THE UNIVERSITY OF HULL

Diffusion of agile supply chains attributes: A study of the UK upstream oil and gas industry cluster

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by

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ABSTRACT

This study examines agile supply chain capabilities in oil and gas clusters, in the light of cluster and industrial district theory. The aim is to provide evidence of their potential impact on competitiveness and business performance within the UK upstream oil and gas cluster. Agility is the ability of organisations to operate and prosper in market conditions characterised by dynamism and constantly changing customer tastes. Clusters and industrial districts refer to the geographic concentration of firms in an industry that enables the firms to benefit from competition and cooperation as well as enhanced productivity within the cluster.

A review of past theoretical and empirical studies on supply chain management, agility and clusters identifies four dimensions of agility: customer enrichment, cooperating to compete, mastering change and uncertainty, and leveraging the impact of people and information. The cluster theory points to the competitive advantage of being in geographic proximity to the members of a supply chain, including enhanced productivity, easy access to enriched and high quality factors of production, reduction of transaction and transportation costs as well as increased innovativeness. These all contribute to improving the competitive capability of a firm as well as having impact on the business performance of organisations. A survey of 880 firms in the UK upstream oil and gas cluster was conducted to determine the specific impact of cluster location attributes on the agility of supply chains. Six case studies involving the three tiers of the supply chain and supporting organisation were carried out.

Structural equation modelling revealed strong impact of clusters on competitive objectives but weak impact on business performance. Results from the survey show that cluster agility has strong impact on both competitive objectives and business performance. The case study revealed that agility is a strategic tool adopted by the smaller organisations within the supply chain to mitigate the scale of large organisations. Equally, SMEs consider that being in UK oil and gas cluster enhances their responsiveness.

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NOMENCLATURE

Boepd: Barrel Oil Equivalent per Day

BNR: Business Network Re-Engineering

BPR: Business Process Re-Engineering

CADCAM: Computer Aided Design Computer Aided Manufacturing

CE: Concurrent Engineering

CRINE: Cost Reduction In the New Era

DSS: Decision Support System

DTI: Department of Trade and Industry

EDI: Electronic Data Interchange

EPOS: Electronic Point of Sale

ERP: Enterprise Resource Planning

ETO: Engineer To Order

FCCU: Fuel Catalytic Cracking Unit

FPAL: First Point Assessment Limited

IADC: International Association of Drilling Contractors

ICT: Information and Communication Technology

IMCA: International Marine Contractors Association

JIT: Just in Time

KPI: Key Performance Index

LOGIC: Leading Oil and Gas Industry Competitiveness

MMboe: Million Barrels of Oil Equivalent

MRP: Material Requirement Planning

MRPII: Manufacturing Resource Planning

OCA: Offshore contractors Association

OKP: One-of-a-Kind Production

PLC: Product Life Cycle

PRT: Petroleum Revenue Tax

QFD: Quality Function Deployment

SCMN: Supply Chain Management Network

SMED: Single Minute Exchange of Dies

TQM: Total Quality Management

UKCS: United Kingdom Continental Shelf

UKOOA: UK Offshore Operators Association now known as Oil and Gas UK

VLCC: Very Large Crude Carrier

WSCA: Well Services Contractors Association

WWW: World Wide Web

CHAPTER 1: INTRODUCTION

1.1 Introduction

In a business environment characterised by market instability and complex products, dynamic responses by organisations are a necessary condition for survival. However, the effectiveness of an organisation's response to rapidly changing market conditions will depend, to a great extent, on the capabilities of all members of the supply chain. Thus, an effective agile supply chain is necessary for the long term competitiveness of an organisation. The agility concept is relevant to supply chains, given its holistic nature and strategic focus rather than functional or single company focus (van Hoek et al, 2001). It is for this reason that this research explores agility in the context of cluster-based oil and gas supply chains.

A supply chain describes the linkages between stakeholders in the value creating process. The traditional form of supply chain involves long-term collaboration upstream with suppliers. The inherent limitations of the traditional form of supply chain led to its evolution, with emphasis now being placed on downstream alliances with customers and in some cases, partnering with competitors. Downstream collaborations with customers aim to integrate the members of the supply chain such that they act in a synchronous manner as one, rather than individual elements of the supply chain acting at cross purposes. Integration enables concurrent execution of activities and enhances the agility of the supply chain. The agility of a supply chain is a measure of how well the relationship both upstream and downstream involved in value creating processes enhance four pivotal objectives of customer enrichment ahead of competitors, achieving mass customisation at the price of mass production, mastering change and uncertainty and leveraging the impact of people across enterprises through technology (van Hoek et al., 2001; Yusuf et al., 2004).

1.2 Background of the study

In this research it is intended to study cluster-based supply chains. The need for the study arises from the fact that changes in customer tastes necessitate corresponding changes in the manner of producing goods and services. In this respect there have been changes in the mode of production from traditional mass production – which characterized manufacturing methods in the period up to the 1970s – to lean manufacturing which was dominant after the mass production era. Lean manufacturing

was focused on shop floor operations with the sole aim of reducing and eliminating waste (Womack et al., 1990; Christopher, 2000). However, gains from the focus on shop floor efficiency at a single operation are limited and consequently, there has been a shift in focus to the entire supply chain; upstream to encompass the supplier and downstream towards the consumer (Figure 1.1, section 1.2.1 below illustrates this further). Thus, supply chain management is recognised as an area enabling companies to gain competitive advantage over competitors. However, managing supply chains effectively is a complex and challenging task. The complexity of the business environment could partly be due to the current trend for expanding product variety orchestrated by ever-demanding customers, shorter product life cycles, increased outsourcing, globalisation and continuous advances in information technology (Lee, 2002).

Indeed, studies of supply chain management have shown that in this era of changing competition, a significant paradigm shift of modern business management is that individual business no longer competes as solely autonomous entities, but rather as supply chains. Instead of brand versus brand or store versus store, it is now suppliers-brand-store versus suppliers-brand-store, or supply chain versus supply chain that compete (Christopher and Towill, 2000; Lambert and Cooper, 2000). A new form of competition transcending inter supply chains is emerging; as Carrie (2000; 1999) notes, it is between regional clusters. Thus, competition will be between clusters of interrelated industries that cooperate to add and generate value. Accordingly, the agility of a single enterprise depends on its internal operations and systems, and the other organisations that it collaborates with.

The first treatise on agility was attributed to Goldman et al. (1995). They contend that the dimensions of agility are built on four key attributes. They are as follows: 1) Enriching the customer; 2) Cooperating to enhance competitiveness; 3) Organizing to master change and uncertainty; and 4) Leveraging the impact of people and information.

However assuming that the principles of agility would be unfamiliar, and in an effort to foster better understanding of the concept to both industry and academia within Europe van Hoek et al. (2001) undertook further exposition of the subject. Accordingly based on the previous four principles of agility as a template, van Hoek et al (2001) characterise agility as follows:

- Customer sensitivity. Customer centred versus product centred logistics policies: assumes that "agile" policies emphasize customers and markets, while "lean" policies focus on the elimination of waste in products and processes.
- Virtual integration. Immediate conversion of demand information into new products using knowledge-based methods versus multi-stage, multi-function methods: assumes that agile policies focus on instantaneous demand capture, interpretation and response while lean policies emphasize stable production periods and protecting the "operations core".
- Process integration. Self management versus work standardization: assumes that agile policies focus on operator self-management to maximize autonomy and immediate response, while lean policies emphasize work standardization to ensure conformance to quality and productivity standards.
- Network integration. Fluid clusters v. long term supply chain partnerships: assumes that "agile" policies emphasize fluid clusters of network associates, while lean policies focus on a more fixed set of long-term stable partnerships.

Drivers of agility include the need to counter the effect of a constantly changing global competitive environment. In this regard Carrie (1999) points to a European project – Factories of the Future Study – in which companies in the UK, France and Germany were compared. The European project tried to predict the evolution of companies in response to changing nature of the business environment. It was anticipated that the following types of factories of the future will evolve in order to cope with challenges of global competition: 1) elastic enterprise, 2) flexible enterprise, 3) total services enterprise 4) technological leader and 5) virtual enterprise. A key characteristic of the typology is that it has highlighted the contextual nature of agility and its variations, such that it can be concluded in respect of the production system of the future that there will be a need for agility to:

- alter production volumes
- alter product specifications
- identify and meet customers' requirements
- adopt emerging technology
- conceive of the total service package, not just the physical product

- convert concept to production (Carrie, 1999).

Although some interaction between suppliers and customers takes place, agility as shown above is seen as a characteristic of single enterprise rather than the infrastructure of which organisations are members or as encompassing all the members of the supply chain. Thus, it can be argued that the agility of an organisation depends more on the cluster to which it belongs rather than on efficient operations between an organisation and its supply chain.

Sustainable competitive advantage determines competitiveness of an organisation and competitive advantage is crucial to enterprises (Porter, 1990). Factors such as lower costs and superior products or service are ways of attaining competitive advantage (Lau and Hurley, 2001). Clusters have been argued to represent a new way of enhancing competitiveness through their influence on productivity and productivity growth (Porter, 2000). The impact of geographical location of facilities and suppliers in close proximity to customers in order to reduce transportation cost, reduce lead time and enhance responsiveness has long been recognised in many industrial settings (Hallwood, 1991b; Mason et al., 2002; Lublinski, 2003; Molina-Morales, 2002; Reichhart and Holweg, 2008). Nevertheless, clusters and industrial district indicate the role of location in competitive advantage (Porter, 1998a; 2000). London and Kenley (2001) also corroborate the importance of clusters by contending that the emergence of a wider perspective of industrial organisation through models such as supply chains, industrial networks and clusters is often attributable to improving competitiveness and innovation. Perhaps the popularity of the concept of clusters and industrial districts is as a result of the success observed in similar economic activities that are geographically concentrated (Molina-Morales and Martinez-Fernandez, 2004).

Industrial districts are concentrations of firms in an industry, either in a single town or in a zone of a city, whilst a ‘cluster’ is a broader concentration of industries that may be connected by common products, technologies, markets (either of supply or demand) or institutional frameworks (Wilson and Popp, 2003a). The essence of clusters and industrial districts is similar, as both the clusters and industrial districts emphasise concentration of firms within an industry in a defined geographic space. Thus, the difference is attributable to semantics rather than theoretical or conceptual differences. The scope of strategy and competition has often been limited to a single organisation. However, the theory of clusters argues the existence of competitive advantage outside

the boundary of the single company or even outside the industries the company may belong to. Rather, the cluster concept contends that competitive advantage resides in the locations of the business units of the company (Porter, 2000). Lin et al. (2006a) note that building strong relationships among complementary organisations facilitates the formation of clusters and improves competitiveness. Thus upstream and downstream integration of supplier and customers respectively is a driver of clusters and industrial districts.

1.2.1 Research setting: The UK upstream oil and gas industry

The oil and gas industry faced significant changes in the business environment in terms of fluctuating oil prices as well as escalating cost of exploration, development and production of the product resource. Adjustment arising from uncertainty in business environment provides a useful backdrop for studying the way the supply chain organises and adjusts in view of the uncertainty faced.

Crude oil and gas products are the outcome of the upstream value chain. Thus whereas the companies operating at the upstream oil and gas value chain produce and sell the crude oil and gas that is extracted, the products are not altered by the efforts of the producers – that is organisations operating at the upstream value chain. Thus the products are not the focus of competitive effort as there is no differentiation between the products from one producer to another. Rather, it is the processes (comprising many technologies and techniques) by which these products are identified, accessed and extracted that generate the competitive domains for the oil operators and the service companies that supply them (Acha, 2002). Given that about ninety percent (90%) of inputs into the offshore industry is sourced through the supply chain (Finch, 2002; 61), there is relatively little research effort dedicated in the supply chain management literature of the upstream petroleum industry. Thus the choice of this industry was considered appropriate for this dissertation research.

Oil and gas extraction involves three main stages including exploration, field development and production (Hallwood, 1991a). The value stream with typical supply chain activities from exploration and intermediate processing to delivery to the customer is illustrated in Figure 1.1. As the figure indicates the upstream part of the oil and gas industry is composed of exploration and production of the crude oil and natural gas (Acha, 2002) while all other activities involved with processing such as refining, petrochemicals and chemicals, as well as, associated logistics such as warehouse,

pipelines and carriers for storage and transportation in order to deliver the product to the customer represent the downstream sector of the supply chain. However with respect to the oil and gas industry, where exploration and production of the oil and gas resource is carried out on land the activity is termed onshore oil and gas production. Whilst offshore oil and gas production involves prospecting and production of oil not on land but in the ocean or sea environment with the UK North sea, Nigeria, West Africa as well as Gulf of Mexico, USA being examples of offshore oil and gas production.

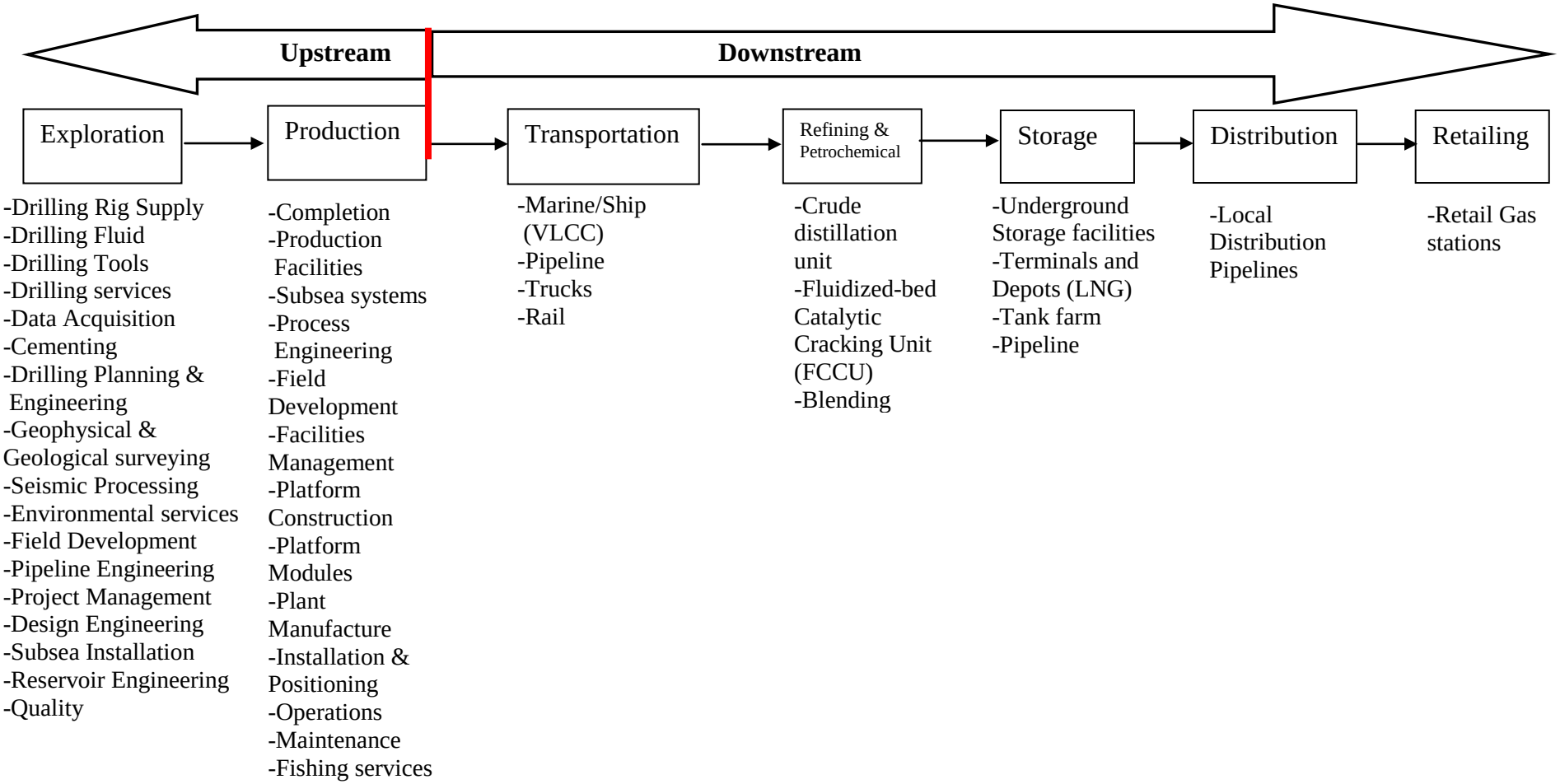

Figure 1.1: Typical Oil and gas value stream

1.3 Research aims

The aim of this research is to examine the adoption of agile supply chain attributes in the context of clusters and industrial districts in the oil and gas sector. The research is different from previous studies of this phenomenon in that the "cluster" is the unit of analysis rather than a single enterprise, as in traditional supply chain analysis. This helps to focus the study on an identifiable section of the supply chain. Furthermore, the majority of prior studies on supply chain agility are in manufacturing and therefore, by looking at agility in the oil and gas industry, this research sheds light on, and provides new insights into agility in process industry supply chains. Additionally, by focusing on clusters, it brings greater clarity to the study of supply networks and allows more meaningful inter-chain analysis of competitiveness. The overall aim of the research is to study the factors underpinning the development of agile capabilities and potential inhibitors in the oil and gas clusters. This research examines what inhibits or facilitates the diffusion of agility attributes in oil and gas clusters. Figure 1.2 shows a conceptual model of the cluster agility attributes and their potential impact on business performance as well as competitive objectives. This model was tested through survey by questionnaire and the results were validated using case studies.

1.4 Research questions and hypotheses

In order to achieve the aims of the research it is important that the following questions are addressed. The relationships between the variables depicted in Figure 1.2 were tested using the empirical study (reported in chapter five) carried out to enable the research questions to be evaluated in light of the findings from the testing of hypotheses.

Q1. What is the impact of cluster location attributes on supply chain agility?
Q2. What is the impact of cluster location attributes on competitive objectives?
Q3. What is the impact of cluster location attributes on business performance?

Accordingly the following six hypotheses were proposed in order to answer the above research questions:

1a There is high diffusion of established dimensions of agile supply chains into oil and gas clusters

1b There is a strong relationship between cluster attributes and dimensions of agile supply chains

2 Agility dimensions are related to attainment of competitive objectives

3 Being in clusters is related to the attainment of competitive objectives

4 Agility dimensions are related to the business performance

5 Being in clusters is related to the business performance

6 Attainment of competitive objectives is related to business performance

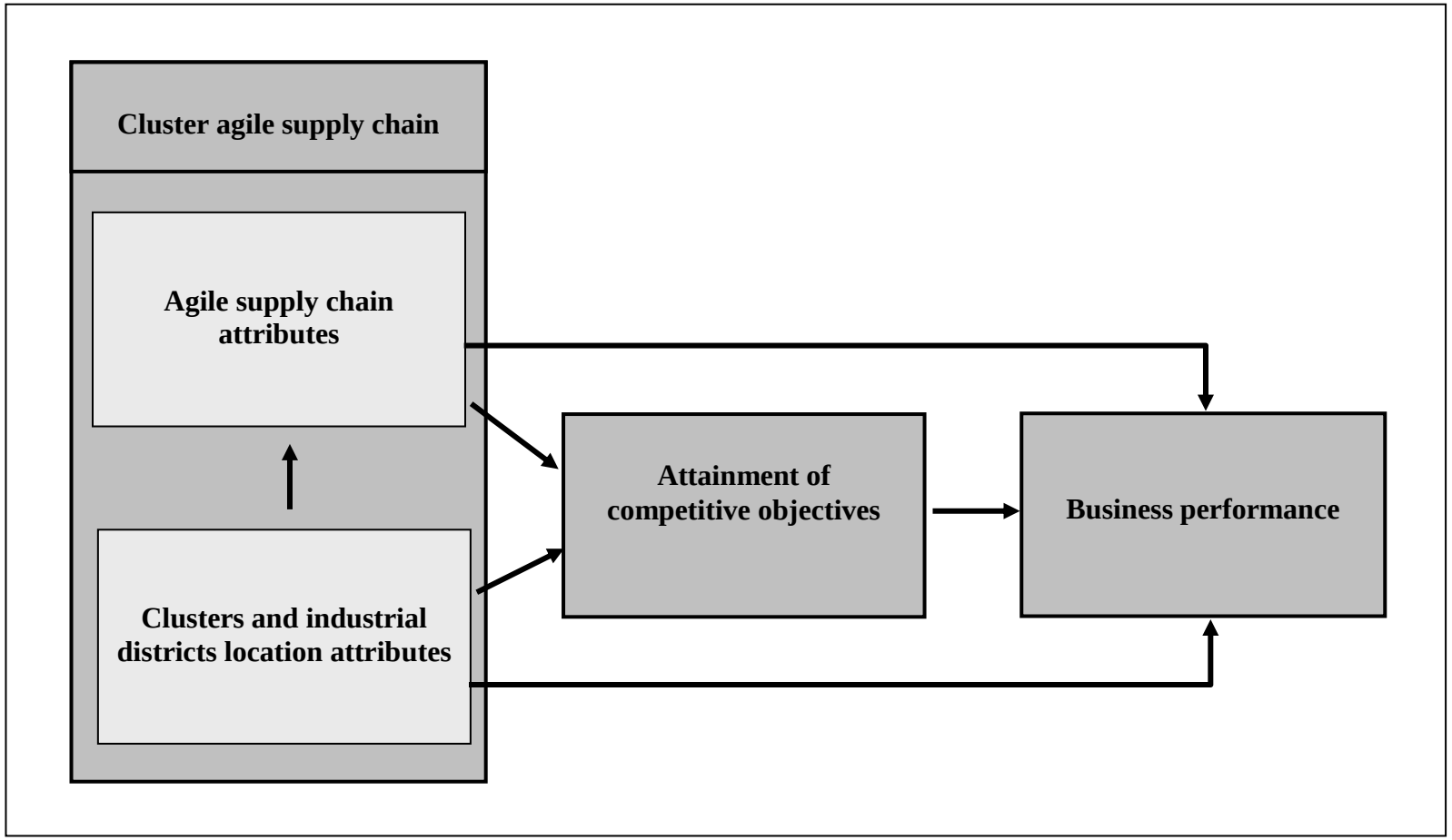

Figure 1.2: Elements of cluster based agile supply chains

This thesis will set out to test the hypotheses enumerated above, which will consequently attain the aims of the study as well as answer the research questions set out.

