methods used to control cost, time and quality) have explicit governance mechanisms, which have a consequential effect upon the governance of a supply chain party.

P40: Project procurement arrangements (in the methods used to control cost, time and quality) have an effect upon ex ante process adopted by organisations with their supply chain.

P41: Project procurement arrangements have an effect upon the types of constraints m/c can adopt with their s/c.

P42& P43: Project procurement arrangements have an impact on the informational environment of the estimator and have a consequent limiting effect on the estimators decision making.

P44: The ex ante processes adopted by mc have an effect on a supply chain org's specificity.

P45: The ex ante processes adopted by mc have an effect on the market governance of the supply chain

P46: The ex ante processes adopted by mc have an effect on the project governance of the supply chain.

P47: The ex ante processes adopted by mc have an effect on the clients project governance of the supply chain.

P48: The ex ante processes have an effect upon the types of constraints m/c can adopt with their s/c.

P49: The client governance mechanisms have an effect upon the supply chain opportunism.

P50: The client governance mechanisms have an effect upon the ex post governance.

P51: The client governance mechanisms have an effect upon the ex ante processes with the supply chain.

P52: The client governance mechanisms have a effect upon the financial constraints that apply to projects.

P53: The client's governance mechanisms effect the environment and the estimator's motivation to learn.

P54: The project technology has an effect upon the asset specificity of the supplying organisations.

P55: The project technology has an effect upon the type of effective governance for the supplying organisations.

P56: The technology has an effect on the ex ante processes of the M/c organisation.

P57: Note need to reflect on the definition of these, are they constraints or are they implied by the project procurement mechanism.

APPENDIX 11

Nvivo Coding Structure

Appendix eleven: Nvivo coding structure

Vivo revision 2.0.161 Licensee: Andrew Ross

Project: Supply chain and estimating 12 User: Administrator Date: 08/02/2005 - 14:57:25

NODE LISTING

Nodes in Set: All Nodes
Created: 09/12/2004 - 20:06:22
Modified: 08/02/2005 - 14:36:05
Number of Nodes: 219

1 accuracy
2 advantages
3 antecedent process
4 at risk
5 broader role
6 change
7 design coordination
8 design impact M and E
9 design input M and E
10 director
11 discount
12 early design
13 estimating costs
14 estimators opinion on specificity
15 future
16 geographic
17 initial selection
18 integration
19 Life cycle
20 M and E consultant
21 maintenance
22 post contract governance
23 price perception
24 project opportunity
25 qualification
26 relationship value
27 sc feedback
28 SC org resources
29 sc tender cost
30 sceptisicm
31 scope of estimating
32 standardisation
33 strategic resource
34 transformation
35 value chain
36 work package contents
37 (3) /Method
38 (3 8) /Method/interview context

Description:
Some reflections on the methodology

39 (5) /Project environment
40 (5 1) /Project environment/Small Numbers
Description:
Lower order factor within the project environment coded to reflect the availability of subcontractors to gather prices from
41 (5 2) /Project environment/Governance Structure
Description:
A lower order factor child relating to the use of the market/quasi integration of the subcontractor and other contractors and also the market sectors.This is defined using Williamson's terms as the control of organisations supplying a good or service
42 (5 2 1) /Project environment/Governance Structure/Components
43 (5 2 1 5) /Project environment/Governance Structure/Components/Suppliers
44 (5 2 2) /Project environment/Governance Structure/opportunism
45 (5 2 3) /Project environment/Governance Structure/Indirect cost estimate
46 (5 2 4) /Project environment/Governance Structure/Autonomy
47 (5 3) /Project environment/Processes
48 (5 3 2) /Project environment/Processes/Estimating
49 (5 3 2 1) /Project environment/Processes/Estimating/Parties involved
50 (5 3 2 2) /Project environment/Processes/Estimating/Definition
51 (5 3 2 7) /Project environment/Processes/Estimating/Enablers
52 (5 3 3) /Project environment/Processes/Tender
53 (5 3 3 1) /Project environment/Processes/Tender/Process
54 (5 3 3 1 1) /Project environment/Processes/Tender/Process/Parties responsibility
55 (5 3 3 1 2) /Project environment/Processes/Tender/Process/Estimators role
56 (5 3 3 1 3) /Project environment/Processes/Tender/Process/Mark up
57 (5 3 3 1 4) /Project environment/Processes/Tender/Process/Decision making
58 (5 3 3 2) /Project environment/Processes/Tender/competition
59 (5 3 3 2 1) /Project environment/Processes/Tender/competition/competitive element
60 (5 3 3 2 2) /Project environment/Processes/Tender/competition/Interfirm
61 (5 3 3 3) /Project environment/Processes/Tender/Assessment
62 (5 4) /Project environment/Temporal specificity
Description:
Lower order factor in the projectl environment coded to reflect the time/hold up specificity of subcontractors relationships
63 (5 4 1) /Project environment/Temporal specificity/specificity M and E
64 (5 4 2) /Project environment/Temporal specificity/steelwork specificity
65 (5 4 4) /Project environment/Temporal specificity/Specificity threat