The following section will outline the methodology, in terms of the research approach, adopted in order to undertake the study.

1.5 Research methodology

In this research, triangulation of quantitative and qualitative data collection methodology is adopted. Firstly, data was collected using a survey by questionnaire and then case studies were undertaken with some of the companies that participated in the survey. The questionnaire for the survey was pilot tested and the result from the pilot study was used to review the questionnaire. The reviewed questionnaire was then used to undertake a general survey of the responding organisations. Based on the survey result six case studies were undertaken. The case studies were used to validate the survey results, as well as determine the context in which agility dimensions were adopted and the interaction between cluster attributes and agility dimensions.

1.6 Structure of the thesis

This thesis consists of seven chapters, including this introductory chapter 1 which introduces the research context. Chapter 2 reports the development in supply chain management from operational and strategic perspectives. Also in chapter 2, an account is given of agility as the dominant operations strategy for surviving in a business environment that is dominated by change and uncertainty. Then Chapter 3 follows, whereby the articulation of industrial clusters as a production model is carried out. This is followed by elucidating the supply chain issues within industrial clusters. Chapter 4 discusses the methodology adopted in this research, describing the different methods together with justification of the adopted methodology; also chapter 4 presents a research conceptual framework and its elements are discussed. Chapter 5 reports the survey by questionnaire while Chapter 6 reports 6 case study investigations on the adoption of dimensions of agile supply chains and the impact of being in clusters on agility. Finally, conclusions and recommendations from the research are presented in Chapter 7.

CHAPTER 2: THE EVOLUTION OF SUPPLY CHAIN MANAGEMENT

2.1 Introduction

This chapter presents the theoretical basis of the thesis. The chapter begins by presenting the development and concept of supply chain management. Then definition, concept and attributes of agile supply chain were elucidated. Furthermore, the need for agility within the supply chain of oil and gas industry is justified and finally the nature of competitive objectives and business performance of the firm were highlighted.

2.2 The development of supply chain management

The Global Supply Chain Forum defines Supply chain management as "…the integration of key business processes from end user through original suppliers that provides products, services and information that add value to stakeholders" (cited in: Lambert and Cooper, 2000; 66). In tracing the evolution of Supply chain management (SCM) Lambert and Cooper (2000) observe that the term SCM was introduced by consultants in the early 1980s and has since generated wide interest. Initially, supply chain management was perceived as logistics that extends outside the firm to include customers and suppliers. However, SCM is now conceptualised as the integration of all the business processes across the supply chains. Thus the new model of SCM encompasses all the other business functions including extended suppliers and extended customers.

In trying to understand the circumstances leading to the evolution of SCM, Hill (2000) states that companies rarely own the resources and activities to make a product or provide a service from the beginning to the end. Indeed Ramdas and Spekman (2000; 18) contend that, since "purchased goods and services account for 50 to 70 percent of manufacturing company's potential value [thus] a firm's competitive advantage…depends on the links it forges with external organisations." rather than its internal capabilities. Furthermore, Richardson (1972) argues, from a transaction cost economics point of view, that organisation of industry should take cognisance of similarities and complementarities of activities. In addition, Loasby (1998; 153) points to the fact that "all firms depend on the capabilities of their suppliers, and every firm which is not a retailer depends on the capabilities of those who provide it links to the final consumer." In fact some activities in the value stream of the product or service delivery system are not undertaken by the organisation, but rather sourced from external vendors. This underpins the need to manage effectively the internal and external phases of the supply chain as an integrated whole.

The supply chains is a network of organisations involved – through upstream and downstream collaboration – in the different processes and activities that produce value in the form of products and services with the ultimate goal of satisfying consumer demands (Christopher, 2005). Lambert and Cooper (2000) state that the supply chain encompasses, as members, companies or organisations with whom the company in question interacts, directly or indirectly, through its suppliers or customers, from the point of origin (of the product or service) to the point of consumption. Typically, a shirt manufacturer constitutes a part of a supply chain that extends upstream from yarn makers, weavers of fabrics and manufacturers of fibres, and downstream to distributors and retailers of the final product to the consumer. It is therefore evident that each of these organisations is dependent on the other in ensuring that the product reaches the customers and that supply chain agility is contingent upon the effective coordination of the entities of the supply chain.

According to Lamming (1996) the eventual product or service will be commercially advantageous to the organisations involved in its creation and provision if value is added to the product or service faster than cost across the supply chains. In fact this thinking accounts for the growth in significance of effective supply chain management in recent years (Kehoe and Boughton, 2001). As a result of this the supply chain management perspective has taken precedence over the concept of vertical integration. It must be recognised that while vertical integration used to be the dominant strategy, an increasing number of organisations now focus on their core competencies (Prahalad and Hamel, 1990) giving rise to the popularity of outsourcing as a means of achieving responsive and agile supply chains.

Ballou et al, (2000) distinguish three dimensions of supply chain management to include intrafunctional, interfunctional and interorganisational. The scope of coordination associated with these three levels of supply chains varies from simple harmonization of internal processes typical of a single site manufacturing facilities – intrafunctional – to the more challenging inter-organisational coordination. Therefore, determining which parts of the supply chain deserve management attention should be weighed against the organisation's capabilities (Richardson, 1972) or core competencies (Prahalad and Hamel, 1990) as organisations tend to specialise in activities for which their capabilities offer some comparative advantage.

2.3 Supply network

All firms participate in a supply chain, from the raw materials to the ultimate consumer (Lambert and Cooper, 2000). Furthermore, rarely do firms participate in only one supply

chain; firms belong to more than one chain. A supply network is the situation in which an organisation participates in more than one supply chains. Accordingly supply networks are sets of supply chains describing the flow of goods and services from original sources of raw materials or service creation to the ultimate end customer (Lamming et al., 2000). A distinguishing feature between supply chains and supply networks is that supply chains connote linear flow or layout, while supply networks are characterised by complex interaction with other firms and organisations. Despite the perceived differences between supply chains and supply networks, supply networks have often been denoted as an extension of supply chains (Harland, 1996; Lamming et al., 2000). According to Christopher (2000), to succeed in the turbulent global markets, there is the need to harness the respective strengths and competencies of network partners to achieve greater responsiveness to market needs. Therefore, supply network is a form of collaboration involving (and extending beyond the traditional) supply chain members.

Bal et al. (1999) observe the importance of networks in maximising the benefit of close regional contacts and strong ties between resources. Previously, Porter (1990) pointed out the benefits of close regional networks, including enhanced innovation and new product development. The benefits of regional networks are derived from the following three key attributes: firstly, network organisations co-located in one region have the potential for enhanced personal interaction, thus leading to increased collaboration through information exchange among members. Secondly the interpersonal interaction evolves over time to engender trust between network members; trust is crucial to improving time and quality performance (Flynn et al, 1990). Finally, networks provide a knowledge base to benefit other organisations. The thrust of the argument here is that networks stimulate interpersonal interaction. Moreover, the intense interpersonal interaction could lead to enhanced innovation.

Spekman et al. (1998) differentiate three hierarchical levels of collaboration: relationships, alliances and networks. A relationship is the bedrock of alliance formation, while a network is more than bilateral relationship or even an alliance. Rather, *networks* are formed from configurations of alliances and relationships that range from partnerships to simple transactions like buying and selling on a competitive basis or exchange of views or information.

Complementing the infrastructural setup of the supply chain network is the organisational aspect. Accordingly, in appraising the organisational evolution in terms of restructuring undertaken as a result of changes in the competitive arena, Miles and Snow (1992) argues

that organisations, in the 1980s, moved away from the hierarchical centrally coordinated structure towards flexible structures that closely resembled networks. These networks are mostly clusters of firms or specialist units coordinated by market mechanisms. Networks consist of three basic variables: Actors, Activities and Resources (Harland, 1996; Pihkala et al., 1999). Actors defined as individuals, groups of individuals or firms. On the other hand, functionally actors control activities, resources or both. Activities occur when actors combine, develop, exchange, or create resources by using other resources (Pihkala et al., 1999). Essentially, actors, resources and activities relate to different fields of operation in multiple ways, thus bringing the dynamism of the business networks (Pihkala et al., 1999). However, unlike the clusters where rivalry and competition is one of its characteristic (Porter, 1998a), in a dynamic network each organisation displays its own distinctive competence (Miles and Snow, 1987), complementing rather than competing with others in the network.

2.4 Lean supply

The concepts of leanness and agility are developments in management thinking (Naim and Barlow 2003) distinct from the traditional mass production outlook of functional organisational form. Lean production is the precursor to lean supply. In lean strategy the emphasis is on efficiency of processes, while agility is aimed at process responsiveness. The lean concept originated from lean production that is synonymous with Toyota Production System (TPS) (Womack et al., 1990). Lean production synonymous with the TPS is underpinned by the Just-in-time (JIT) business system, which is responsive to customer requirements. JIT is a scheduling technique that works in an environment where longer requirements for materials are known and short time production schedules are frozen (Doll and Vonderembse, 1987). Accordingly, the essence of the lean principle is elimination of waste within networks by optimum utilisation of resources; in a way, efficiency of utilisation of resources.

On the other hand, lean supply comprises the purchasing function, material use and transformation to provide the goods or service packages geared towards customer satisfaction. In an organisation, that serves a diverse customer base, a business involved in numerous sectors or a market with a global base, lean supply will include decisions relating to development of appropriate organisational structure aimed at accommodating the diversity in operations to serve global markets effectively. Essentially, the lean supply concept takes “a holistic approach to managing operations within collaborative inter-organisation networks, allowing the formulation and implementation of rational strategies

for creating, stimulating, capturing and satisfying end customer demand through innovation of products, services, supply network structures and infrastructures, in a global dynamic environment" (Harland et al., 1999; 663). It is worth highlighting that in lean supply, supply network and infrastructure is of strategic importance. Furthermore, collaboration – a purposeful cooperation between independent firms along a value-added chain creating competitive advantage – ranges from loose alliance to integration.

A lean supply system provides a flow of goods, services and technology from supplier to customer, coupled with pertinent flows of information and communications, without waste (Lamming, 1996). In lean supply, emphasis is on elimination of waste by reduction in lead times and set-up times, and improving product quality to minimize raw material, work-in-process and finished goods inventory. Thus, the entire flow within the value chain, from raw materials to consumer, is considered as an integrated whole. Furthermore, lean supply can be viewed as the product of an operating attitude that recognizes the cost associated with any departure from perfect execution of the tasks necessary to provide long term customer satisfaction, thereby achieving total eradication of those costs. The reality of market competition makes lean supply implementation inevitable, despite the seeming difficulties associated with its implementation. Suffice it to say that a key paradigm of vantage point and customer superiority that are central to supply chain management are not crucial or in the extreme directly negated by those of lean supply (Lamming, 1996). Further study (Lamming et al., 2000) demonstrated that lean production, which entails the removal of anomalous and wasteful practices from processes, and agility, as the ability of a system to adapt quickly to changes in market requirements, clearly have much in common. Indeed, researchers have proposed that lean chain is complementary to, rather than conflicting with, an agile supply chain (Sharifi and Zhang, 1999) such that the term "Leagility" is used as to signify the integration of both paradigms (Naylor et al., 1999).

The concept of lean supply has led firms to conclude that they will more readily attain long-term cost reduction by forming closer working relationships with key suppliers (Harland et al., 1999). Furthermore, there has been a growing trend towards rationalisation of the supplier base, from multiple adversarial trading to single or dual sourcing used by the firm (Harland et al., 1999). Supply strategy relates to the integration of supply activities within the firms in supplier/customer relationships, chains of firms and in inter-organisational networks. Indeed, apart from the closer cooperation and integration of the customer, suppliers are often looked at as partners, becoming more deeply involved in cooperative problem-solving, especially in new product development (Harland et al, 1999).

Lean supply – as part of waste elimination – aims to reconfigure the way responsibility for value management is shared, in order to exploit expertise wherever it lies within the supply chain and to recognize the impacts in one part of the supply chain of decisions made in another (Lamming, 1996). Similarly, the organisational aspect of the lean strategy as observed by Pihkala et al. (1999) does not allow "hierarchy building" behaviour. Rather, it favours flexible specialisation, which is critical for the emergence of networking. Flexible specialisation, whereby various aspects of the value chain are performed by different organisations, is also a feature of clusters and industrial districts; such that it can be observed there are attributes of lean supply and lean supply that are similar.

2.5 Evolution of integrated operation: from integrated supply chain to integrated clusters

The trend in integrated operation is revealed by the way companies have been organising to perform their activities since the 1960s (Hill, 2000). Material Requirement Planning (MRP) and Manufacturing Resource Planning (MRP II) signalled the beginning of integrated operations. It enabled companies to standardise daily operations. As a result, companies developed functional expertise and system design was conceptualised on functional tasks. This phase of development of integrated operations utilised the computing power of the mainframe computers. Next followed the second phase, whereby the PC application was used for the development of cross-functional processes with the goal of harnessing the functional units to achieve overall business objectives. This was the dominant activity characterising the period ranging from 1970s to well into the 1980s.

In the third stage, networking of the members of the supply chain – suppliers all through to customers – was achieved so that they think and act as one. In this case, emphasis is on leveraging the efficiencies of the functional expertise (phase 1) and cross-functional business processes (phase 2) to satisfy customer demand. Harnessing both the functional and cross-functional efficiencies was achieved by networking the system entities. Furthermore, networking capability was achieved through electronic data interchange (EDI), electronic point of sale information (EPOS) and electronic mailing systems were used to reduce the transaction costs, at the same time speeding the information exchange that allows real time systems response. The last phase represents the ubiquitous e-commerce based on the Internet and the World Wide Web (WWW). Indeed, Terry Hill (2000) remarked "by fostering better communication and interchange of information between companies, this phase enables fully integrated processes between businesses, not only customers to suppliers but also between suppliers" (Hill, 2000; 419-420). Table 2.1

summarises the evolution of supply chain integration by tracing the phases of the integration and the main changes that were undertaken in each of the stages.

Table 2.1: Evolution of integrated operations

Phase	Aspects of change
1. Cross - individuals	Breaking down barriers between functional experts themselves and between these and the executives responsible for managing core parts of the business, particularly operations.
2. Cross - functional	Facilitating links between functions by requiring and helping the interchange between different parts of the same business.
3. Cross - business	Impact on the way companies conduct business by removing barriers within an organisation and between parts of the immediate supply chain.
4. Cross - corporate	Facilitating co-operation of businesses within a supply chain including tier 2 suppliers (multi-echelon).

Source: Hill, 2000; 421

Naylor et al (1999) observe that an integrated supply chain's goal is to remove all barriers to easy flow of information, material, cash and other resources, while Tolone (2000) contends that to be competitive, companies have to integrate their supply chains and build strong relationships with their suppliers and customers. More recently Brown and Cousins (2004) provide empirical evidence to show that integration of a firm's supply and operations leads to enhancement in performance. Citing case studies from the aircraft and automotive industries Quinn (1992) asserts that cross-functional integration increases effectiveness and decreases cost of operations of an organisation. Additionally, Lee (2000) cites Seven Eleven, a major retail company in Japan, and Dell as being among the leaders in integrating their supply chains. In espousing the advantages of supply chain integration Lee (2000l; 31) states that "[it] creates profits, increases market share, strengthens competitive position, and enhances the value of the company."

Figure 2.1 indicates the development from functional orientation to a fully integrated supply chain operations. Indeed, with the integrated supply chain both material and information flows are "simplified, streamlined and optimised reducing wastes and lead times" (Naylor et al., 1999; 110) thus achieving cycle time compression (Mason-Jones and Towill, 1999). The essential argument of Naylor et al (1999) is that supply chain integration is both internal and external and thus the various functions of the organisation need to be integrated, as well as the external members of the supply chain. Accordingly the

integration proceeds from integration of the various functions and departments within the organisation so as to achieve internal integration. This is followed by external integration in which the suppliers and customers are integrated with the activities of the organisation. However, supply chain integration encompasses integration of both forward physical flow of materials and feedback flow of information as well as financial flows between a firm and its supply chain partners (Rai et al., 2006).

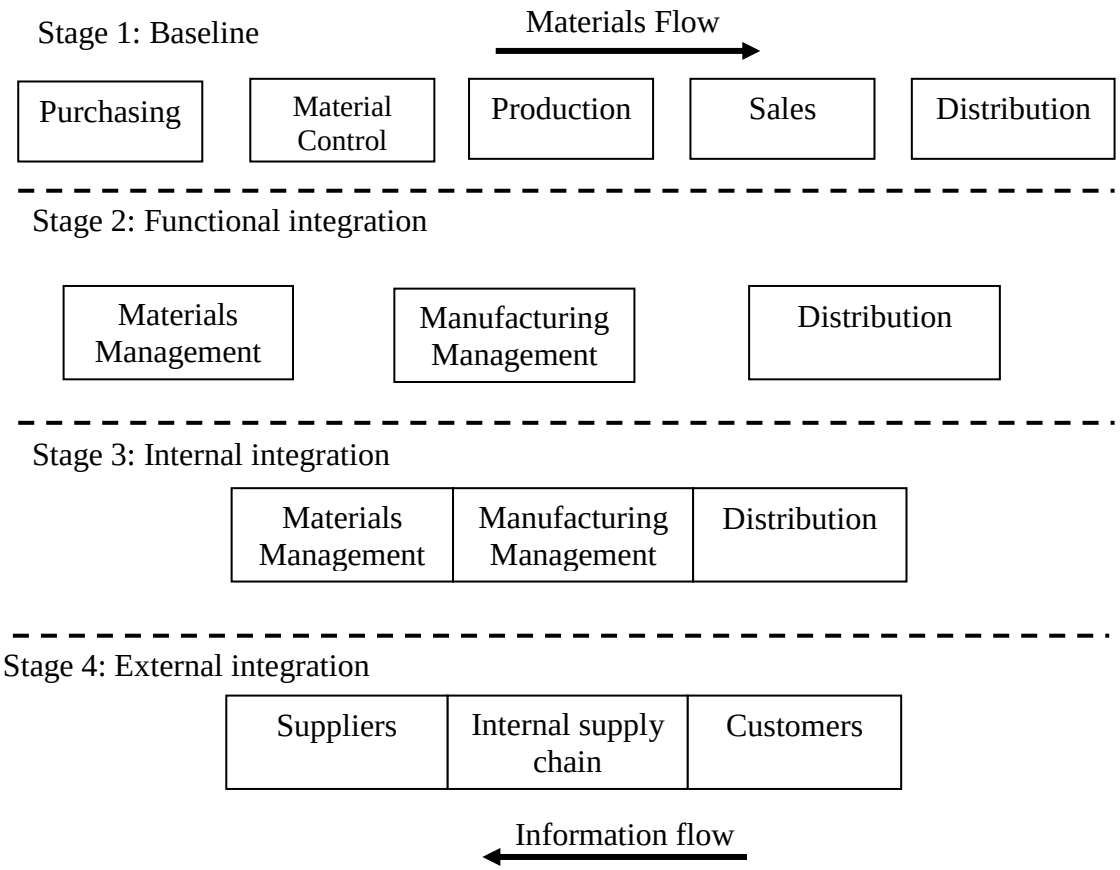

Figure 2.1: Supply chain integration (Source: Naylor et al., 1999; 110).

The model of an integrated supply chain as shown in Figure 2.1 indicates a forward movement of materials upstream from the supplier to the customer with a corresponding backward movement of information downstream from the customer upstream to the supplier. The movements are complementary for effective supply chain management. Moreover, information serves as the connection between the various stages of a supply chain. Information is crucial to the daily operations of each of the various stages of a supply chain, as it has been used by organisations as a tool to increase efficiency and responsiveness (Chopra and Meindl, 2001). For example, a production scheduling system uses demand information to produce factory schedule that will allow a production of the right product in an efficient manner. A warehouse management system uses information on available inventory to make visible the level of inventory being carried in the system. This information is then used to orchestrate the order cycle.

The baseline stage of the supply chain integration conforms to the situation synonymous with the traditional forms of interaction within the supply chain. In a traditional supply chain, the organisations behave in an adversarial way, such that information is withheld by the members of the supply chain in an effort to retain power. The need to retain some power within the supply chain is due to lack of trust by the supply chain members towards each other. Accordingly, there is a lack of visibility by the supply chain upstream, as demand information retained by the members downstream nearest to the customer exerts the greatest influence in this situation (Childerhouse et al., 2003).

Lee (2000) observes that achieving supply chain efficiency requires accurate real-time information. Accordingly, Gehani (1995) points out that inter-departmental integration of enterprise-wide information enables efficient use of organisations' resources. Such pooling of resources will lead to competitive advantage over less integrated competitors. Moreover, as stated elsewhere (Lee et al., 1997; Mason-Jones and Towill, 1997), sharing demand information among supply chain members reduces uncertainty in operations and improves the overall speed of response.

Leveraging the impact of people and information has been defined as one of the primary dimensions of agility (Goldman et al., 1995). Crucial to agile supply chains, therefore, is availability of real-time information amongst networks of collaborating companies. Childerhouse et al.(2003) note the dependence of partnerships and alliances on information support. Indeed it is critical that supply chain partners have access to information on activities they do not control (Childerhouse et al., 2003); this will enable integrated operation of all the units involved in the value creation. In lean supply, integration ensures system adherence to cost and quality commitments. It also creates an enabling environment for level scheduling, minimum distortion to plans and regular batch productions for delivery of small volume orders (Naylor et al., 1999; Yusuf et al., 2004).

Since information is essential for integrating supply chain members, it is crucial that reliable information is transmitted to all supply chain entities. Accordingly, Radjou (2000) reports a case study in which relying on outdated forms of communication between a global manufacturer and its supply chain led to inflexibility in the production system – leading to high overtime costs, lost sales and disappointed customers.

Although companies and firms are implementing projects and programmes to enhance their competitive advantage through flexibility, unfortunately the techniques used would reduce flexibility rather than enhance it; this is because the techniques used largely enable

"hard" (machinery) integration. "Soft" (people) issues are equally important in achieving flexibility. Crowe (1992) argued that integration is not synonymous with flexibility and that without thorough analysis and design, the integration of computers, networks and manufacturing systems often reduces rather than enhances flexibility. Thus, he advocated flexible "soft" rather than hard integration by organisations. Flexible integration can be achieved through planning and design performed by systems professionals and with top management support, otherwise hard integration might in the extreme make processes inflexible, concluded Crowe (1992). In a later study, Marien (2000) found the "soft" side of SCM implementation as equally important as the "hard" side of technology.

Kidd (1994) defined three complementary forms of integration:

- People integration (people communicating and cooperating with each other)
- Human-computer integration (interaction between people and computers)
- Technological integration (machine to machine interface).

Kidd (1994) contends that the last form of integration – technological integration – is the most popular. However, for an agile system equally important is people integration, which involves many linkages between people, groups and functions as part of human networking. Thus, human-computer integration and technological integration should all be harnessed and channelled towards supporting people integration.

2.6 Supply chain agility: review of origins, concepts, attributes and enablers

Supply chain agility is an emerging theory on strategic change for organisations that originated from agile manufacturing. Agility, which is the precursor of the lean manufacturing paradigm, underlies effectiveness, rather than efficiency, which is the dominant focus of lean manufacturing. Additionally agility is about increasing customer responsiveness and time of response. Agile manufacturing is the result of a US government sponsored research programme (Goldman et al., 1995). The concept was discovered in 1991 as a new manufacturing paradigm by researchers at Lehigh University, USA. Agility was popularised by its proponents as a means of response to competition to American manufacturing organisations, particularly from Japanese corporations. Agile manufacturing is now seen as a strategy that enables an organisation to thrive in an environment of continuous change. It seeks to cope with demand volatility by making changes in a timely and economical manner (Kidd, 1994). Furthermore, it involves fundamental change in operations to overcome changes in the whole business enterprise such as markets, technologies or business relationships (Sanchez and Nagi, 2001). Accordingly, agile manufacturing is a market driven strategic manufacturing response suitable for an

environment of competition characterized by unpredictable change (Kidd, 1994). Agile manufacturing emphasises design of a complete enterprise that is flexible, adaptable and capable of thriving in a rapidly changing business environment where markets are characterised by individualised demand (Robertson and Jones, 1999). Goldman et al. (1995) identified four strategic dimensions of agile manufacturing: enriching the customer; cooperating to compete; organizing to master change and uncertainty; and leveraging the impact of people and information. Sarkis (2001) presents operational definition of the four dimensions of agile manufacturing using a framework of agility that focuses on inputs, outputs, external influences and internal operations. The four components of the model were defined as follows:

- Outputs is about customer enriching "solution" products
- Inputs focuses on cooperating to enhance competitiveness
- External influences include unpredictable change and social values; and finally
- Internal operations leverage the impact of people and information.

Jackson and Johansson (2003) propose that agile capabilities can be divided into the following four dimensions: product-related change capabilities to deal with turbulent environment; change competency within operations (relates to competencies, methods and tools) used within operations to surmount dynamic changes within production system; co-operation internally and externally within the departments of an organisation, also with its suppliers and customers; and people knowledge and creativity being the basis of handling changes in a turbulent environment.

Although agility has been presented as a concept that is suitable for a dynamic and constantly changing business environment, its implementation had been manufacturing biased and most of the research shows a bias towards the USA (van Hoek et al., 2001). Accordingly, there is the need for sector-focused study of industries other than manufacturing based. Thus, Katayama and Bennett (1999) contend that the concept is applicable to non-manufacturing functions despite the apparent manufacturing focus of agility concept. Additionally, in assessing the adoption of the agility concept by Japanese companies, they demonstrated that agility focused companies aspire to reduce fixed costs and lower break-even point rather attempting to convert fixed costs into variable cost. They contended that companies are trying to realize their cost adaptability through agility enhancement. Thus in high cost high complexity non - manufacturing industry agility

adoption could reduce fixed costs in addition to enhancing speed and flexibility in operations.

Gunasekaran (1998) suggests a conceptual framework for agile manufacturing in which key enablers of agile manufacturing are presented. The enablers of agile manufacturing include: (i) virtual enterprise formation, (ii) manufacturing architecture and teams, (iii) rapid partnership formation, (iv) concurrent engineering (CE), (v) integrated information system, (vi) rapid prototyping tools and (vii) electronic commerce. Moreover, strategy in an agile manufacturing enterprise will entail: (i) cooperative work among small and medium enterprises to organize around competencies of each company for mutually profitable projects; (ii) teaming among companies and (iii) process re-engineering for effective communication and integration of various partnering firms (Gunasekaran, 1998).

Sharp et al. (1999) developed a conceptual model for agile manufacturing in which key agility enablers were identified as: virtual enterprise, information technology, empowering, team working, core competencies, concurrent engineering, multi-skilled and flexible workforce, change and risk management, continuous improvement and rapid prototyping.

Agility is contingent on the organisation as well as people. Agility drivers include the factors of the competitive environment that encourage organisations to be agile, the strategic intent of being agile, and the strategy (reactive or proactive) adopted. Accordingly, agile capabilities consist of the practices, methods and tools directed at being agile. Burgess (1994) highlighted organisational and cultural issues to be the main problems encountered in adopting agile capabilities. Additionally, information technology (IT's) ability to enable major organisational change was explored with specific links to agile manufacturing. It was revealed that business process redesign (BPR) and business network redesigns (BNR) are mechanisms for achieving agile capabilities. Accordingly, an organisation's speed of response to external pressure determines its competitive survival and growth. Time-based management determines how agile an organisation is (Gehani, 1995). A case in point, is the effect of Exxon's response time to the Alaskan oil spill on its corporate existence (Gehani, 1990).

Towill and Christopher (2002) summarise the core dimensions of attributes of an agile supply chain as shown in Table 2.2. They state that supply chains should view leanness and agility as complementary rather than mutually exclusive. Accordingly they propose that for a supply chain the leagile (combining lean and agile) may be the most appropriate,

as a leagile supply chain will have the dual advantage of efficiency of leanness as well as the responsiveness of agility.

Table 2.2: Distinguishing attributes of an agile supply chain

Activity Level	Agile Attributes
Marketing	Customer enriching, individualised combinations of products and services
Production	Ability to produce goods and services to customer orders in arbitrary lot sizes
Design	Holistic methodology integrating supplies, business processes, customer and products use and disposal
Organisation	Ability to synthesise new productive capabilities from expertise of people and physical facilities regardless of their internal or external location
Management	Emphasis of leadership, support, motivation and trust
People	Knowledgeable, skilled, and innovative work force

Source: Towill and Christopher (2002)

The drivers for agility are market uncertainty as fallout of globalisation, increasing product obsolescence as a result of falling product life cycle (PLC), perennial change in customer demand and product complexity. One of the attributes of agile manufacturing is to undertake mass customisation of products at the cost of mass production. However, the resource capabilities required for this are often beyond the reach of a single company but can only be attained by integrating core competencies of separate companies to form a network of virtual corporation (Adeleye, 2002). Agility has been shown to be dependent on internal "employee and communication integration" (Hormozi, 2001; 134). However in some cases, the ability to seize an opportunity is impaired by internal resource limitations. Accordingly, to be proactive in pursuing emergent market opportunities, Hormozi (2001, 134) argues that an agile enterprise should transcend "...internal cross-functional teams ... through the cooperation of suppliers and sometimes even with competitors."

2.6.1 The agile supply chain

It has been observed that increasingly competitive advantage is contingent on the combined capabilities of the integrated network of organisations (Christopher and Towill, 2001). This contrasts with the traditional view of business being based on a single firm. Additionally, markets today are increasingly volatile and therefore less predictable. To be competitive and successful requires organisations to be agile in their response to market demand. However, often organisations do not possess all the resource competence to satisfy the dynamic customer tastes. Accordingly, the capabilities of the whole supply chain should be leveraged to satisfy customer demand. The turbulence in business environment leads to the requirement for agile supply chains. Moreover, the strategy for

competing on the basis of agility is a strategy for management of the whole supply chain (Power et al., 2001). Thus, agility in supply chain demands top management involvement to restructure the supply chain and associated services such as logistics, in order, to achieve the level of responsiveness desired in the supply chain. In agile supply chain settings, flexibility and responsiveness in relationships between suppliers of products or services are important. Indeed, to be truly agile, supply partners must be able to move more quickly in addition to using existing equipment and facilities more efficiently, (Gunasekaran, 1999) but importantly, agility in the supply chain is contingent on the nature of material and information flow. van Hoek et al., (2001) developed agile supply chain framework which they subsequently used to audit agile capabilities in the supply chain. The results of the audit show that, though customer sensitivity is of major concern in an uncertain operating environment, realizing the agile attitude will require further efforts on organisational capabilities such as process, network and virtual integration. Using insights from the existing literature, their study tried to integrate the agility dimension into the supply chain.

Christopher (2005) presents principles of competition between supply chains by stating that "4Rs" guide the nature of competition between supply chains. The 4Rs are summarized as follows: Responsiveness, Resilience, Reliability and Relationships. Among the key attributes of responsiveness of a supply chain is the need to have an agile supply chain so as to meet the dynamic demand of customer for customized product or a make-to-order product. Additionally, responsiveness is closely linked with the reliability of the supply chains in terms of process capability and competence. The following summarises the responsiveness and reliability in the 4Rs:

1. Responsiveness: The contemporary business environment often demands products in a just-in-time (JIT) mode, such that the need to satisfy the customer promptly is of critical importance. This necessitates the lead time for products to be shortened. Moreover, the need for customized products leads to the call for flexibility of the supply chain to provide customer driven products that have a lot of variety. Accordingly, the forecast driven nature of the traditional supply chain is inadequate to satisfy customer demand effectively. Hence only an agile supply chain or agility being inbuilt in the supply chain is capable of satisfying the demand in situations of this nature. In a way the agile supply chain can be explained from the "demand pull and technology push" perception of the demand satisfaction process. In this regard the demand pull is based on the need for the product as orchestrated by the specific customer need, and hence is dependent on the customer order being received first, which triggers the process for making the product. Typical organisations that work

on this type of process are Dell computers, Zara and Seven Eleven of Japan. On the other hand, the technology push type of supply chain is that which is dependent on demand forecast such that a standard product is made and then sent to the market with the hope that the market will accept the product. In this case no effort is made within the supply chain for mass customisation of the product; in fact, this type of supply chains tries to reduce variability in the demand by forecasting and aggregating the demand for the product based on past sales or the consumption of production inputs. Indeed, the main attribute of the pull supply chain is that it is demand driven while the technology push supply chain is forecast driven.

2. Reliability: The second guide for competition according to Christopher (2005) is reliability of the supply chain to satisfy the demand in the face of uncertainty. An unreliable process creates uncertainty and variability. The source of uncertainty could be in terms of future demands or the supplier's ability to meet delivery promise or about the quality of materials and components. Essentially lack of visibility of demand within the supply chain adds to uncertainty. The reliability of a supply chain would be improved through re-engineering the processes that impact performance, as well as, provision of real demand information supply chain wide enhances reliability of response.

3. Resilience: The prevailing business environment is characterised by turbulence and volatility which imposes the risk of disruption and ultimate breakdown. Accordingly resilient supply chains are more capable of surviving the incidence of unexpected disturbances typical of uncertain business environment. Key attribute of resilience include recognising the part of the supply chain that is most vulnerable. Vulnerability could be dependence on a single supplier, or a supplier with long lead times, or a bottleneck in a process. Thus managing the critical part of supply chain, that is most susceptible to failure in challenging times, becomes key priority. Resilient supply chain also utilises strategic inventory and spare capacity to attenuate the impact of disruptive effects.

4. Relationships: The need for relationship management becomes critical as supply chains become more complex and outsourcing increases dependency on suppliers. Thus companies are discovering that, the need for an agile and responsive supply chain built on reliable process systems that posses the resilience to cope with turbulent and volatile markets, requires that companies that are legally independent be interdependent. Moreover companies realise that advantages can be gained by

seeking mutually beneficial relationships with suppliers. Buyer/supplier relationships based on partnership benefits buyers in terms of improved quality, innovation sharing, reduced costs and integrated scheduling of production and deliveries. Whilst suppliers the mutual dependencies increases barriers to entry making it more difficult for competitors to break in.

Duclos et al. (2003) present an integrated conceptual model of supply chain flexibility, based on the notion that in the contemporary business environment, it is supply chains rather than individual organisations that compete (Christopher, 2000). They argue that to be successful, firms must raise flexibility from an operational level to a strategic inter-organisational perspective, thereby attaining supply chain wide flexibility, thus encompassing departments within an organisation, and the external partners, including suppliers, carriers, third-party companies and information systems providers. It also includes the flexibility to capture market demands and exchange information between organisations. They conclude that flexible supply chains will outperform their less agile competitors. In other words, Duclos et al (2003) linked flexibility as an indicator of how agile an organisation is.

Agility is very much dependent on the operating environment of the supply chain which a particular company operates. Therefore, Fisher (1997) identified two types of supply chain based on the operating environment. A physically efficient or responsive supply chain is suitable for functional products with predictable demand, while innovative products with unpredictable demand would best be served by a market responsive supply chain. For functional products the emphasis of the supply chain is to minimize "physical" cost, but for innovative products, speed of response and flexibility in satisfying customer demand are crucial. Fisher(1997) introduced the matching of supply chain strategies to the right level of demand uncertainties of the product. Lee (2002) extended Fisher's framework to include supply uncertainties. Lee (2002) went on to deduce four strategies for a supply chain based on demand and supply uncertainties. The supply chain strategies are: Efficient supply chains, Risk-Hedging supply chains, Responsive supply chain and Agile supply chain. Thus an agile supply chain is an integrated operation encompassing the entire range of upstream and downstream activities. It can be deployed to take advantage of temporal windows of opportunity in the business environment coupled with empowering employees from all dimensions (Adeleye, 2002). In view of the fact that agility entails reading and responding real demand in order to enrich the customer (Goldman et al, 1995), Bal et al (1999) then argue that an agile supply chains is contingent on rich relationships among members of the supply chains.

A range of contingency models in supply chain networking that will enable smooth operation of an agile supply chain have been identified (Adeleye, 2002). These are: conditional alliances, lean supply chains and agile supply chains. Conditional alliances are used especially by multinationals to enter new territory while lean supply chains are used for outsourcing and distribution to avoid distortion in schedule and finally agile supply chains provide a means for leveraging core competencies on a global scale to exploit change. The agile supply chain is capable of meeting customer demand effectively, particularly for complex products and in situations of market instability.

Christopher (2000) argues that the key to being an agile organisation is the quality of supplier relationships. Often it is the lead-time of in-bound suppliers that determines the response of a producer to customer requirements. Similarly, involving the suppliers in the innovation process will considerably reduce new product introduction time. Barlow (2000) reports that in the UK North Sea oil operation, BP had 53% of its expenditure (totalling $3 billion in 1993) spent with third parties. This was spread among 4200 suppliers and contractors, 70% of which accounted for 0.5% of expenditure. This is a manifestation of a fragmented supply. Techniques like supplier base rationalisation and agile supply chain could be useful in aligning the supply chain for better performance. Furthermore, partnership with suppliers is crucial to development of more responsive supply chains. However, to partner successfully, there must be supplier rationalisation.

The work on agility is mostly focused on discrete high volume production manufacturing, and there is a lack of work on agile supply chains in the process industry. Hence, there is a need to carry out empirical research to determine the suitability of some of the attributes of agility in other industrial sectors. Diversity of the industrial sectors in which study of agility is carried out will both enrich and extend the theory espoused so far.

In the following section a comprehensive definition of agile supply chains will be discussed. This is necessary as the myriad definitions of agility available emphasise different aspects.

2.6.1.1 Definition of agile supply chain

Various definitions of agility have been advocated in the literature. Agility has been defined with respect to the agile enterprise (Gehani, 1995; Browne and Zhang, 1999; Goranson`, 1999), products, workforce (Breu et al., 2002), capabilities (Yusuf et al., 2004), and the environment (Robertson and Jones, 1999). The main features of an agile supply are summarised as follows (Yusuf et al., 1999; 36):

- High quality and highly customised products
- Responsiveness to change and uncertainty
- Synthesis of diverse technologies
- Mobilisation of core competencies
- Intra-enterprise and inter-enterprise integration
- Products and services with high information and value-adding content
- Responsiveness to social and environmental issues.

The early proponents of agility have defined agility as a:

"...system with extraordinary capabilities (Internal capabilities: hard and soft technologies, human resources, educated management, information) to meet the rapidly changing needs of the market place (speed, flexibility, customers, competitors, suppliers, infrastructure, responsiveness). A system that shifts quickly (speed and responsiveness) among product models or between product lines (flexibility), ideally in real-time response to customer demand (customer needs and wants)." (Youssef, 1994; 4). It is clear that the preceding definition does not link agility to outcome in terms of overall organisational performance such as financial performance.

Goldman et al. (1995: 42) gave a working definition of agility as *"... dynamic, context specific, aggressively change embracing and growth oriented ... succeeding...winning profits, market share and customers"*, meaning that agility is the ability of a business to grow in a competitive market of continuous and unanticipated change, to respond quickly to rapidly changing markets driven by customer-based valuing of products and services (Kidd, 1994; Gehani, 1995). Furthermore, Gehani (1995: 29) emphasises that *"An agile organisation can quickly satisfy customer orders; can introduce new products frequently in a timely manner; and get in and out of its strategic alliances speedily."* In this case the nimbleness of alliance and partnership formation also constitute agility, which highlights the notion of agility being context specific (Goldman et al, 1995).

Agility has also been defined in terms of specific activities and operational issues. Kidd (1994) proposed an operational definition of agility as *"the synthesis of a number of enterprises that each has some core skills or competencies which they bring to a joint venturing operation..." thus enabling the cooperative enterprises to adapt and respond quickly to changing customer requirements* (Kidd (1994) cited in Yahaya et al., 1999; 36). Kumar and Motwani (1995; 36) defined agility in terms of *"...a firm's ability to accelerate activities on critical path, and is a direct indicator of firm's time-based competitiveness."* Thus, agile supply chains compete on the basis of total cycle time-compression (Mason-

Jones and Towill, 1999). Similarly, agile supply chains were defined as being "*...all about customer responsiveness and mastering market turbulence and requires specific capabilities, on top of those that can be achieved using lean thinking." (van Hoek et al., 2001;127).* A key consideration in this definition is the fact that agility is built on leanness. Thus an organisation needs to become lean by implementing practices that will reduce waste in its operations before it can achieve agility. Thus, leanness and agility are complementary rather than mutually exclusive; accordingly they needs to be integrated (Naylor et al., 1999; Yusuf and Adeleye, 2002).