66 (5 4 5) /Project environment/Temporal specificity/Incentives
67 (5 5) /Project environment/Subcontractor Price
Description:
A lower order factor within the project environment reflecting the specificity suggested by a price to a main contractor. Price that is specific to one organisation
68 (5 5 1) /Project environment/Subcontractor Price/asset protection
69 (5 5 2) /Project environment/Subcontractor Price/small number
70 (5 5 4) /Project environment/Subcontractor Price/Design capability
71 (5 5 5) /Project environment/Subcontractor Price/Price communication
72 (5 5 6) /Project environment/Subcontractor Price/trade differentiation
73 (5 5 7) /Project environment/Subcontractor Price/trust
74 (5 6) /Project environment/Specificity technology
Description:
A lower order factor within the project environment reflecting the specificity suggested by technology to a main contractor. Project technological requirements
75 (5 6 2) /Project environment/Specificity technology/small number
76 (5 6 3) /Project environment/Specificity technology/Pricing capability
77 (5 6 4) /Project environment/Specificity technology/Design capability
78 (5 6 5) /Project environment/Specificity technology/Price communication
79 (5 6 6) /Project environment/Specificity technology/trade differentiation
80 (5 6 7) /Project environment/Specificity technology/trust
81 (5 7) /Project environment/Organisational capability
Description:
Perception of the product complexity during the estimating process and the organisations ability to cope with the project.
82 (5 7 3) /Project environment/Organisational capability/Risk Management
Description:
Lower order factor within project environment organisational capability
83 (5 7 3 1) /Project environment/Organisational capability/Risk Management/Risk registers
84 (5 7 3 1 1) /Project environment/Organisational capability/Risk Management/Risk registers/Risk register reuse
85 (5 7 3 2) /Project environment/Organisational capability/Risk Management/Design risk
86 (5 7 3 3) /Project environment/Organisational capability/Risk Management/Risk adjudication
87 (5 7 10) /Project environment/Organisational capability/Postcontract
88 (5 8) /Project environment/Product development
Description:

A lower order factor within the project environment reflecting the ex ante processes between mc and subcont as the design develops. The extent the design required development

89 (5 9) /Project environment/Transaction protection
Description:
A lower order factor within the project environment coded to reflect the asset protection from subcontractor to main contractor. Non-release of information to protect price.

90 (5 9 1) /Project environment/Transaction protection/negotiation

91 (5 10) /Project environment/Subcontract capability
Description:
Child within the project environment high level category of factors that reflected the design and price capability of the SC. Subcontractor capability pricing

92 (5 11) /Project environment/Client control
Description:
This node relates to the relationship between the clients and the main contractors and is a child within the project environment defined as mechanism adopted to financially control a contractor

93 (5 11 2) /Project environment/Client control/Supply chain manager

94 (5 11 12) /Project environment/Client control/Client

95 (5 12) /Project environment/Constraints
Description:
Lower order factor within the project environment to relfect the constraints faced by the estimator when gathering and analysing data. Constraints imposed by client procedures

96 (5 12 1) /Project environment/Constraints/resource constraint

97 (5 12 2) /Project environment/Constraints/Time constraint

98 (5 12 3) /Project environment/Constraints/Information constraint

99 (5 12 4) /Project environment/Constraints/Prof resource constraint

100 (5 13) /Project environment/Bilateral dependency
Description:
Two way dependence between organisations

101 (5 13 1) /Project environment/Bilateral dependency/work package contents

102 (5 13 2) /Project environment/Bilateral dependency/transparency

103 (5 13 3) /Project environment/Bilateral dependency/transaction protection

104 (5 13 4) /Project environment/Bilateral dependency/trade differentiation

105 (5 13 5) /Project environment/Bilateral dependency/alignment
Description:
Refers to the alignment of price risk, specification and ex post governance misalignment risks.