Furthermore, a definition of agility with manufacturing as the focus was given as follows:

"...the successful exploration of competitive bases (speed, flexibility, innovation proactivity, quality and profitability) through the integration of reconfigurable resources and best practices in a knowledge rich environment to provide customer-driven product and services in a fast changing market environment." (Yusuf et al., 1999: 37).

Although similarities exist between this definition and the former ones, there are four key differences: First it distinguishes between input, operating tools and mechanisms and the desired output. Second, explicit competitive bases have been given. These are speed, flexibility, innovation, proactivity, quality and profitability. Third, the definition highlighted three levels of agility, the three agility levels are the individual (and other resources), enterprise and inter-enterprise agility known as "*elemental agility, micro-agility and macro-agility."* Thus, an agile enterprise harnesses the capabilities of individual resources (people, facilities and management) and complementary organisational attributes to achieve the best output. The system wide enhancement of the resources rather than individual enhancement leads to agility. Macro-agility, which is at the highest level of agility, is achieved by joining core competencies of prospective partners for cooperative gains. Thus, an agile supply chain will easily form/enter into cooperative alliance even with competitors in order to exploit temporal business opportunity.

The various definitions of agility from the existing publications are summarised in Table 2.3. Although each of the definitions highlights distinct issues, there are themes that are common to all the definitions. For example, the various definitions highlight the following themes and issues:

- Synthesis of technologies and methods to organise production systems
- Provision of quality customised products

- Enterprise integration (internal, external), also through relationships with customers and suppliers
- Responsiveness.

In light of the review carried out above, it can be stated that agility encompasses products and services, production systems, technologies, enterprise/organisation, integration, customers/suppliers, responsiveness, change and uncertainty, relationships and visibility of demand.

The following section will provide existing classification of the attributes of agile supply chain from which a summary of the adopted classification in this study is made.

Table 2.3: Definitions of agile supply chain

Main definitions of agile supply chain in literature
1. Synthesis of diverse technologies and **methods of organizing** production systems (Burgess, 1994).
2. Agility is being able to **provide high quality and highly customised** products and services (Kidd, 1994).
3. Intra-enterprise and inter-enterprise **integration** (Vastag et al., 1994).
4. Agility means delivering products and services with **high information content and value-adding to customers.** Also being ready for **change**, valuing **human knowledge and skills and virtual partnership** formation (Goldman et al., 1995).
5. Agility is successful **exploration of competitive bases** through the **integration of reconfigurable resources** and best practices in a knowledge-rich environment to provide **customer-driven** products and services in **fast changing market environment** (Yusuf et al., 1999).
6. Using **market knowledge and virtual corporation** to exploit profitable opportunities in **volatile business environment** (Mason-Jones and Towill, 1999).
7. The ability of an organisation to **respond rapidly** to changes in demand, both in terms of volume and variety (Christopher, 2000).
8. Effectively **integrating supply chain** and **forging close and long term relationships with customers and suppliers** (Tolone, 2000).
9. All about customer **responsiveness** and **market turbulence** and requires specific **capabilities** (van Hoek et al., 2001).
10. Agility is an ability to have **visibility of demand, flexible and quick response** and **synchronized operations** (Aitken et al., 2002).

2.6.2 Classification of the agile supply chain attributes and enablers

In this section drivers and attributes and supply chain management in general and agile supply chains in particular will be presented. This is necessary as a prelude and to guide operational tools and metrics for empirical audit of the diffusion of agile supply chains within the oil and gas clusters.

Enablers are the critical success factors for implementation of agile supply chain, while attributes are the important components of an enabler. In a survey, four key enablers to effective supply chain management were identified. The enablers of supply chain management are: organisational infrastructure, technology, strategic alliances and human resources management. The attributes of each of the enablers are set out in Table 2.4 (Marien, 2000).

Information sharing between supply chain partners (Chopra and Meindl, 2001) is crucial to the performance of a supply chain because it is the basis for decision making by managers. Information binds the other supply chain drivers - Inventory, Transportation and Facilities - to work together to create an integrated and coordinated supply chain. Information makes the supply chain visible to managers to make decisions that will improve performance (Chopra and Meindl, 2001). Chopra and Meindl consider information to be the most important of the supply chain drivers, because without it, none of the drivers can be used to deliver a high level of performance.

Information and Communication Technology (ICT) consists of tools used to gain awareness of information and to analyse the information to make the best decisions for the supply chain (Hooper et al., 2001). Information is necessary for supply chain performance improvement; ICTs in supply chain enable capture and delivery of information for decision making. Lin et al. (2005) classified information integration as one of the key enablers of agile supply chains. Information integration includes the ability to use ICT to share data between buyers and suppliers.

Goldman et al. (1995) pioneered the subject of agile manufacturing. Through their "strategies for enriching the customer" they postulate the four dimensions of agility to be:

- customer enrichment through delivering value to the customer;
- cooperating to enhance competitiveness by forming virtual partnerships;
- being ready for change by organizing to master change and uncertainty, and;
- leveraging the impact of people and information through valuing human knowledge and skills.

Based on the pioneering deduction of the four basic elements of agility, researchers attempted to explain and conceptualise the dimensions of agile manufacturing (Yahaya et al, 1999) and agile supply chain (Christopher, 2000; 40). According to Christopher (2000) agile supply has four elements: customer sensitivity, virtual integration, process integration

and network integration as shown in figure 2.2. Following van Hoek et al (2001) these four dimensions can be explained as follows:

- Customer sensitivity: Products are perceived as solutions to individual customer problems. As such, organisations strive to provide total solution products.
- Virtual integration: in an attempt to satisfy customer needs, cooperation is used to harness the available resources not just within the organisation but throughout the supply chain. Thus, through virtual integration an organisation achieves both instantaneous response as well as stable production flows.
- Process integration: relates to mastering change and uncertainty through managing the whole supply chain rather than merely having the ability of mastering change across the organisation. This is achieved through self-managing teams rather than through work standardisation and conformance.
- Network integration: by which supply chain members cooperate in a bid to enhance competitiveness. This evokes the critical issue of supply chain governance. Thus flexible, innovative organisational structures become the norm in an effort to form and reconfigure appropriate organisational arrangement to exploit any window of opportunity. Indeed such organisations are termed "entrepreneurial organisations" (Hooper et al., 2001).

Essentially, all the acts of integration involved in the process, virtual and network integrations are achieved through the mechanisms of leveraging the impact of people and information on organisational operations.

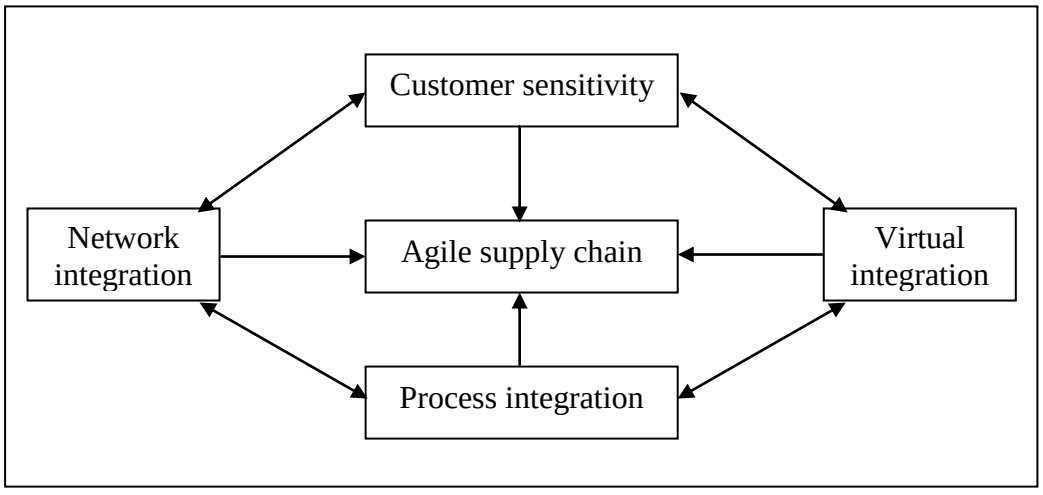

Figure 2.2: Elements of an agile supply chain (Source: Christopher, 2000; 40).

Table 2.4: SCM enablers and attributes

Enabler	Attribute
Organisational infrastructure: Having	-A coherent business strategy -Formal process - flow methodologies to enable SCM improvements -People committed and responsible for cross-functional processes -Right process metrics identified to guide the operating units performance toward the strategic organisational SCM objectives -Cross-functional design teams implement change -Business processes shared within the organisation vs being owned by functional units -One business function driving the SCM initiative
Technology 1. Information technology: Having	-Operations, marketing and logistics data coordinated within the company -Data readily available to managers, not embedded within legacy systems -Operations, marketing and logistics data coordinated between companies
2. Manufacturing and Materials Handling: Having	-Products designed for production flow-through and inventory velocity -Physical production processes designed to facilitate SCM initiatives -Products designed to facilitate flow-through inventory velocity
Strategic alliances: Having	-Expectations clearly stated, understood and agreed upon up front -Collaboration on supply chain design and product and service strategies -Top management of partnering companies interface on regular basis -Compatible IT systems -Top management communicate why strategic alliances are important and being pursued -Agreeing on a process to incorporate business changes -Developing an alliance partner-selection process -Lead persons responsible for building alliances on the job at least for a year
Human Resource Management	-Sourcing, hiring and selecting skilled people at all management levels -Finding change agents to manage SCM programs in place -Compensation and incentive programmes in place for SCM performance -Finding internal process facilitators knowledgeable in SCM -Appropriate job descriptions and responsibilities -Performance appraisal system for people working in cross-functional supply chain projects

(Source: Marien, 2000)

Power et al (1999) undertook an empirical study of manufacturing companies to identify critical success factors to enable agile organisations manage their supply chains. Their result distinguished "more agile" from "less agile" organisations. More agile companies are customer focused, and apply a combination of "hard" and "soft" methodologies in order to meet the changing customer requirements. Furthermore, supplier involvement is crucial in organising to attain high levels of customer satisfaction. The "less agile" organisations are more internally focused, with a bias towards internal operational outcomes. They use technology solely for enhancing internal operations rather than geared towards attaining high levels of customer satisfaction. An earlier survey of 1,000 companies and 12 case studies by Zhang and Sharifi (2002) concluded that practices related to people and organisation issues were both more effective and important for manufacturers. Additionally, a key determinant of the ability to make rapid changes in manufacturing is the selection, development and integration of suppliers with appropriate capabilities. It can be concluded that employee empowerment and training is an important attribute that enhances organisational agility.

Based on literature, Yusuf et al. (1999) suggest 32 attributes of an agile supply chain organisation, broadly classified into ten decision domains. The decision domains, are as follows: integration, competence, team building, technology, quality, change, partnership, market, education and welfare. A summary of the decision domains and their accompanying attributes is shown in Table 2.5. Based on these attributes and decision domains, Ren et al. (2002) undertook a study of effects of the agile attributes on competitiveness and found speed and proactivity to be the most dominant agile attributes impacting competitiveness. Proactive organisations are those that are able to deploy rapid partnership formation to exploit business opportunities. Thus Ren et al. (2002) contend that adopting the operational strategy such as rapid partnership formation will enable an organisation to be competitive.

In summary the classification of agile supply chain dimension adopted in this study is based on Meade and Sarkis's (1999) model. For example enriching the customer is viewed as outward focussed because it points to the outcome of being an agile supply chain. Thus enriching the customer ensures that an organisation concentrates on meeting the changing market requirement, maximise customer service level as well as minimise the cost of goods. This enables an organisation to be competitive in a global market which ensures profitability and sustainability (Gunasekaran and Yusuf, 2002; Vazquez-Bustelo et al., 2007). Furthermore, agility dimension of cooperating to compete is an input by the

organisation and it relates to the need for cooperation internally and externally in order to reduce product development costs, time to market and risk to the supply chain. As part of cooperating to compete, formation of strategic alliances based on core competencies irrespective of location is undertaken in order to be first to market (Goldman et al., 1995). Additionally, agility thrives in a dynamic business environment characterised constant change and uncertainty. Thus an agile supply chain should be able to survive the dynamic change by being organised in order to master change and uncertainty. This requires the supply chain to have flexible structure that allows rapid reconfiguration of human and physical resources. Mastering change and uncertainty is achieved through having skilled workforce, distributed resources and authority as well as fostering culture of creativity and innovation within an organisation. Finally leveraging the impact of people and information constitute the last input of an agile supply chain. Leveraging the impact of people is achieved by instituting human resource practices that develop highly trained, motivated and empowered work force working in teams. Whilst leveraging the impact of information results by making quality information widely and readily accessible to the motivated workforce. Indeed Meade and Sarkis (2001; 243) state that "An agile organisation sells its ability to convert the knowledge, skills and information embodied in its personnel into solution products for its individual customers." Accordingly leveraging the impact of people and information is the mechanism that utilises cooperative relationships to attain customer enrichment.

Table 2.5: Operationalization of agility attributes (Source: Yusuf et al., 1999: 41)

Concept	Attributes
Integration	• Concurrent execution of activities • Enterprise integration • Information accessible to employees
Team building	• Empowered individuals working in teams • Cross functional teams • Teams across company borders • Decentralised decision making
Competence	• Multi-venturing capabilities • Developed business practice difficult to copy
Technology	• Technology awareness • Leadership in the use of current technology • Skill & knowledge enhancing technologies • Flexible production technologies
Quality	• Quality over product life • Products with substantial value-addition • First time right design • Short development cycle times
Change	• Continuous improvement • Culture of change
Partnership	• Rapid partnership formation • Strategic relationship with customers • Close relationships with suppliers • Trust-based relationship with customers/suppliers
Market	• New product introduction • Customer-driven innovations • Customer satisfaction • Response to changing market requirements
Education	• Learning organisation • Multi-skilled and flexible people • Workforce skill upgrade • Continuous training and development
Welfare	• Employee satisfaction

The following section will shed light on the chosen field of study. The area chosen for testing the impact of being in an industrial cluster on agility, competitiveness and business performance of a supply chain is the oil and gas supply chain. The choice of the industry is due to the fact that the oil and gas industry is an industry that is based on exploitation of natural resources; hence, it is often location-specific. Accordingly, in the UK the location of the upstream oil and gas industry is considered as an industrial cluster, as it is a dense milieu of firms active in the oil and gas business.

2.7 Oil and gas supply chain

The oil and gas supply chain consists of upstream, focal firm and downstream activities (often modelled as raw material sourcing, production and delivery of oil products undertaken by suppliers, producers and distributors). This categorisation is similar to the established supply chain model consisting of suppliers, producer and customers represented by the supply chains of manufactured goods (Peters and Hood, 2000). Although the oil and gas supply chain compares to the nominal supply chain, they are by no means the same. The oil and gas supply chain differs from the supply chain of low value, high volume commodity products in the mode of its organisation upstream to extract crude oil (which is the raw material for petroleum products). Moreover, studies of industrial dynamics in supply chains have concluded that upstream businesses suffer greater volatility than do downstream businesses (Hallwood, 1990; Hallwood, 1991b).

Activities at the upstream end of the oil and gas supply chain can be decomposed into two parts. The first is the fabrication of the equipment to be used in oil production and the second is production of gas and crude oil. Oil equipment is often produced by contractors and suppliers of specialised equipment; on behalf of oil operators. A project form of organisation is used in oil equipment fabrication. The activities involved in the second part are essentially operations-based, that is, after the equipment for the oil extraction is fabricated and installed the crude oil production will be undertaken until all the oil and the well (reservoir) has been depleted. It is in this upstream oil and gas equipment fabrication and subsequent operations that we find the existing mode of classification of supply chains inadequate or, in the extreme, misleading. Organising to undertake the activities of crude oil production involves three tiered players; operators, contractors and suppliers. A high level of innovation is required in the activities of the contractors and suppliers in undertaking their tasks (Crabtree et al., 1997; Crabtree et al., 2000). Currently there are issues related to lowering of costs of operations associated with oil extraction, and long lead time in delivering services by contractors, all of which affect the competitiveness of operations of the oil and gas supply chain generally and in the North Sea oil and gas cluster in particular (CRINE Network, 1999). Another characteristic of the offshore oil and gas production industry is the presence of all the players clustered within a defined geographic location (Hallwood, 1990; Hallwood, 1991a). Hallwood (1991) found that instances arise in which oil operators refuse to transact with organisations that are not located close to their operations. Additionally, the international dimension of operations and players in the oil and gas industry also brings the issue of agility (particularly speed and flexibility) in their network, organisation and operations (Prater et al., 2001).

Oil and gas have been classified as commodity products. As such, their supply networks should focus on costs (Miles and Snow, 1987; Fisher, 1997). However, the previous classification looks at the final product (for example gasoline and other refined petroleum products) at the point of consumption only, but does not consider the complex range of activities and companies involved in the exploration and production of crude oil - which is the raw material for refined petroleum products. Indeed, the gathering of crude oil is an example of heavy industrial activity in which the production method is complex. It was observed that the production method adopted by heavy industries is known as one-of-a-kind production (henceforth OKP) (Tu, 1997). We classified the oil and gas exploration to be OKP because of the similarities between characteristics of the offshore oil and gas industry operations and typical properties of the OKP. It was stated that the OKP production method converts the customer's development ideas or requirements into a product by a 'once' successful approach constrained by a "critical delivery date, cost and quality" (Tu, 1997: 272). High complexity and uncertainty are typical of the environment in which high value engineer-to-order (ETO) one of a kind (OKP) products are made. High value OKP are usually specified by the customer and manufactured by engineer-to-order companies, where the main order winning criterion is fitness for purpose through innovative product design and development (Little et al., 2000). Little et al. (2000) note the propensity for customers to change their requirements over the time of the manufacture of high value ETO product. Thus, the ability to respond to the evolving modifications is a prerequisite for success in many ETO firms and requires remarkable agility in the supply chain. The main characteristics of a high value engineer to order OKP are as follows (Tu, 1997):

- High customisation;
- Get it right first time approach on the product;
- Continuous customer influence through the production processes;
- Optimal or rational utilisation of technologies and resources;
- Prototype-based evolutionary and concurrent approach of product development and production;
- Distributed control and inter-organisational autonomy;
- Virtual company structure and global production; and
- Adaptive production planning and control.

Accordingly, critical success factors for organisations require the supply chain to be agile in order to effectively meet customer requirements. Additionally, in order to be

competitive organisations must integrate their supply chains more effectively and collaborate with their customers as well as suppliers more quickly (Tolone, 2000).

Supply networks have been extensively studied (Hakansson and Snehota, 1989; Harland, 1996; Johnsen et al., 2000; Lamming et al., 2000; Camuffo et al., 2001; Harland et al., 2001; Harland and Knight, 2001; Harland et al., 2004). These studies recounted the experience of firms that managed their supply networks to achieve competitive advantage, for example Toyota (Womack et al., 1990), Nissan (Nishiguchi, 1994) and Benetton (Camuffo et al, 2001). However Lamming et al. (2000) observe that

"…these accounts have typically explored particular industries…automotive industry; *managers in other industries dealing with some different business problems, thus lack theoretical underpinnings for managing their particular kinds of [supply chains]"* (Lamming et al., 2000; 676).

In the oil and gas industry sub-sector, major oil companies believe that agile supply chain alliances rather than internal operations will offer the main source of performance improvement. In fact supply chain management practices are now seen as "...an opportunity to improve performance when scope for cutting internal costs and re-engineering business processes has been exhausted." (Ernst and Steinhubl, 1997; 145).

Thus, following the trend already set in other sectors (Ramdas and Spekman, 2000) and inspite of the need for greater supply chain management practices to bring their supply chain performance in line with other sectors, evidence suggests that about 80% of oil companies have doubts about the effectiveness of their supply chains and less than half are aware of tools and techniques to optimise their supply chains (Ernst and Steinhubl, 1997). Furthermore, Ernst and Steinbuhl (1997) note that industry leaders think that a significant part of oil and gas activities will be sourced from the supply chain over the next ten years, highlighting the need for better understanding of the interactions across oil and gas supply chains and the emergent complexity. As oil companies outsource most of their internal operations, greater integration and SCM capability becomes important.

Within the UK oil and gas upstream operations in the North Sea, there is government and industry based initiative directed with the aim of extending supply chain management practices to the oil and gas industry (Crabb, 1998). This is based on the finding that oil and gas prospecting and production costs remain the one of the highest in the world (CRINE Network, 1999). Accordingly, this study will investigate oil and gas supply chains with the aim of determining the extent of adoption and diffusion of established agility attributes in

the supply networks of oil and gas supply chains. Furthermore, the impact of the clusters, in which the oil and gas companies are located, on the performance of the oil and gas industry operations will also be examined.

2.8 Competitive advantage of the firm

Competitive advantage arises from the ways in which a firm chooses to compete in the marketplace and the types of markets it pursues (Hayes and Wheelwright, 1984; Porter, 2004; Quinn, 1992). The competitive objectives on which organisations base their operations are many and varied. They include low cost, quality, dependability, speed, flexibility, product customisation, innovation, delivery and proactivity. Ideally, a company would strive towards simultaneous attainment of a wide range of competitive objectives even as the trade off syndrome persists in most companies (Vokurka and Fliedner, 1998; Ward et al., 1998; Rosenzweig et al., 2003; Gonzalez-Benito, 2005; Zhang and Sharifi, 2007). However, innovative methods such as TQM, JIT, and concurrent engineering have led to significant advances in cost, quality and speed. They also facilitate a shift in the position of competitive trade-off from most of the basic objectives such as cost and quality to higher order objectives such as speed and product customisation (Ward et al., 1998; Gordon and Sohal, 2001).

In light of rapid changes in market requirements, relative emphasis placed on competitive objectives is crucial to business performance (Fliedner and Vokurka, 1997; Vokurka and Fliedner, 1998; Vokurka et al., 2002; Lau and Hurley, 2001). This is in addition to systematic extension of competitive objectives beyond cost and quality to higher order objectives such as flexibility, product customisation, innovation and dependability (Hayes et al., 1988; Li, 2000). Ultimately, a company should improve its agility in terms of enhanced ability to compete from all fronts simultaneously.

Differentiation based on low cost is the most basic competitive advantage. It seeks cost savings through economies of scale, baseline products with relatively stable life cycles, standardised machines, regular equipment maintenance, maximum labour utilisation, lower overhead costs, long production runs, and right first time practices (Edwards, 1996; Silveira and Slack, 2001). The quality objective follows low cost. It emphasises product confidence through quality assurance, parts availability, serviceability, user serviceable designs, guarantees, warrantees, and incremental additions to product features. Innovative programmes such as JIT, TQM, QFD, SMED, continuous improvement, concurrent engineering and automated process control of quality have

succeeded in reducing traditional trade-offs between cost and quality (Flynn et al., 1995a; Flynn et al., 1999; Curkovic et al., 2000).

Next to cost and quality is dependability. It means adherence to and compliance with the terms and conditions earlier agreed with or expected by the customer. Such terms include continuous realisation of fair or agreed prices as well as delivery dates or call-off quantities. Dependability is influenced by relative stability in sourcing inputs, synchronised operational processes and production flows as well as machine, equipment and personnel reliability. Dependability also requires just in time improvement in ethical and contractual obligations as well as designs and terms (Ling X, 2000). The emphasis on dependability has increased due to unprecedented instability in the competitive environment (Gordon and Sohal, 2001).

While it is important for manufacturers to deliver on low cost, quality and dependability objectives, unprecedented instability in the business environment has focused attention on speed and product customisation (Browne et al., 1995; Jagdev and Browne, 1998; Browne and Zhang, 1999). Speed means timely fulfilment of scheduled orders and developing new solutions ahead of competitors. Enhanced operations speed requires elimination of adversarial relationships, destructive interfaces, queues, breakdowns, incompetence in supply chains, operations processes, equipment and systems (Gordon and Sohal, 2001). Information technology has become the main tool for advancing speed as plant operatives could access requirements real time, just as customers' databases can be penetrated remotely for information on stocks and potential orders. Accordingly, routing, batching and scheduling can be initiated in real time.

Closely related to speed is the competitive objective of product customisation. It seeks to satisfy unique customer needs, accommodate design change at ease, and support a wider range of product configurations as a means of competing in mass and niche markets (Lampel and Mintzberg, 1996; Khalil and Wang, 2002; Brown and Bessant, 2003; Yusuf et al., 2003; Squire et al., 2006). If nurtured through agile supply chain networks, the potential to add value to current products and customers is crucial for surviving market instability (Dove, 1995; Dove, 1996)).

As product customisation becomes intensified, order size requirements per custom product will tend to fall (Yusuf et al., 2003). However, a company should be able to vary capacity and manufacture any size of orders at the same unit cost. This is volume flexibility, whose significance arises from increasing product fragmentation with attendant decrease in order

size quantities. Furthermore, a mass product may be customised for low volume supplies in specific market niches just as the basic features of a low volume customised product can be standardised for mass production. Accordingly, flexibility is the ability to change gears swiftly and intermittently from standard to custom product lines, to manufacture any order quantities, and adjust capacity at no extra cost to accommodate the need for frequent changes in demand (Stevenson and Spring, 2007).

Achieving flexibility can pose a challenge for an organisation, in that, although supply chain networking can lead to cost savings, quality improvement, speedy deliveries and rapid customisation, competence in flexibility seems to depend on internal competence of an organisation solely in terms of process and workforce. The process capability is indicated by the production planning and control efficiency. The most important are routing and batching flexibility so that custom orders can be processed in parallel, while the workforce capability depends on workers skills (Breu et al., 2002) and the ease of mobilising, shedding and reconfiguring vital production resources and much less on intelligent machines and technologies.

Ward et al. (1994) defined proactiveness in operational terms and demonstrated the impact of manufacturing proactiveness and performance. This and similar studies (Gonzalez-Benito, 2005) demonstrated the importance of a proactive posture for manufacturing and the link between manufacturing proactiveness and good business performance. However traditional manufacturing management has largely been reactive (Yusuf et al., 1999), whereas a proactive system will integrate with customers and help identify their problems and requirements and acquire capabilities just ahead of need. Thus proactivity offers strategic advantage for competing in a market characterised by turbulence and uncertainty.

In the light of the foregoing discussion, it was expected that an agile supply chain would impact widely on competitive objectives. It was also expected that positive influence on the competitive objectives would translate into significant gains in business performance measures.

The impacts of competitive objectives on business performance measures have been reported in a number of works (Swamidass and Newell, 1987; Droge et al., 1994; Li, 2000; Gordon and Sohal, 2001; Lau and Hurley, 2001). Such studies exclusively used financial measures of business performance mainly sales turnover, net profit, ratio of operating income to assets and return on investment (Li, 2000). Financial measures are popular as short-term indicators of potential reward to investors. However, they may be inadequate as

indicators of the level of activities, long-term survival and investment justification in situations of continuous change. Accordingly, a balanced score card of performance measures - financial, market and environmental is crucial in evaluating the impacts of change initiatives (Flynn et al, 1995). Accordingly this study reports five business objectives on which the impacts of clusters and agility enablers were tested. These business performance measures had been used frequently in prior related studies (Flynn et al., 1995b; Flynn et al., 1995a). The five business performance measures used in this study are: Turnover, Net profit, Market share, Customer loyalty based on repeat orders and Performance relative to competitors. Similarly, nine competitive objectives were used in this study in order to audit the most widely used within the studied organisations. The competitive objectives, summarised in Table 2.6 with the authors advancing them, are as follows: Customisation, Flexibility, Innovation, Speed, Reliability, Dependability, Delivery, Cost and Quality.

Table 2.6: Main competitive objectives discussed by authors

Author(s)	Competitive objectives
Squire et al. (2006)	Customisation, Cost, Quality, Delivery Reliability, Flexibility
Ward et al. (1994); Gonzalez-Benito, (2005)	Proactivity
Li (2000)	Cost, quality, delivery, flexibility
Rosenzweig et al. (2003)	Quality, Delivery reliability, Process Flexibility, Cost, Leadership
Zhang et al. (2003);Vickery et al. (1999); Narasimhan and Das (1999); Swafford et al. (2006a); Stevenson and Spring (2007); Duclos et al. (2003)	Flexibility
Gehani (1995)	Responsiveness, Flexibility
Kaipia (2008); Narasimhan and Das (2006); Cordero (1991)	Speed
Vastag et al. (1994)	Product Innovation and time-to-market, Delivery, Flexibility, Quality, Environmental effect, Integration
Swamidass and Newell (1987); Noble (1995)	Innovation, Flexibility, Cost, Delivery, Dependability, Quality

2.9 Summary

In this section the background to the need for implementation of agility was provided after giving an account of the development of supply chain management. Then the need for agility within the supply chain of oil and gas industry was evaluated with aim of highlighting the need to adapt to a new way of doing business. Indeed the global nature of the competition in the oil and gas industry business and the need for responsiveness to customer demands for inputs by oil producers justified the need for change.

CHAPTER 3: CLUSTERS AND INDUSTRIAL DISTRICTS (ID)

3.1 Introduction

This chapter will explore the concept of clusters and industrial districts as a distinct production model. First a definition of clusters and industrial districts will be given to highlight the key attributes of clusters. Then the competitive advantage of clusters will be enumerated and finally an account of supply chains management in clusters and industrial districts will be given. The aim of this section is to build the basis for selecting the site for this research work. The premise of this research is that an organisation is part of a cluster to such an extent that competition now is between clusters rather than between individual organisations or their supply chains. Within the UK there are 12 designated locations and regions that have been identified as having a significant clustering of industrial and economic activities to warrant their being referred to as clusters and industrial districts.

Location of firms within a defined geographic area has, in the recent past, been a subject of interest among scholars and policy makers (Porter, 2003; Martin and Sunley, 2003). Indeed clusters and industrial districts is a subject of intense debate in areas as diverse as economics, business, regional economics, industrial economics, economic geography and sociology (McDonald and Bellusi, 2002), as a result of which different models of inter-firm arrangements can be recognised (McDonald et al., 2006). The context of clusters and industrial districts has created a variety of concepts and approaches attempting to explain and shed light on the phenomenon. Accordingly concepts and approaches such as flexible specialisation, production system, regional cluster (Porter, 1990; Enright, 1999) and national system of innovation and hot spot (Molina-Morales, 2001; 278) have been used to describe the phenomenon.

Literature on the subject of industrial agglomeration reveals a semantic ambiguity with respect to the concepts of clusters and industrial districts. Clusters (Porter, 1998a; Porter, 2000) and industrial districts (Brown and Hendry, 1998) have been used interchangeably to describe the concentration of firms in an industry within a defined geographic location (geographic proximity) and social and economic interactions (supporting institutions and economic interdependency) (McDonald et al., 2006). The difference in the terminology arose as a result of the literature on the subject developing from diverse disciplines and a large number of contributions, such that it is impossible to denote with one term a large variety of phenomena. The concept of industrial districts is synonymous with the Italian experience and research on industrial spatial agglomeration and consequent social

dynamics within (Pannicia, 1999). On the other hand clusters or industrial clusters are terms most often associated with the research on industrial agglomeration research in the US (Porter, 1994; Porter, 1998a). Although the two terms are often used to mean the same thing, they emphasise different aspects. For example, the term industrial districts as shown by the Italian experience highlights the social network benefits whilst the American clusters emphasise market condition advantages that lead to enhanced productivity and organisational performance (Porter, 2000).

The terms are distinct from the concept of supplier parks that was highlighted by Lyons et al (2006). Supplier parks often are tailored towards the need of a single organisation, whereas industrial clusters owe their existence, not to the aim of harnessing the need of a single client, as is the case in most of the automotive sectors, but they are there to satisfy the needs of multiple customers. An example is the extractive and mining based industries whereby all the firms located at the source of resource will be involved directly or indirectly in the production of the resource and often many organisations will be involved in all the activities taking place. Moreover, the concept of supplier parks (Larsson, 2002), business hubs (Perry, 2007) and co-location (Reichhart and Holweg, 2008) as is evident in the automotive sector, is purely to enable synchronous and sequential JIT operations systems.

3.2 Definition of clusters and industrial districts.

Michael Porter, a leading exponent of competitive advantage of clusters, suggested a definition of clusters as:

"…a geographic concentration of interconnected companies and institutions in a particular field. It includes a range of related industries and other entities important to competition. They include suppliers of specialized inputs such as components, machinery and services and providers of specialized infrastructure. Clusters also often extend downstream to channels and customers and to manufacturers of complementary products and companies in industry related by skills, technologies, or common inputs. Finally, many clusters include governmental institutions-such as universities, standards-setting agencies, think tanks, vocational training providers, and trade associations-that provide specialized training, education, information, research and technical support." (Porter, 1998a; 78).

Equally McDonald (McDonald and Bellusi, 2002; 60) presents a definition, according to which:

"Clusters are geographically proximate firms in vertical and horizontal relationships, involving a localised enterprise support infrastructure with shared developmental vision for business growth, based on competition and cooperation in a specific market field".

Hill and Brennan (2000; 67) defined competitive industrial clusters:

"as a geographic concentration of competitive firms or establishments in the same industry that either have close buy-sell relationships with other industries in the region, use common technologies, or share a specialized labour pool that provides firms with a competitive advantage over the same industry in other places.".

Here, a cluster is identified as a system in which individual organisations and institutes as members are involved in generating higher unit earnings and more efficient operations due to innovations. The innovations are a result of intense competition and cooperation within the cluster (Lin et al., 2006a). Additionally, Hill and Brennan (2000) contend that industrial clusters are underpinned by five elements. These are: driver industries, technology, labour, consumer industries and supplier industries. The conceptual relationship between the five elements of a cluster is shown in Figure 3.1. Furthermore, based on the identified relationships shown in Figure 3.1, the competitive advantage of an industrial cluster is dependent on buy-sell relationships, the use of common technologies and innovation as well as sharing specialised pools of labour.

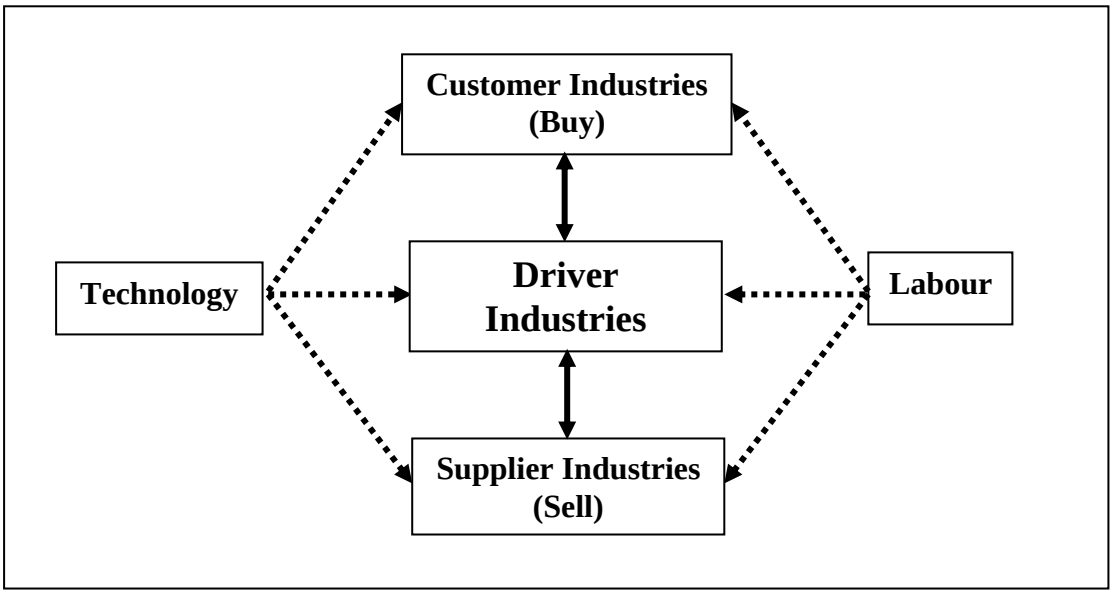

Figure 3.1**:** Structure of an industry cluster (Source: Hill and Brennan, 2000; 69)

The dominant characteristic of clusters and industrial districts is the co-location of companies, customers and suppliers. An example of an industrial cluster is in a place like Silicon Valley, where "industry participants rely on the benefits of proximity to help build

and manage global-scale production networks" (Sturgeon, 2003; 199). Within the cluster, the relationships that exist between the producers of the main products and supportive government agencies and other organisations such as universities, research centres, and trade associations create synergies that result in product and process innovations. The consequent innovations in products and processes as a result of cooperation between the members of the cluster lead to industry's improved performance and to the cluster's competitiveness (Austrian, 2000). Another advantage that is attributed to industrial clusters is increases in real productivity (Porter, 1994). The increase in productivity is as a result of decrease in production time and cost, on the one hand, and increase in quality on the other which all contribute to the benefit of being in clusters and industrial districts.

From the Italian experience, Industrial districts (henceforth IDs) have been defined as a socio-geographic system existing in a specific location, naturally and historically defined by active presence and interaction of people and firms (Carbonara, 2004). Thus, in the Italian ID's, we encounter both the voluntary/evolutionary agglomeration and intense social interaction between participating firms. Brown and Hendry (1998; 133) described IDs as "a network comprising interdependent firms operating in the same or related market segment and a shared geographic locality, benefiting from external economies of scale and scope from agglomeration." Furthermore, IDs have been characterised as a production model (Carbonara et al., 2002), with its salient feature of long tradition of networking, rather than results of recent trends within business strategy – such as outsourcing (Pihkala et al., 1999). A dominant feature of industrial districts is a network of producers united in supply chain relationships (Brown and Hendry, 1998).

However, there are critical observations on the cluster concept, where definitional ambiguity and inconsistency were highlighted (Martin and Sunley, 2003; Yamamura et al., 2003), Moreover it is debatable whether the cluster concept is solely responsible for regional economic development (Martin and Sunley, 2003). Table 3.1 summarises definitions of clusters and industrial districts by some researchers reported in Martin and Sunley (2003).

Table 3.1**:** Summary of cluster definitions

Cluster definitions
1. "A cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities" (1998b; 199).
2. "The more general concept of 'cluster' suggests something looser: a tendency for firms in similar types of business to locate close together, though without having a particularly important presence in an area" (Crouch and Farrell, 2001; 163)
3. "A cluster is very simply used to represent concentrations of firms that are able to produce synergy because of their geographical proximity and interdependence, even though their scale of employment may not be pronounced or prominent." (Rosenfeld, 1997; 4)
4. "Economic clusters are not just related and supporting industries and institutions, but rather related and supporting institutions that are more competitive by virtue of their relationships." (Feser, 1998; 26)
5. "Clusters are groups of firms within one industry based in geographical area." (Swann and Prevezer, 1996; 139)
6. "A cluster means a large group of firms in related industries at a particular location." (Swann, 1998; 1)
7. "We define an innovative cluster as a large number interconnected industrial and/or service companies having a high degree of collaboration, typically through supply chain, and operating under the same market conditions." (Simmie and Sennet, 1999; 9)
8. "Clusters can be characterised as networks of producers of strongly interdependent firms (including specialised suppliers) linked each other in a value-adding production chain." (Reolandt and den Hertog, 1999; 9)
9. "The popular term cluster is most closely related to this local regional dimension of networks … Most definitions share the notion of clusters as localised networks of specialised organisations, whose production processes are closely linked through the exchange of goods, services and/or knowledge." (Van den Berg et al.,1999; 187)
10. "A regional cluster is an industrial cluster in which member firms are in close proximity to each other." (Enright, 1996; 191)

Source: Martin and Sunley (2003; 12)

3.3 Concept and evolution of clusters and industrial districts

Wilson and Popp contend that during "the nineteenth and twentieth centuries, the industrial economy of England remained a patchwork of industrial districts, clusters and regional system." (Wilson and Popp, 2003a; 1). Early examples of industrial districts include the Lancashire textile industry, the Sheffield cutlery industry and the Swiss watch industry (Brown and Hendry, 1998). Present day examples of clusters and IDs include Silicon Valley in California, USA (Porter, 1998a; Kenney and von Burg, 1999; Sturgeon, 2003), Baden Wurttemberg in Germany, Northern Italy (Carrie, 2000) and London's – financial services sector (Brown and Hendry, 1998). Tables 3.2 and 3.3 are examples of high-technology based clusters in the USA and some European industrial districts respectively. Equally Table 3.4 shows two regional development agencies in the UK. The two regions – Yorkshire and Aberdeen – are the sites in which data was collected for further analysis as part of the empirical study, to answer the research question in this study.