106 (5 13 6) /Project environment/Bilateral dependency/ex post governance

107 (5 13 7) /Project environment/Bilateral dependency/ex ante process

108 (5 13 8) /Project environment/Bilateral dependency/Opportunism

109 (6) /Task environment

110 (6 1) /Task environment/Motivation to learn
Description:
The incentives/ absorption capacity of the estimator
111 (6 1 1) /Task environment/Motivation to learn/Spot meetings
112 (6 1 1 1) /Task environment/Motivation to learn/Spot meetings/Membership
113 (6 1 2) /Task environment/Motivation to learn/from site
114 (6 1 3) /Task environment/Motivation to learn/site process learning
115 (6 2) /Task environment/Comparability
Description:
The comparability of prices between different trades
116 (6 3) /Task environment/Information impactedness
Description:
The informational bounds imposed on the estimator
117 (6 3 1) /Task environment/Information impactedness/Uncertainty
118 (6 3 2) /Task environment/Information impactedness/project cost information
119 (6 3 3) /Task environment/Information impactedness/project information
120 (6 3 4) /Task environment/Information impactedness/information augmentation
121 (6 3 5) /Task environment/Information impactedness/From Site
122 (6 3 5 1) /Task environment/Information impactedness/From Site/Trust
123 (6 3 5 2) /Task environment/Information impactedness/From Site/cvr meetings
124 (6 3 5 3) /Task environment/Information impactedness/From Site/feedback
125 (6 3 6) /Task environment/Information impactedness/IT system
126 (6 4) /Task environment/Estimator capability
Description:
Ability to assess technological alternatives
127 (6 4 1) /Task environment/Estimator capability/Estimator
Description:
First definition after interview with John Rogers
128 (6 4 1 1) /Task environment/Estimator capability/Estimator/Experience
129 (6 4 1 1 1) /Task environment/Estimator capability/Estimator/Experience/Current firm
130 (6 4 1 1 2) /Task environment/Estimator capability/Estimator/Experience/Past firm
131 (6 4 1 1 3) /Task environment/Estimator capability/Estimator/Experience/Previous Functions
Description:
The previous function of the individual is gathered to ascertain their experience with information sources within the organisation.
132 (6 4 1 2) /Task environment/Estimator capability/Estimator/Construction Knowledge

133 (6 4 1 2 1) /Task environment/Estimator capability/Estimator/Construction Knowledge/Theoretical
Description:
Qualifications and educational background
134 (6 4 1 2 2) /Task environment/Estimator capability/Estimator/Construction Knowledge/From others
135 (6 4 1 2 3) /Task environment/Estimator capability/Estimator/Construction Knowledge/Practical
136 (6 4 1 3) /Task environment/Estimator capability/Estimator/Role
137 (6 4 1 4) /Task environment/Estimator capability/Estimator/Motivation
138 (6 4 1 4 1) /Task environment/Estimator capability/Estimator/Motivation/Satisfaction
139 (6 4 1 5) /Task environment/Estimator capability/Estimator/Attributes
Description:
Coding note: relates to quals and personal attributes
140 (6 4 1 5 1) /Task environment/Estimator capability/Estimator/Attributes/Defensive
141 (6 4 1 5 1 1) /Task environment/Estimator capability/Estimator/Attributes/Defensive/bias
142 (6 4 1 5 2) /Task environment/Estimator capability/Estimator/Attributes/Multiskilled
143 (6 4 1 5 3) /Task environment/Estimator capability/Estimator/Attributes/reflective
144 (6 4 1 5 4) /Task environment/Estimator capability/Estimator/Attributes/Qualifications
145 (6 4 1 6) /Task environment/Estimator capability/Estimator/Judgement
146 (6 4 1 7) /Task environment/Estimator capability/Estimator/others perception
147 (6 4 1 8) /Task environment/Estimator capability/Estimator/Skills
148 (6 4 1 8 1) /Task environment/Estimator capability/Estimator/Skills/exent of pricing
149 (6 4 1 8 2) /Task environment/Estimator capability/Estimator/Skills/datagathering process
150 (6 4 2) /Task environment/Estimator capability/Estimators role
151 (6 4 4) /Task environment/Estimator capability/Intra org
152 (6 4 7) /Task environment/Estimator capability/Org estimating capability
153 (6 5) /Task environment/Governance
154 (6 6) /Task environment/Completeness
Description:
Extent of project information at time of adjudication
155 (6 7) /Task environment/Know of SC org
Description:
Personal knowledge of the subcontractor
156 (6 7 1) /Task environment/Know of SC org/qualification
157 (6 8) /Task environment/Ex ante commun
Description:
Extent of clarification communication