Table 3.2: High-technology clusters in the USA

State	Cluster	Industry/Specialisation	Pivotal Institution
Massachusetts	Route 128 Boston	Aerospace, Electronics, Computers	MIT, Harvard University, Federal Labs
California	Silicon Valley Orange County	Electronics, Computers, Aerospace	UCLA, Other Universities
Kansas	Lawrence	Consumer durables	University if Kansas, Kansas Technology Enterprise Corp. Centres of Excellence
Georgia	Atlanta	Aerospace, Telecommunications	

Source: Adeboye, (1997; 220)

Table 3.3: Typical European clusters

Country	Cluster	Industry Specialisation
UK	Aberdeen	Oil and gas, Electronic, Semi-conductors
Italy	Piacenza	Machine tools
Germany	Baden Wurttenburg	Precision Engineering, Machine tools and Machinery
Denmark	West Jutland	Garment/Clothing and Furniture
Belgium	South West Flanders	Carpet weaving and Upholstery

(Source: Adeboye, 1997; 222)

Table 3.4: Some UK regional development agencies (RDAs) and their specialisations

Regional Development Agency (RDA)	Typical Clusters and Industrial Districts
Scottish Enterprise	Oil and Gas, Biotechnology, Opto-Electronics, Semi-Conductors, Software including multimedia; Tourism
Yorkshire Forward	Advanced Engineering, Chemicals, Food and Drink, Bioscience, Digital Industries

Molina-Morales (2001) contend that the main characteristics of clusters and industrial districts are the existence of strong networks of small firms. Wilson and Popp (2003b) gave an account of the nature of cluster life-cycles, network operation and leadership in English industrial districts. Various aspects are responsible for the evolution of clusters and industrial districts. For example, military productions have been cited as instrumental in the creation of high technology firm clusters (Geiger, 2003). Lorenzoni and Ornati (1988) gave an account of the evolution of industrial districts based on firm size, network and boundaries. Porter (1998a) argues that history and external factors are responsible for cluster evolution. Included in external factors are things that an organisation has no control over, such as climatic conditions, tax, high quality university or research institutes and facilities of similar characteristics. He characterises cluster development into distinct phases of birth, evolution and decline. Carrie (1999), drawing from existing clusters, contends that clusters, evolve through industry participants' activities. Hallwood (1991b) gave an example of industry clustering by pointing to the oil service companies establishing their presence in Aberdeen in order to supply the input requirements of UK upstream oil and gas industry. However, in other regions government seeks to lead the

process. For example in Korea, the government directed certain industries to specific cities where suppliers could establish themselves close to customers. Although governmental agencies have a role to play all the stakeholders in economic development have to make their contribution. In this regard, the Scottish Enterprise – a governmental agency – is leading the effort to disseminate the cluster concept and strengthen Scotland's clusters (Carrie, 1999).

Albino et al. (2000), based on the study of Italian industrial districts identify three main evolutionary stages of an industrial district (ID): formation, development and maturity.

The evolutionary stages are briefly explained as follows:

Formation of industrial districts is a result of two main processes:

1. a leading firm within or outside the district decentralises the production carried out by local firms within the industrial district. The leading firm outsources the production of subassemblies to labour-intensive small firms who also reside in the district. These firms are captive to the leading firm, because all their output (or capacity) goes to the "leader" firm. Thus, firm network is based on hierarchical and exclusive relationships between the craft-based firm and the leading firm. Inter-firm relationships here are stable but task specialisation is very low.

2. growth of craft-based firms specialising in a particular activity or product within a local area.

In the development stage, there are small and medium-sized firms that are highly specialised in aspects of the production process. There are one or several leading firms that have a focal position in the network. These firms develop specific production or marketing competencies and generally have direct access to the external market. Furthermore, inter-firm relations between leading firms and the SMEs are usually for capacity or specialised subcontracting.

In maturity the firm could pursue industrialisation, decentralisation or vertical integration. Furthermore, the hub firm acquires a leading position within the cluster to strengthen inter-firm relations and coordinate knowledge management processes. Specifically in this stage the leader firm undertakes growth mechanistic - hierarchical - inter-firm relationships. The leader firm could adopt an integration – backward and/or forward – based growth strategy through internal investment or acquisitions to internalize competencies. Alternatively, the leader firm would adopt an external growth strategy allowing it to focus on a few strategic

core competencies and establish close relationships with its specialised subcontractors (Albino et al., 1999; Albino et al., 2000; Carbonara et al., 2002).

Pannicia (1999) explored the measurement of performance of IDs and found that external economies of cluster formation positively affects performance. However, specialisation was found to be neither a dominant and empirically relevant feature nor a factor able to ensure the future survival of the ID. That is, cluster development is linked to the absolute size of the most dominant industry or business rather than to the degree of specialisation, as indicated by Italy's southern area - despite the area's high specialisation, it could not generate the clustering of enterprises to form a distinct industrial district. In line with Porter (1998a), Pannicia (1999) found that the evolution of industrial districts can be activated only after a "critical mass" or threshold of industrial production is generated.

3.4 Clusters and competitive advantage

The basis of clusters as a factor in competitive advantage was espoused by Porter (1990) in his seminal book, "*The Competitive Advantage of Nations".* Some of the competitive advantages derivable as a result of geographical proximity are reduced input costs, development of a common supplier base, availability of skilled labour, spill-over of technical know-how and the diffusion of the working knowledge of a particular industry into individuals and firms (Porter, 1998a). Porter's view in part was supported by Carrie (1999) who stated that an important part of any cluster is the network of supporting firms that supplies inputs and provides sub-contracting functions. Some researchers point to the improved competitiveness within clusters in terms of increased productivity of cluster firms and industry, the capability to innovate more, and new enterprise formation (Lin et al., 2006a). What the cluster concept underlines as a source of competitiveness is that within the cluster there is enhanced productivity and innovation and accordingly this is a source of competitive advantage (Porter, 1990).

Clusters and industrial districts lead to competitive advantages by generating a number of benefits that are not available to non cluster based firms. Some of the benefits of being in clusters and industrial districts include:

- Reductions in transaction costs
- Innovation and technological development
- Reduction in costs as a result of effective learning - learning by imitation and emulation.

- Benefits provided by localised external economies (specialised labour market, specialisation led by the increased local division of labour, and competent specialised suppliers).
- Advantages related to being customer driven organisations and to product diversification.

Lublinski, (2003; 456) highlights the competitive advantages that can be derived from being in an industrial cluster. The benefits of being in industrial clusters can be summarised as follows:

Labour market pooling - Labour costs savings due to a privileged access to specialised skills especially in an environment where firms have non-positive correlations in the temporal variations of their demands.

Accessibility to a great variety of specialised intermediate goods and services - privileged access to a local supplier base that has great product variety and a high degree of specialisation.

Knowledge spillovers - access to tacit knowledge in geographic proximity by means of both fashioned transmittal processes as well as through informal channels such as knowledge leakages made possible by causal inter-firm interactions, workers changing jobs, etc.

Complementarities - privileged sales opportunities of firms due to search cost savings of buyers of complementary products offered in proximity and privileged opportunities for cooperation (sales, marketing etc) between nearby suppliers of complementary products.

Transportation and transaction cost advantages

Transportation cost advantage - transportation cost savings due to geographic proximity especially in the case of just-in-time delivery of contracts.

Trust - transaction cost savings due to a geographically proximate environment that enhances trust-building processes.

Carbonara (2002; 2004) contends that industrial districts base their competitive advantages on two distinct aspects: 1) the inter-networking processes and 2) the speed and ease of circulation of information and knowledge. It was asserted that for competitive advantage to function at the cluster level, knowledge must be shared among the firms in the regional cluster (Tallman et al., 2004). However Tallman et al. (2004) point to a paradox in clusters by stating that competitive advantage at the firm level requires some knowledge to remain

private. Wilson and Popp (2003b) stressed the importance of networks as key institutions of governance in clusters and industrial districts. While providing insight into several of England's industrial districts, they contend that networking is responsible for their growth and development. Extending Wilson and Popp's (2003) assertion, Casson (2003) identified "good" and "bad" networking in clusters and industrial districts. Good networking is "open, transparent and entrepreneurial…Bad networking is typically closed and opaque…[and] is exemplified by *rent-seeking* in which…weak clusters [are protected] against external competition (Casson, 2003; 24, emphasis in original).

Critiques of clusters point to the proliferation of ICTs, and indicate the potential of ICTs to create a virtual world such that factors of production – such as capital, goods, labour – can be sourced easily (Porter, 1994). However, Porter (1994; 1998a) argues otherwise and goes on to assert that the economic landscape – all over the world – is dominated by what he calls "*clusters*: critical masses" in distinct locations showing unusual competitive success in one particular field. For example, world-class mutual funds are found in Boston, much more than in other places, textile-related industries in North and South Carolina, high-performance automobiles in southern Germany and fashion shoe companies in northern Italy. Competitive advantage rests on making more productive use of inputs. This requires continues innovation in process and product characteristics. It was argued that the capacity to innovate and upgrade draws on the proximate environment in which a business resides (Porter, 1994). Moreover, not only what happens inside a company but equally what goes on outside it plays a significant role in its innovativeness. The immediate business environment contributes to the innovativeness of an organisation. Firms within the cluster share resources that give them competitive advantage (Porter, 1998a). Thus, innovation and competitive success is location-based. That is why we associate entertainment with Hollywood, finance with Wall Street or consumer electronics with Japan (Porter, 1998a).

Productivity affects competition much more than the access to inputs or the level of integration of an organisation (Porter, 1998a). In other words, how companies compete affects productivity, but the specific industry in which the competition is taking place is immaterial. For example, companies can be highly productive in any industry – automotive, oil and gas, electronics – if they employ advanced manufacturing technology and offer differentiated products and services. However, the former is not unique, as all industry can access technology or means of differentiation – indeed services can be outsourced to distant suppliers or technology licensed or sourced elsewhere. What is unique is the local business environment, because the ability of a location to have the infrastructure to support a particular production technology differs. For example,

companies cannot employ advanced logistic techniques without a high quality transport infrastructure. Nor can companies compete in knowledge-intensive products or services without well-educated employees. The ability to source these critical inputs depends on locational attributes. Therefore clusters affect competition through (Porter, 1994; Porter, 1998a):

- increasing productivity of companies based in an area – local sourcing of inputs reduce transaction costs (Hallwood, 1991b). Indeed, even where inputs are sourced from a distance, a cluster offers advantage (Porter, 1998a) as a result of prevalence of complementarities (Richardson, 1972) in the cluster. It is the differences between firms in the same trade that cause them to be complementary in developing capabilities of the industry to which they belong (Loasby, 1998).

- driving the direction and pace of innovation (Carbonara, 2004) which underpins future productivity growth – clusters make innovation opportunities visible and provide capacity and the flexibility for time-based competition (Gehani, 1995) at lower cost. Furthermore, competitive pressure, peer pressure and constant comparison which occur in clusters all spur innovation (Porter, 1998)

- stimulating the formation of new businesses which expands and strengthens the cluster itself – new suppliers thrive within clusters to take advantage of the concentrated customer base which lowers risks and makes it easier for them to spot market opportunities (Porter, 1998a). The business risk in this case is mitigated by the level of demand for an innovation as a result of concentration of potential users in a specific location.

Clusters and industrial districts offer the benefit of "externalities or nontraded interdependencies", contributing to the "superiority of this form of organisation over mass production and vertically integrated companies" (Molina-Morales 2001, 279). These benefit individual firms from increased pooling of common factors such as skilled human resources, specialised suppliers of inputs and technological spillovers.

3.5 Supply chains of clusters and industrial districts

The concept of clusters and industrial districts has been addressed from many fields such as economic geography, economic and industrial development (Porter, 2000). However, issues relating to ICT and operations management within clusters have been given little attention (Carbonara et al, 2002). For example IT, Groupware and e-commerce

developments implemented in the SCM field can be extended to the cluster. Indeed Carrie (2000; 295) remarked that "SCM [supply chain management] is a very large field, in which logistics, operations management and IT issues are prominent, but ... the cluster concept is not mentioned." Yet even the supply chain concept has a limited scope. This is because most considerations of supply chains assume linear flow and are often limited to the dyadic (two party) relationship such as between the manufacturer and the supplier. A linear supply chain viewpoint prevails among researchers and practitioners of supply chain management as was highlighted by New and Payne (1995). Thus it was stated that "few models adopt a genuinely network approach and very few go beyond supply of physical materials and take into account the supply of manpower, capital, equipment, research…"(Carrie, 2000; 295).

Supply chains involve collaboration between firms engaging in commercial transactions for the exchange of goods and services, while industrial districts are concerned with firms in close proximity, which leads to customer-supplier relationships and may also include horizontal collaboration between the firms residing in the district (Brown and Hendry, 1998). This capacity for intra-district collaboration enables smaller firms to survive the larger competitive force of larger firm, and this is the dominant advantage of industrial districts. Another attribute of industrial district – distinct from supply chains – is a shared labour market which stimulates circulation of people between firms and the social networks that link people across companies fosters exchange of information and knowledge (Brown and Hendry, 1998).

Brown and Hendry (1998) investigate learning processes in supply chains and industrial districts. They contend that industrial districts are increasingly influenced by supply chain factors. Industrial districts are basically a hybrid of economies of scope and a vertical division of labour which essentially means supply chain relationships in a region. Further, they observed that most industrial districts includes large firms that dominate the supply chain, while supply chains attempt to acquire such industrial district attributes as trust and partnership and often involve clusters of firms in close geographical proximity. With respect to the learning processes, they point to the distinctively different emphasis by the two networks. However, organisations need to exploit learning from dynamic, professional networks as found in industrial districts –since individual learning takes place within a group context – to manage the internal processes of supply chains.

Carrie (1999) observes that in the decade between 1960 and 1970, companies competed among themselves, and companies tended to have integrated operations by making all their components and assembling their products themselves. One decade after – 1980 to 1990 –

companies out-sourced much of their components and assemblies, and became extended enterprises. Thus, competition was between supply chains, and supply chain management became an important management skill. Additionally, models such as lean and agile manufacture became the panacea. However, with globalisation of competition in the new century, competitiveness of industry in any region of the world will depend to a large extent on the total business infrastructure, which will attract companies to and retain them in any region of the world. Competition will be between clusters of interrelated organisations that cooperate to add and generate value. Therefore, leanness or agility of individual companies depends not just on their own activities and systems but also on those of the related organisations.

Carbonara et al. (2002) characterise IDs as a production system whose operations can be looked at from strategic, physical, technological, and organisational perspectives. Operations management is used to explain the strategic and technological attributes of the ID production system. The physical and organisational aspects of the ID as a production model will be explained using the SCM aspect of operations management.

An aspect of manufacturing strategy is choice of competitive priorities. Four competitive bases have been identified (Hill, 2000). These are: cost, quality, flexibility and time. Competitive priorities are linked to the production processes as well as the product life-cycle – introduction, growth, maturity and decline. The product life cycle has also been used to characterise the evolution of IDs (Albino et al., 1999).

Technological issues in IDs relate to complexity of process and product technologies, especially in choosing appropriate Information and Communication Technologies (ICTs). ICT have a profound impact on firm effectiveness and efficiency by improving quality and reducing time and cost. Generally, there are coordination and process ICTs. Coordination ICT can be information processing (e.g. Enterprise Resource Planning (ERP), Decision Support System (DSS), MRP) or communication (Electronic Data Interchange (EDI), Internet, Groupware). Process ICTs are manufacturing technologies such as CAD and CAM.

The physical dimension is derived from the supply chain model. Supply chain management is the integration of the key business processes from end users to suppliers to add value for the customers. The key business processes to be linked along the supply chain are: customer relationship management, customer service management, demand management, order fulfilment, manufacturing flow management, procurement and product development

and commercialisation (Lambert and Cooper, 2000). The physical dimension also provides structure and configuration of the supply chain network. The three aspects of the network structure are: 1) the members of the supply chain, 2) the structural dimensions of the network, and finally, 3) the different types of process links across the supply chain.

The organisational issues in supply chain management mostly address supply relationships, (Carbonara et al., 2002). Four types of supply relationships, according to level of integration, have been identified: internal, two party (dyadic), external and network (Harland, 1996). The governance associated with supply chain management ranges from fully vertically integrated to completely independent organisations. However, there is a general shift in trend of relationship from an arm's length adversarial approach towards partnership, where suppliers and customers are strategic partners, and hence cooperate among themselves to share risks and rewards, and exchange operating and financial information.

The supply chains in industrial districts have been classified into four dimensions: strategic, physical, technological and organisational. Using the latter classification of the supply chains (SC) variables, Carbonara et al. (2002) describe the production model associated with the industrial districts as follows:

Strategic dimension: this is concerned with the primary business objectives, the operations strategy adopted by the leader firm in the industrial district, the point of product differentiation in the supply chain, the length of the product life cycle and the degree of centralisation of supply chain planning activities.

Physical dimension: This determines the supply chain structure, i.e. the stages spanning the supply chain (physical depth), the number of production units in a given stage (physical width) and the geographic spread of the supply chain units (international dimension). Also it concerns the product structure in terms of bill of material (BOM) levels (product depth) and the number of components for a given BOM level (product width).

Technological dimension: describes the process and product technology complexity, and the type of information and communication technology adopted in the manufacturing process. The adopted ICT could be for process, information processing or communication.

Organisational dimension: deals with:

- control of SC structure by leader firm (dyadic – buyer-supplier – for tier-one supplier, external for tier-two supplier and network if the leader firm controls horizontal as well as vertical relationships).

- level of vertical integration, as represented by the extent of SC firm ownership of the value creating processes.

- distribution of contractual power in the network

- Time horizon of relationship

- aim of relationship – as a capacity buffer (scale) or specialisation (process) decentralisation.

- level of cooperation among SC actors

- level of formalisation of relationship ranging from high such as contractual agreement, to low i.e. informal arrangement. It also includes mechanisms adopted to manage inter-firm relationships – market price, transfer prices or incentives mechanisms.

- structural flexibility - agility in reconfiguring the SC in response to customer needs

- information sharing - type (tacit or explicit) and amount of information shared by firms within the supply chain.

Table 3.5 summarises all the characteristics of supply chains of industrial districts discussed above.

Table 3.5: Supply chain of industrial districts.

Variables	Value
Physical dimension	
Physical depth	Low – high
Physical width	Low – high
Product depth	Low – high
Product width	Low – high
International dimension	Yes – no
Technological dimension	
Product technology complexity	Low – high
Process technology complexity	Low – high
ICT	Process, information processing, communication
Strategic dimension	
Primary business objectives	Cost reduction, flexibility, quality, differentiation
Operations strategy	Buy, or assemble to order, make to stock
Product differentiation	Early, late
SC planning activities (demand planning, inventory management, production planning, distribution planning, transportation planning, order management)	Centralised, decentralised
Organisational dimension	
Control of SC structure	Dyadic, external, network
Vertical integration	Low – high
Distribution of contractual power	Centralised, decentralised
Time horizon of relationship	Short, long
Aim of relationship	Scale, process
Level of co-operation	Low – high
Coordination:	
• Formalisation	Contractual agreement, standard procedures, informal arrangements
• Mechanisms	Transfer price, incentive mechanisms, quantity discount, market price
Structural flexibility	Low – high
Information sharing	
• Amount of knowledge	Low – high
• Type of knowledge	Codified, tacit

(Source: Carbonara et al., 2002)

3.5.1 The role of ICTs in clusters and industrial districts

A clusters is a kind of production system. It operates as an extended enterprise characterised by a dense network of relationships, trades, and flow of both tangible and intangible assets. Thus, the performance of such a production model is related to the level of integration and coordination among the various tiers and players along the supply chain within the cluster. Improvement in the level of integration and coordination within the cluster is underpinned by efficient and effective exchange of pertinent information (Carbonara, 2005; Carbonara et al., 2002). Information fidelity has to be maintained at all times. ICT in clusters improves the processes carried out at the local level and also enables undertaking the same processes on a global scale in spite of the firm size. ICT in clusters offers the following advantages:

- strengthens existing relationships among cluster firms and external firms, by integrating members of the supply chain through tools such as EDI, business-to-business, Extranet etc. (Wilson, 2000).

- increases the sphere of influence of the cluster firms, thus extending networking opportunities of the firm by connecting with firms located outside the cluster using technologies like business-to-business, electronic auctions. An intermediary actor, who assumes the role of a market broker, can manage procurement on behalf of cluster firms by using an electronic auction model. For example, this will be suitable for procurement of inputs by small technology based oil related (STBOR) companies. It has been reported that STBORs experience long delay in procuring raw materials for fabricating oil well components in their North Sea operations (Crabtree et al., 1997; Crabtree et al., 2000).

- provides opportunities for expansion of business sphere of cluster firms at minimum costs (websites, electronic portals).

- managing the relationships with the end-markets, offering new services and new ways to create value (electronic commerce, on-line marketing etc) (Chambers, 2001).

- supports both the joint innovation processes developed by cluster companies and companies located outside the cluster and by the adoption of external innovations.

The diffusion of ICTs within economic activities generally and organisational operations has been recognised. Indeed, ICTs' implementation is so endemic to such an extent that concepts such as extended and virtual enterprises are now a reality (Browne et al., 1995; Browne and Zhang, 1999; Jagdev and Thoben, 2001; Jagdev and Browne, 1998; Thoben and Jagdev, 2001).

Carbonara (2005) explored the adoption and implementation of ICT as support solutions, and the actual trend of diffusion (adoption and implementation) of e-business models in Italian industrial districts. The study reports that the degree of diffusion of the ICTs within the Italian industrial districts is still low. In part the low level of diffusion was due to lack of relevant investment and significantly, business process re-engineering. A key observation was that the traditional way of operating was the most preferred rather than an optimized business model. Particularly, the survey points out that connection to the Net does not support the unstructured and informal communication processes within the IDs. For example, utilisation of e-mails for the inter-firm relationships or for intra-firm informal communications is very limited. The internet is used as a simple means of communication, more often with firms outside the cluster than within. However, there are experiences of inter-firm websites (district portals) testifying that the connection to the Net is used to support networking processes within the IDs. These are aimed at creating a virtual space supporting the collaboration among firms and/or at promoting the cluster globally and/or expand the business boundary of the cluster firm beyond the district. Furthermore, there is a low level of diffusion of advanced ICT solutions, such as shared database or the development of shared software for the integration of inter-organisational processes and the supply chain management. In a bid to improve the adoption of ICTs in clusters and industrial districts, Carbonara (2005) observed that ICTs and e-business models suitable for clusters should incorporate some of the unique cluster features, such as:

- the small size of firms - which requires shared technological infrastructures
- the fragmentation of the production process - which requires integrated technological infrastructures and
- the local specificity - which requires dedicated technological solutions enabling the enhancement of those cluster features on which the competitive success of this production model has been based.

In the light of the diffusion of ICTs within clusters and industrial districts, it can be contended that technologies (such as ICTs) will enhance rather than diminish the cluster structure.

3.6 Operationalisation of clusters and industrial districts

Most studies on industrial clusters have looked at then from either the strategic (Porter, 1998a), Economic geography (Martin and Sunley, 2003; Yamamura et al., 2003), Regional development (Peters and Hood, 2000), Economic history (Wilson and Popp, 2003b), Organizational (Brown and Hendry, 1998; Kenney and von Burg, 1999) or Regional geography (Enright, 1999) perspectives. So far, very little research effort has been directed at clusters from the operations management perspective. The paucity of empirical work on operations management in clusters has long been echoed (Carrie, 1999; Carrie, 2000). In appraising the concept of clusters, Carrie (2000; 296) points out that it still remains a theory "rather than being supported by well-defined body of knowledge." Furthermore, there is a lack of explanation of the cluster concept in the area of operations management, both in terms of theoretical development and empirical investigation. Accordingly, there is the need for empirical research on clusters to establish operating principles and guidelines. Specifically, the impact of operations management on the competitiveness of clusters is worth exploring (Carrie, 2000) in an empirical study.

Carrie (1999) points to the fact that globalisation of manufacturing function has had a profound impact on the basis for competition. Accordingly, in the 21st century, the basis of competition will switch from individual companies and their supply chains to regional clusters. The proposition that in reality clusters, rather than supply chains, competes thus needs to be empirically verified through a systematic evaluation of organisations located within clusters. Recently, an attempt has been made to conceptualise clusters and industrial districts as a production model equivalent to a collection of supply chains (Carbonara et al, 2002). To be able to explain and study the clusters concept from an Operations management point of view, four dimensions need to be used as a tool. The four dimensions of decomposing the cluster concept into supply chain management are: physical, technological, strategic and organisational dimensions. Additionally and in line with developments in the nature of supply chains - i.e. from traditional, lean and agile (van Hoek et al., 2001) the agility paradigm is a necessary tool for the clusters to gain competitive advantage. Essentially the strategic importance of agility needs to be recognised and internalized in clusters to enable a particular cluster have a competitive advantage. Thus, this study will examine the diffusion of agility dimensions in clusters and

industrial districts with a view to determining the competitiveness (in terms of attainment of competitive objectives) of oil and gas clusters. The result of the study will be used to enhance the competitiveness of the clusters studied.

Therefore it will be imperative to gain insight into the relevance of the cluster concept in operations management. Accordingly, this study aims to determine the impact of cluster location attributes on supply chain agility, competitive objectives and business performance of organisations based in an industrial cluster.

In this study, to operationalise the cluster concept to test the locational factors, insight was drawn from many sources (Badri et al., 1995; MacCarthy and Atthirawong, 2003; Bhatnagar and Sohal, 2005; Lublinski, 2003). Specifically, to develop the questionnaire to measure the cluster and location factors, locational factors, enumerated by Badri et al (1995), MacCarthy and Atthirawong (2003) and Bhatnagar and Sohal (2003) were used in formulating the questions. To measure the dynamic transaction costs and associated factors that are relevant to the cluster concept, insights were drawn from Pannicia (1999) as well as Lublinski's (2003) postulation of cluster attributes.

MacCarthy and Atthirawong (2003) present both quantitative and qualitative factors that influence location decisions from an operations management perspective. Based on a literature survey, they found that location decisions depend on factors that are both quantitative and qualitative. This comprehensive set of factors and sub-factors summarised in Table 3.6 includes operational, strategic, economic, political, social and cultural dimensions.

A dominant critique of the location factors in the operations management arena is that they emphasise static factors, while the cluster concept encompasses both static and dynamic characteristics of location factors. In industrial clusters as well as logistic advantage through transportation cost reduction, there is the added dynamics of face to face contacts and the communication that takes place. In this way innovation and productivity will be enhanced among the cluster based organisations, as well as transaction cost being reduced. Accordingly, industrial clusters were said to offer transportation and transaction cost advantages over non cluster based organisations.

Table 3.6: Factors responsible for location decisions

Major factors	Sub-factors
Costs	Fixed costs, transportation costs; wage rates and trends in wages; energy costs; land cost; construction/leasing costs and other factors (e.g. R&D costs, transaction and management costs etc.)
Labour characteristics	Quality of labour force; availability of labour force; unemployment rate; labour unions; attitudes towards work and labour turnover; motivation of workers and work force management
Infrastructure	Existence of mode of transportation (airports, railroads, roads and sea ports); quality and reliability of modes of transportation; quality and reliability of utilities (e.g. water supply, waste treatment, power supply, etc) and telecommunication systems
Proximity to suppliers	Quality of suppliers; alternative suppliers; competition for suppliers; nature of supply process (reliability of the system) and speed and responsiveness of suppliers
Proximity to markets/customers	Proximity to demand; size of market that can be served/potential customer expenditure; responsiveness and delivery time to markets; population trends and nature and variance of demand
Proximity to parent company's facilities	Close to parent company
Proximity to competition	Location of competitors
Quality of life	Quality of environment; community attitude towards business and industry; climate, schools, churches, hospitals, recreational opportunities (for staff and children); education systems; crime rate and living standard
Legal and regulatory framework	Compensation laws; insurance laws; environmental regulations; industrial relations laws; legal systems; bureaucratic red tape; requirements for setting up local corporations; regulations concerning joint ventures, mergers and acquisitions and regulations on transfer of earnings out of country rate
Economic factors	Tax structure and tax incentives; financial incentives; custom duties; tariffs; inflation; strength of currency against US dollar; business climate; country's dept; interest rates/exchange controls and GDP/GNP growth; income per capita.
Government and political factors	Government stability; government structure; consistency of government policy; and attitude of government to inward investment
Social and cultural factors	Different norms and customs; culture; language and customer characteristics
Characteristics of a specific location	Availability of space for future expansion; attitude of local community to a location; physical conditions (e.g. weather, close to other businesses, parking, appearance, accessibility by customers etc); proximity to raw materials/resources; quality of raw materials/resources and location of suppliers

Source: MacCarthy and Atthirawong, (2003: 797)

3.7 Summary

This chapter gave an account of clusters and industrial districts. It started with definitions and clarifications. The comparative advantage of clusters was presented, Next supply chains in industrial districts were discussed and finally the application of information and communication technologies in clusters was highlighted. In conclusion a significant attribute of clusters and industrial districts as pointed out by Molina-Morales (2001; 290) is that "within the clusters and industrial districts firms have some kind of social or moral capital. This capital based on personal relationships and internal reputation facilitates support of banks and suppliers even when firms have no significant financial resources."

The factors inherent to clusters are collaboration, labour availability, complementary service availability, cost advantage, and opportunity for knowledge spillover as well as the networking process that close geographic proximity engenders (Porter, 1998a; Molina-Morales, 2001; Lublinski, 2003; MacCarthy and Atthirawong, 2003). These clusters capabilities impact on supply chain operations were highlighted within the previous review. Indeed clusters and industrial districts have been conceptualised as a production model. Thus, in this study it is proposed that clusters can enhance supply chain speed, flexibility and responsiveness. However, as have been shown in the review there are definitional, conceptual and empirical limits to the existing characterisation of clusters and industrial districts which posed problems in operationalising the cluster concept into a measurable instrument. Nevertheless four key aspects of the cluster location attributes were considered for measurement during the survey by questionnaire. These include transportation and transaction cost, source of labour, source of information and source of inputs. Accordingly the impact of the four factors will be investigated on agility dimensions, attainment of competitive objectives and business performance

In the next chapter a conceptual model is developed from the literature review reported here and in the previous chapter. The model captures the main themes highlighted in the previous literature review. A conceptual framework, as a theory of method, expresses in a graphical form the state of prevailing theory about what is going on in a field and why, it also shows the linkages between the various themes impacting on the phenomena under study and the context significant to the changes taking place. It is achieved by synthesising the various aspects from the previous literature reviewed, to arrive at a representative model of the research to be undertaken.

CHAPTER 4: A CONCEPTUAL FRAMEWORK FOR CLUSTER AGILE SUPPLY CHAINS

4.1 Introduction

This chapter describes a conceptual framework that organises the important variables of cluster-based agile supply chains. A conceptual framework is a good starting point for empirical research; it provides the basis for generating hypotheses (Robson, 2002). It also offers a realistic link between theoretical postulations underpinning research and practical implication of the research in terms of direct link with reality. Moreover, conceptual models offer a sound base for the design of research instruments. Also it can act as a good tool to focus the study and guide the investigation of relationships amongst concepts under study (Ren, 2004). In this research the elements of the conceptual framework are agile supply chain attributes, industrial cluster attributes, competitive objectives and business performance. The framework will be used to deduce interim research hypotheses. The hypotheses will be validated using the survey data from the empirical study. Accordingly as well as the conceptual framework for this study, the research design required for validating the framework will also be presented. However, prior to describing the proposed framework it will be useful as well as pertinent to reproduce the research questions so as to provide the right context for this chapter. The research questions are as follows:

Q1. What is the impact of cluster location attributes on supply chain agility?
Q2. What is the impact of cluster location attributes on competitive objectives?
Q3. What is the impact of cluster location attributes on business performance?

The first section of this chapter is the conceptual framework, whilst the second section deals with the methodology for carrying out the empirical part of the research. Finally, a conclusion is made after the two sections so as to highlight the salient points in the chapter and link it with the succeeding chapter.

4.2 A Framework of cluster agile supply chains

Primarily, a conceptual framework is a model depicting the constructs or variables studied and representation of the hypothetical relationships between them. There are four constructs to be investigated in this research and they are as follows: agile supply chain attributes; industrial clusters and location constructs; competitive capabilities and business performance. Figure 4.1 shows the conceptual model of cluster agile supply chains described by four boxes. These are the agile supply chain attributes, industrial cluster

dimension, competitive objectives, and business performance. The direction of cause and effect between the constructs is indicated by arrows to and from the boxes.

In Figure 4.1, the first box corresponds to agile supply chain attributes, while the second box is the industrial cluster dimension. The relationships as shown by the arrow indicate that a supply chain within an industrial cluster will have its agile capability enhanced due to the characteristics of the cluster. An agile supply chain aims to satisfy customers and employees. Lin et al (2006b) observe that enriching and satisfying the customer is achieved through cost, time, product function and robustness of manufacturing systems. At the same time customer requirement, competition, market volatility, and technological innovation, social and environmental pressures all constitute agile drivers and orchestrate the change and uncertainty characteristics of the prevailing business environment. Thus, based on the dynamic business environment and the need to reduce the impact of change and uncertainty within the business environment, an agile supply chain requires various capabilities. The agile capabilities deployed by an agile supply chain in a dynamic business environment include four main elements as follows: responsiveness, competency, flexibility and speed. Furthermore, agility attributes are the aspects of agility content that enable organisations to deploy the agile capabilities to overcome the change and uncertainty within the business environment. Accordingly, Lin et al. (2006) classified the main enablers into four categories as follows:

- Collaborative relationships: suppliers involved in product development.
- Process integration: legally separate organisations are linked into a network.
- Information integration: Virtual supply chain underpinned by information stores information rather than inventory.
- Customer/market sensitivity: visibility within supply chain pipeline ensures transparency of demand information; thus, response is to real customer demand.

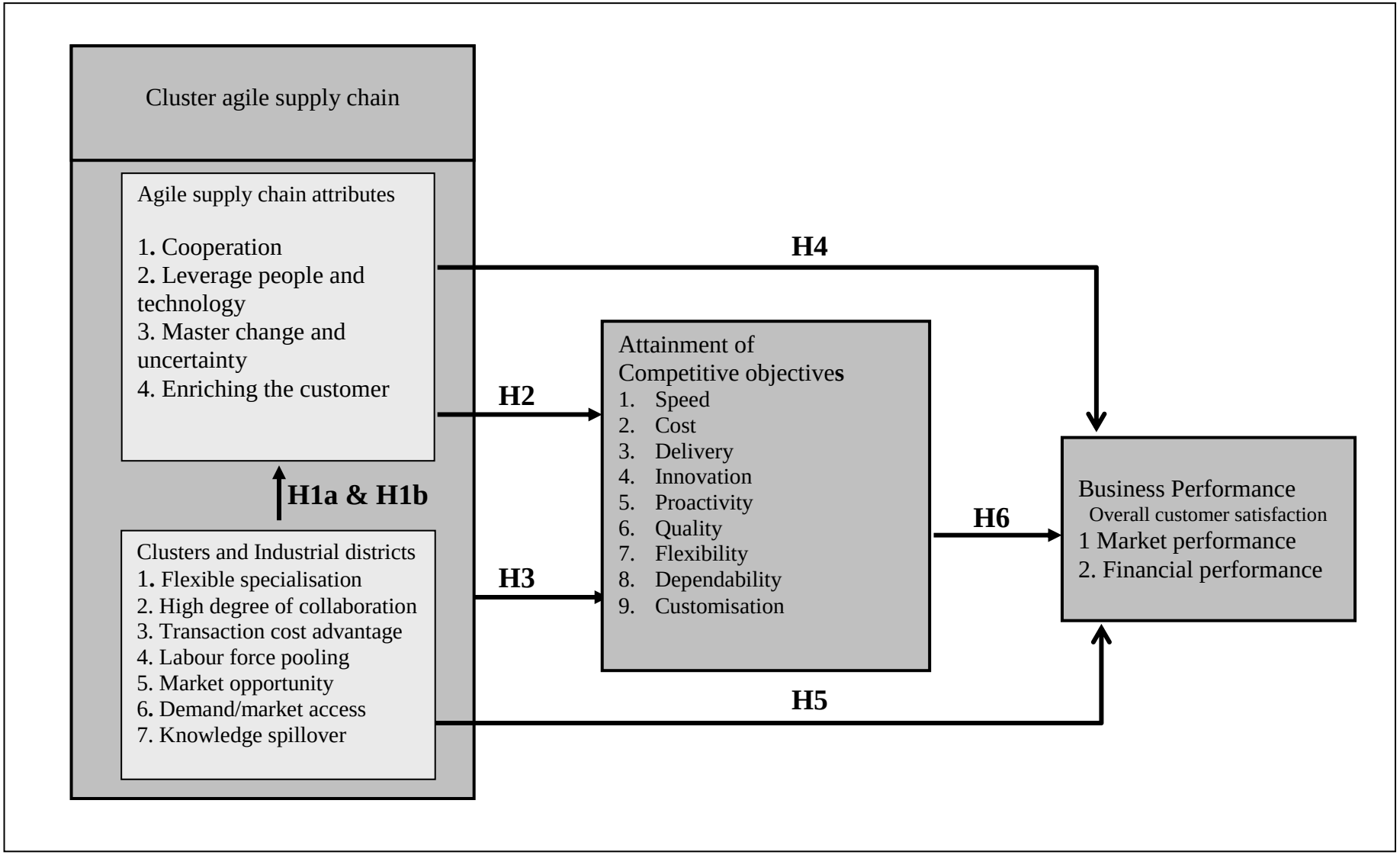

Figure 4.1: Research conceptual framework of cluster based agile supply chains

Agility requires organisations and facilities to be more flexible and responsive to changing needs of customers. The need for flexibility and responsiveness should not be at the expense of cost, speed and quality. Equally, the agile paradigm does not advocate trade-off of Speed, Quality, Cost, Innovation, Flexibility or Proactivity, but emphasises the need for capabilities for holistic provision of the relevant competitive bases in the right mix while recognizing that the balance in those key bases may shift from market to market and over time. Thus, different market types should have a different mix of competitive bases. Nevertheless, a sufficient knowledge of the level of Speed, Cost, Quality, Innovation, Flexibility, and Proactivity is important to the long-term survival of the agile competitor (Tracey et al., 1999; Vokurka et al., 2002; Ward et al., 1998; Gonzalez-Benito, 2005; Tracey et al., 2005).

The second box in Figure 4.1 represents the advantages in being located in an industrial cluster. These advantages include specialisation based on core competences, and collaboration between members of the clusters who also are involved in providing products and service in the supply chain. The direction of the arrow points from the industrial clusters to agile supply chains, indicating that being in clusters could have impact on the agility of a supply chain. The essence of the linkage between industrial clusters and agile supply chains is the basis of the first research question.

Business performance is among the key components of the conceptual framework. This arises from the fact that it takes into account the long-term interest of the company in determining suitable business and operational policies. To achieve good business performance in manufacturing, agility is essential. Indeed, a number of empirical studies link organisational performance and competitiveness to adoption of supply chain management and agile manufacturing. Equally, within the industrial cluster literature although most of the empirical studies are case study in nature, nevertheless, there is empirical evidence that attests to the importance of being in industrial clusters to enhance performance. For example, Patti (2006) reports a case study in a petrochemical plant in which a firm outsourced two raw materials, first to a firm about 200 miles away and then to a firm that built a plant across the street. By sourcing to a co-located firm the company reduced its costs by $280,000 per year while simultaneously increasing quality by 6.5 per cent, reducing lead-time by seven to ten days, and reducing raw material inventory from 800 tons to 30 tons. The need to master the perturbing influence of environmental change drivers on business performance provides the basis for agility. Accordingly, the impact of being in located in close geographic proximity to customers

leads to reduction in static factors such as costs and inventory as well as dynamic factors such as quality and lead time. The impact of clusters on lead time and quality could be due to the ability of ease of face-to-face interaction between supply chain members which stimulates quick resolution of problems and enhance innovation. Mackinnon et al. (2004) did an empirical study of the networking among SMEs in the Aberdeen oil complex. They found that in spite of the growing importance of information and communication technologies, several respondents indicated that spatial proximity remained important in terms of offering customers a responsive and flexible service. Accordingly it is appropriate to expect that being in an industrial cluster could enhance the speed and flexibility of an organisation and by implication its agility. Indeed, this is illustrated using the response to a survey of the UK upstream oil and gas industry carried out by MacKinnon et al (2004). In response to a question about why a firm was established in Aberdeen, 72.4% of respondents cited the need to be in proximity to a growing market or group of customers. Similarly, in a case study of Aberdeen oil and gas industry, a respondent stated as follows when asked about the need for proximty:

> "I think, in a business sense it's still important to be close to your customers. Even in today's world, they still like to see a face, they still like to be reassured that they can call you and you can be there in half an hour if there's a problem, whatever. So, I think, in a business sense, close proximity is still important" (MacKinnon et al 2004; 92).

Additionally, in spite of the overarching influence of information and communication technologies, respondents to the above survey still contend that being in close proximity to their customers is important and enables them to provide responsive and flexible services. Therefore, within this framework the arrow from the box labelled industrial clusters points towards the agile supply chain box, meaning that being in an industrial cluster positively affects agility of a supply chain. By this it is proposed that the linkage of industrial cluster and agile supply chain will lead to a cluster agile supply chain. By implication, this is an extension of the supply chain concept. Hence, here, for a cluster based supply chain, it is argued that clusters compete, and that an industrial cluster that supports agility will be more competitive than a non agile cluster.

The fourth box in Figure 4.1 is named competitive objectives. Companies need to improve on a wide range of competitive objectives as a means of defending business performance measures against the perturbing influence of the change drivers. In order to

improve upon competitive objectives, appropriate competencies that enable competitive advantage need to be identified and deployed (Gunasekaran and Yusuf, 2002; Zhang and Sharifi, 2007). Competitive advantage is the capability to compete in an environment that is turbulent and characterised by frequent and unpredictable change. Thus, competing on a single dimension such as price is no longer tenable to sustain competitiveness; firms need to compete in non – price based dimensions as well (Droge et al., 1994; Li et al., 2006). In this case an agile supply chain possesses the capability to confer competitive advantage, thus the arrow from agile supply chain towards competitive objectives captures this.