158 (6 9) /Task environment/Client control systems
Description:
Methods of controlling uncertainty
159 (6 10) /Task environment/Price risk veracity
Description:
Ability to assess the veracity of a quotation
160 (6 10 1) /Task environment/Price risk veracity/Analysis
161 (6 10 1 1) /Task environment/Price risk veracity/Analysis/comparability
162 (6 11) /Task environment/Documentation
Description:
Specificity of price required
163 (9) /Organisational relationships
Description:
High level node reflecting the factors affecting organisational relationships with the supply chain
164 (9 4) /Organisational relationships/Supply capability
Description:
Availability of resources with known capability
165 (9 4 1) /Organisational relationships/Supply capability/geographic
166 (9 9) /Organisational relationships/Market making
Description:
The economic relationship of main contractor to subcontractor
167 (9 10) /Organisational relationships/Opportunism
Description:
Seeking advantage through guile or information asymmetry
168 (9 10 1) /Organisational relationships/Opportunism/relationship value
169 (9 10 2) /Organisational relationships/Opportunism/sceptisicm
170 (9 11) /Organisational relationships/Trust
Description:
Trust to interpret requirements
171 (9 11 5) /Organisational relationships/Trust/Culture
172 (9 12) /Organisational relationships/Power
Description:
Power relationship of main contractor over subcontractor
173 (9 12 1) /Organisational relationships/Power/specific asset specificity
174 (9 13) /Organisational relationships/Repetition
Description:
Frequency of use of subcontractor
175 (9 13 1) /Organisational relationships/Repetition/integration
176 (9 14) /Organisational relationships/Propensity to price
Description:
The propensity to return a bona fide price
177 (9 14 1) /Organisational relationships/Propensity to price/post contract governance
178 (9 14 2) /Organisational relationships/Propensity to price/price perception
179 (14) /External environment
180 (14 1) /External environment/Small Numbers- availability
Description:

Lower order factor within the external environment coded to reflect the availability of subcontractors to gather prices from.Numbers of subcontractors with capability

181 (14 2) /External environment/Organisational capability
Description:
Ability to gather resources in order to respond to client requests

182 (14 3) /External environment/Competitive advantage
Description:
An external environment child relating to the competition in the environment with other contractors and also the market sectors.An organisations behaviour to s/c in attempting to gain advantage

183 (14 3 1) /External environment/Competitive advantage/Components

184 (14 3 1 2) /External environment/Competitive advantage/Components/Measured works

185 (14 3 1 3) /External environment/Competitive advantage/Components/Contingency

186 (14 3 1 4) /External environment/Competitive advantage/Components/Labour only

187 (14 3 1 5) /External environment/Competitive advantage/Components/Suppliers

188 (14 3 3) /External environment/Competitive advantage/Indirect cost estimate

189 (14 3 6) /External environment/Competitive advantage/Competitive advantage

190 (14 3 6 1) /External environment/Competitive advantage/Competitive advantage/strategic resource

191 (14 4) /External environment/Supply chain relationship
Description:
Chilld within the external environment coded to reflect the strategic organisational relationships.Organisation that has a relationship with a main contractor

192 (14 4 1) /External environment/Supply chain relationship/specificity M and E

193 (14 4 2) /External environment/Supply chain relationship/steelwork specificity

194 (14 4 4) /External environment/Supply chain relationship/Specificity threat

195 (14 4 5) /External environment/Supply chain relationship/Incentives

196 (14 4 8) /External environment/Supply chain relationship/Organisational links

197 (14 5) /External environment/Small numbers market perception
Description:
Lower order factor within the External environment.Number of organisations prepared to bid

198 (14 6) /External environment/Network effect
Description:
Lower order factor within the external environment to reflect the network intelligence informing sc of tenders.Effect of subcontract intelligence on pricing behaviour.

199 (14 10) /External environment/Client requirements
Description:
Child within the external environment coded to reflect the procurement relationships with clients and the long term relationships.The expectation of information type
200 (14 10 1) /External environment/Client requirements/GMP
201 (14 10 2) /External environment/Client requirements/Design and Build
202 (14 10 3) /External environment/Client requirements/Documentation quality
203 (14 10 4) /External environment/Client requirements/PFI
204 (14 10 5) /External environment/Client requirements/partnering
205 (14 10 6) /External environment/Client requirements/Procurement information
206 (14 10 6 11) /External environment/Client requirements/Procurement information/BQ
207 (14 10 7) /External environment/Client requirements/frameworks
208 (14 10 8) /External environment/Client requirements/procurement trends
209 (14 10 9) /External environment/Client requirements/drawings and spec
210 (14 10 10) /External environment/Client requirements/Tendering
211 (14 10 10 1) /External environment/Client requirements/Tendering/tendering procedures
212 (14 10 10 2) /External environment/Client requirements/Tendering/unbalancing
213 (14 10 10 8) /External environment/Client requirements/Tendering/two stage tendering
214 .Organisations
215 .Organisations.~5m
216 .Organisations.~99
217 .Organisations.25-49
218 .Organisations.50-99
219 .Organisations.5-24