The main driver for agility is change and uncertainty, so although not explicitly represented in the model, this agility driver, in other words change, is the originating point for discussing the conceptual framework. Agility drivers have two broad dimensions of market instability and product complexity. The intensity of pressures imposed by these two dimensions impacts negatively on business performance outcomes. This negative impact in turn calls for higher attainment of competitive objectives, which is made possible through significant adoption of the agility enablers (Dove, 1996; Sharp et al., 1999; Lau and Hurley, 2001; Yusuf et al., 2004; Zhang and Sharifi, 2007). In other words, an increase in the strength of the change drivers justifies the deployment of the agility enablers as a means of boosting competitive objectives and business performance.

With reference to the conceptual framework, the box labelled as business performance is the second step in discussing the conceptual framework. Business performance provides a measure for business success. The nature of business performance was explored by studying the direction of change in five broad-based measures of business performance that were more frequently discussed in the literature. The five measures are sales turnover, net profit, market share, customer loyalty based on repeat orders, and performance relative to competitors. Financial measures of business performance such as sales turnover, net profit and return on investment have been used quite extensively in prior studies. Business performance measures that were exclusively limited to financial measures without accounting for non-financial measures such as market share and customer loyalty or retention might be inadequate for assessing overall strength and survival prospects in industries faced by unprecedented market instability.

In the conceptual framework, competitive objectives represent the strategy adopted by an organisation in its bid to respond or overcome competition. The third box represents

competitive objectives and it is the third focal point in discussing the conceptual framework. Competitive objectives are the goals sought by an organisation in terms of the set of values delivered to customers. Seven competitive objectives that have been commonly discussed were compiled from the literature (Swamidass and Newell, 1987; Swink and Hegarty, 1998; Ferdows and De Meyer, 1990; Vokurka and Fliedner, 1998; Dangayach and Deshmukh, 2001; Squire et al., 2006). They are cost, quality, speed, dependability, product customisation, flexibility, delivery, proactivity and innovation. Simultaneous adoption and deployment of a wide range of competitive objectives will enhance the ability to cushion the impacts of the change and agility drivers whilst also boosting business performance. The need to deliver simultaneously on a wider range of competitive objectives including customisation and flexibility gives rise to the agility enablers. The need to identify and deploy agility enablers as a means of boosting the attainment of a wide range of competitive objectives has been stressed (Fliedner and Vokurka, 1997; Vokurka and Fliedner, 1998; Meredith and Francis, 2000). In other words, if agility enablers were correctly identified and deployed, it should be possible to minimise trade-offs amongst competitive objectives and compete from all fronts.

The first box named as agile supply chain capabilities is the focal point in discussing the conceptual framework. The agile capabilities are the resource competencies for boosting competitive objectives in markets characterised by sporadic changes and therefore requiring a significant amount of agile intervention. It is pertinent to identify and justify appropriate enablers of competitive objectives in today's unstable markets (Willis, 1998; Rosenzweig et al., 2003; Flynn and Flynn, 2004; Yusuf et al., 2004; Tracey et al., 2005; Lau Antonio et al., 2007). To this end, in the literature review conducted earlier, four dimensions of agility enablers were presented. These were customer enrichment ahead of competitors by providing solutions rather than just products; cooperation among supply chain members, network integration such that legally separate organisations act as one; process integration and leveraging the impact of people and information. This study argues that being in an industrial cluster will enhance the agility of a supply chain which will improve the attainment of manufacturing competitive objectives, and in turn enhance business performance.

The following section will provide the justification for the conceptual model with the view of providing a valid basis for drafting research hypotheses, collecting data and deducing inferences.

4.3 Justification of the proposed conceptual model

The previous section which discussed Figure 4.1, shows how this research explains and develops the relationships amongst the several factors that have been identified from the literature as important to the discussion of agile supply chain capabilities in clusters. The conceptual framework is based on the literature review undertaken in the preceding two chapters. The discussion in this section focuses on variable role definition as well as the explanation and illustration of the reason underlying the specified relationships. The arrows shown are those that are perceived as likely to reflect and fit empirical reality. This is the practice in empirical studies that are structured on guiding conceptual frameworks (Moser and Kalton, 1979). Empirical data to be provided in chapter 5 will validate the directional arrows shown in Figure 4.1. The valid direction of the arrows signifying the relationships existing between the variables (as against imaginary reverse arrows) can be confirmed based on the difference between empirical correlation and regression coefficients as the measures of relationship and direction of impact between two variables (Anderson et al., 1995). As Anderson et al. (1995) observe, if the directional arrows are valid as specified, the difference between the correlation and regression coefficients should be no more than 0.1, and alternative reverse arrows would hence be deemed to fail the test of empirical reality.

The agility enablers are expected to have a direct effect on the competitive objectives and business performance. A company may initiate an agile supply chain as a response to temporal windows of opportunity in the business environment whilst also empowering employees from all dimensions. These are in addition to technology utilisation as a means of improving plant and logistics operations. The implementation of the afore-mentioned agile capabilities will be through several measures of operational efficiency such as lead time reduction, operational flexibility, routing flexibility and production throughput times which could translate into a higher attainment of competitive objectives. Thus, it is tenable to state that attainment of competitive objectives and business performance is directly related to the level of adoption of agility enablers. This is the sense in which Sarkis (2001) argues that agile capabilities can reduce the toll of change on production cost, product quality, product availability, organisational viability, and innovation leadership. Therefore, the arrows that originate from the agile supply chain attributes to join the boxes named competitive objectives and business performance are justifiable. However, the reverse arrow originating from business performance and competitive objectives towards the agile supply chains, which

would imply a reversal of the arguments canvassed in the preceding paragraphs – that is competitive objectives and business performance leads to agile supply chains – might be less valid. Equally, a bidirectional arrow, in which the relationship could go either way, although theoretically possible, is not practically and empirically realistic, hence, that nomenclature was not adopted.

The arrow linking competitive objectives to business performance is justified through numerous studies of this relationship in the literature on manufacturing strategy and productivity (Droge et al., 1994; Curkovic et al., 2000; Brown and Bessant, 2003; Squire et al., 2006). For example cost-savings through economic use of space or materials would ultimately reach the end customer through lower prices (low cost leadership), which in turn implies higher sales, market share and profits. The same applies to quality as a competitive objective. Enhancements in quality motivate customer confidence in a product, and through higher sales, profits and market share are elevated.

The foregoing discussion justifies the conceptual framework in Figure 4.1. Based on the arguments presented in the preceding paragraphs, a justification for the four concepts of agile supply chains, industrial clusters, competitive objectives and business performance was presented. Additionally, the rationales for the corresponding arrows as shown in Figure 4.1 linking the constructs have been argued as well. In the next sections the research methodology for undertaking the empirical study and data collection will be presented. The methodology adopted for the research is the positivist, but methodological triangulation was adopted in which both the quantitative and qualitative paradigms were utilised so as to reduce the negative effects of each of the methodologies and benefit from their individual advantages. Thus data was collected through both survey by questionnaire and interview to validate the conceptual framework and test the hypotheses.

4.4 Overview of research methodologies

Research methodology is about choosing the appropriate methodology to address the research questions raised through testing the propositions enacted after the literature review. In this regard taxonomy of the research cycle that includes descriptive, explanation and testing was presented (Meredith et al., 1989). In choosing the appropriate research methodology, Meredith et al (1989) contend that the chosen methodology to undertake a research project should attempt to integrate the two

dominant research paradigms – quantitative and qualitative methodologies. They posit that integrating the two methodologies through triangulation achieves two things simultaneously. Using methodological triangulation achieves gaining the advantages of both methods as well as mitigating the limitations of the overall result of the research by the methods cancelling their individual limitations. Accordingly in this research, to collect the data required for testing the research propositions, survey by questionnaire and case study were adopted.

A number of research approaches exist; they include: survey, case study, action research, longitudinal study, ethnography and grounded theory. However, before a full account of the research methodology adopted in this research, there is a need to highlight briefly the prevailing data collection methods available and justify the selection of the adopted methods in light of the prevailing methods. Thus, the following is a brief account of the methods of data collection.

In *action research* the researcher is part of the research process, both as a participant and principal member with the aim of changing the environment under study and monitoring the result of the change (Oppenheim, 1992; Schutt, 1996). Thus, the researcher purposefully engages with the research setting rather than remaining independent from it. Action research has the advantage of immediacy of the results and their relevance to organisation's situation (Coughlan and Coghlan, 2002). However, the close collaboration required between the researcher and the client company poses problems. There are questions also about the academic rigor of this data collection method. Thus, some instances of action research are seen as merely "problem-solving" or "consultancy projects" (Adler and Adler, 1998). In comparing action research and positivist research, Coughlan and Coghlan (2002) note that while the latter aims to create universal knowledge, action research on the other hand creates knowledge that is contextual and situational.

Longitudinal design takes repeated measures of the same respondents at several time intervals (Oppenheim, 1992) aimed at measuring the changes associated with a variable or group of subjects (Martin and Turner 1986, quoted in Myers, 2003; 6). This contrasts with cross-sectional design, in which data are collected at one point in time (Huberman and Miles, 1998) and we compare unrelated groups (Glaser and Strauss 1967, quoted in Collis and Hussey, 2003; 74). Many versions of longitudinal designs exist (Schutt, 1996). For example, there are longitudinal designs in which the sample is followed over time, while in some designs the sample is rotated or completely changed. Furthermore,

the population from which the sample is drawn can be broadly defined to encompass the general population, or the population will be narrowly defined, such as sampling members of a specific age group at multiple points in time. Finally, the rate of follow-up measurement can vary, ranging from a before-after design with just one follow up, to studies in which various indicators are measured every month for many years (Voss et al., 2002; 195). Bozarth and McCreery (1999) performed a longitudinal study in which relationships between market requirements focus and manufacturing performance in sample of automotive supplier plants were examined. Survey data was collected from the sampled automotive supplier plants at two points in time - 1995 and 1999 - and statistical analysis used to show the existence of positive relation between the degree of market requirements and performance. *Panel is a variant of longitudinal study* which involves initial measurement followed by successive follow-up interviews (Oppenheim, 1992). Panels are aimed at highlighting the processes of slow, informal influence and change or it can be used to illustrate the changes which people go through in adapting to a new variable in their lives. A panel is made by randomly selecting a sample from a target population of respondents. Information is then sought from this sample at intervals of time, either by mail or through face-to-face interviews. Major limitations of the panel design are that it is difficult and expensive to keep track of members over a long period of time. Additionally, the panel members who are interviewed repeatedly may tire of the process. This phenomenon is known as "subject fatigue" (Schutt, 1996).

Ethnographic research originated from the discipline of social and cultural anthropology where an ethnographer is required to spend a significant amount of time in the field. Ethnography is aimed at knowing how a people undertake their daily living (2003; 439). Ethnography is a qualitative research method with participant observation (where the researcher becomes a full working member of the group studied) being the method of data collection. The research takes place over a long period of time, often many months, in a clearly defined location such as the factory floor; it involves direct participation in the activities of that particular workplace (Morgan and Smircich, 1980; Collis and Hussey, 2003). Key considerations in undertaking ethnographic research in business studies are selecting the organisation for data collection, negotiating access, and developing trust in those to work with to ensure that data collection is undertaken. There is also the demand of being a member of the group as well as undertaking the research. Worthy of note is whether the result can be generalised from the findings of the setting studied. Finally in reporting the findings it is important to present the

experiences that the group went through by quoting the participants' own words and describing the context in which they are uttered.

Grounded theory is an inductive, theory discovery methodology that allows the researcher to develop a theoretical account of the general features of a topic while simultaneously grounding the account in empirical observations or data (Eisenhardt, 1989). A key feature of grounded theory is the continuous interplay between data collection and analysis in theory development and this differentiates it and other research methods. The process of grounded theory is iterative, whereby a succession of question and answer cycles is carried out; iteration entails examining a given set of cases and then refining or modifying those cases on the basis of subsequent ones. Collis and Hussey (2003) explain that the iterative process of grounded theory begins with the researcher inductively gaining information which is apparent in the data collected. Next, a deductive approach is used in which the researcher turns away from the data and reflects about the missing information to arrive at a logical conclusion. The researcher then reverts to an inductive approach to verify, refute or modify the preceding conclusion based on the existing or new data. This inductive/deductive approach and the constant reference to the data helps ground the theory. In grounded theory, joint collection, coding and analysis of data is the underlying operation. The generation of theory, coupled with the notion of theory as a process, requires that all three operations be done together as much as possible (Flynn et al., 1990). Grounded theory has been summarised into three stages. The first is to develop categories which illuminates the data. The second is to saturate these categories with many appropriate cases to demonstrate their importance and the third is to develop the categories into more general analytic frameworks with relevance outside the studied setting. Unfortunately the two main problems associated with grounded theory are the difficulty in dealing with a considerable amount of data and generalisability of the findings outside the studied setting (Collis and Hussey, 2003). Moreover, the need for unfettered access to the research site can constitute a problem, especially for an organisational research like this one.

Survey Research: The basic methodology of survey research involves sampling, question design and data collection activities. Survey entails collection of information from a large group of people or a population about themselves or about the larger social units to which they belong (Malhotra and Grover, 1998; Forza, 2002). Questionnaire is the instrument used for collecting information in surveys. The questionnaire is

administered to a sample of the population. Sampling is the process of choosing a fraction of the population that are representative of the demographic characteristics of the whole population. The basic premise in sampling is that resource constraints make it impossible to survey the whole population. However, where the population is not very large or geographically dispersed, it could be possible to survey the whole population. There are various reasons for undertaking survey research. Accordingly, survey research can be descriptive, exploratory or confirmatory (Malhotra and Grover, 1998; Forza, 2002). Exploratory research method takes place in the early stages of the research. Malhotra and Grover (1998) contend that survey research design could be cross-sectional or longitudinal in time. In cross sectional design, measurement is taken at a point in time discounting for the dynamics (or change) in time. Put differently, cross sectional design does not take the effect of change in time, whilst longitudinal design measures the change of a variable in time or time series variation associated with a variable.

Case study is systematic analysis of a real situation that can lead to new and creative insights, and development of new theory. It has high validity with practitioners - the ultimate users of research (Yin 2003). In operations and supply chain management research the most dominant approaches adopted by researchers in this area are survey by questionnaire and case study (Forza, 2002). Voss et al. (2002) note that breakthrough in Operations management such as the Lean production concept and theories in manufacturing strategy were developed through case research. Additionally, case study can be used as a follow-up research in an attempt to examine more deeply and validate previous empirical results (Voss et al, 1997). Accordingly, in this study the results from the survey by questionnaire will be followed by multiple case studies to validate the initial survey results and also determine the factors inhibiting adoption of agility attributes.

An overview of epistemology in social research is briefly highlighted below so as to give an appropriate context for the chosen methodology.

4.5 Epistemological perspective in social science research

The Cambridge Dictionary of Philosophy (1999) defines epistemology as the branch of philosophy which studies the nature of knowledge. Following from this Solem (2003) states that epistemology is about acquiring knowledge and understanding, whilst ontology concerns the nature of reality or nature of knowledge as it is defined as "…the

nature of being, its fundamental features and principles". In other words, ontology is our perception of the world and therefore our worldview. Solem (2003) observes that in approaching a scientific problem we use our worldview as a starting point for the study. Thus, argues Solem (2003), methods to be used in the study are determined by our perception of the world. These methods are used to acquire knowledge, which is a question of epistemology. Since our perception of the world influences our choice of method, ontology therefore determines our epistemology. Indeed, Morgan and Smirich (1980) state that assumptions about ontology and human nature define different epistemological and methodological positions. In Figure 4.2, for example, the ontology of a research could be defined as subjective or objective. The appropriate epistemology will be interpretivist or positivist respectively. Similarly, the corresponding methodology will be quantitative or qualitative respectively. Given that the nature of data or information and knowledge (ontology) involved in supply chain research is quantifiable and measurable, a positivist epistemology is more appropriate. Additionally, the research paradigm is positivist due to the fact that it is based on literature review to determine theoretical concepts followed by hypotheses generation (Forza, 2002). The hypotheses were based on assumed relationships between the study constructs represented in a conceptual framework. The empirical study tests for validation of the hypotheses using the data collected from the field study.

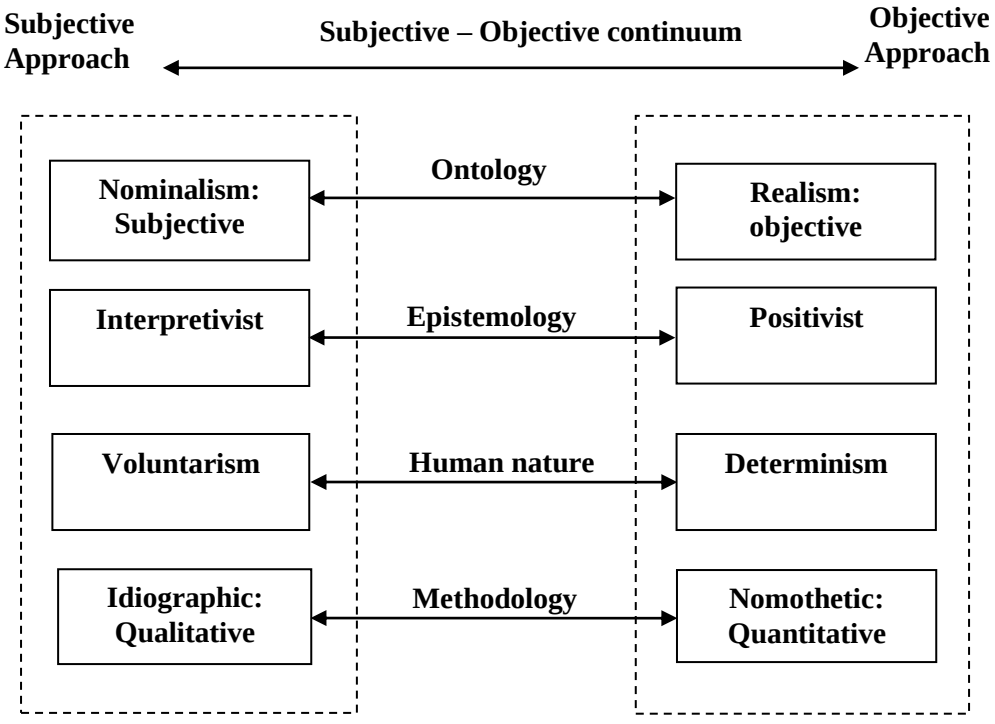

Figure 4.2: A classification of epistemology and ontology in research. Source: (Morgan and Smircich, 1980; 492).

4.5.1 The methodology adopted in this research

Supply chain management is viewed as a normative science whereby reality is perceived to be objective and quantifiable. Accordingly, this research adopts the positivist view. The research proceeds by the development of research questions from existing theory and literature which is then followed by hypotheses (Forza, 2002; Collins and Cordon, 1997; Malhotra and Grover, 1998). This is based on the assumption that there are agile supply chain attributes whose adoption by organisations can improve their performance and competitiveness. Furthermore, these attributes are both measurable and variable whilst susceptible to manipulation. When a research involves quantifiable attributes, survey by questionnaire is particularly suitable (Moser and Kalton, 1979; Collis and Hussey, 2003). As a result, survey by questionnaire was used for data collection. In addition, multiple case studies were performed to complement the survey by questionnaire. The case studies were used to explore and validate the survey results in specific settings. Thus, methodological triangulation is achieved through the combination of the two research methods (Jick, 1979; Scandura and Williams, 2000).

4.6 Survey method

Forza (2002) distinguishes between exploratory, confirmatory and descriptive forms of survey research that have been used by researchers. A brief account of the three forms of survey research is provided as follows:

- Exploratory survey research is the first stage in a research process in which it is used to gain initial insight on a topic and is used as a basis for further more in-depth studies on the subject.

- Confirmatory survey research is the survey technique in which an attempt is made at theory testing through concepts, frameworks and prepositions. This research technique is adopted when knowledge in an area has matured to the extent that a hypothesis linking constructs can be proposed and data collected to verify or refute the linkages.

- Descriptive survey research is used to understand for example the adoption of a phenomenon and provide the description of the distribution of the phenomena in a population. Although it does not aim at theory development, the facts described can be useful for theory building and refinement.

Based on Forza (2002) exploratory survey research was adopted in this research. Thus in designing the questionnaire to undertake the survey an extensive review of the literature on supply chain management, agility, industrial clusters, competitive objectives and business performance was carried out. The aim of the literature review was to collect information about the adoption of agile supply chain attributes and the impact of being in industrial clusters on the agility of the supply chain. Furthermore, the study also explored the link between the agile supply chain attributes and industrial cluster dimension; the linkage between the two factors was proposed to be cluster agile supply chains. The impact of the proposed cluster agile supply chains was then tested on competitive objectives and business performance; this is necessary in order to demonstrate the significance of adopting cluster agile supply chain dimensions on competiveness as well as profitability.

There are a number of ways of administering questionnaire. These include mail, telephone, personal interview and online using the Internet. The choice of a method depends on several factors, including efficiency; speed; cost; Internet availability and usage; literary levels; and sensitivity of questions. The relative advantages of the postal over telephone or the Internet questionnaire is the low cost. Moreover, postal questionnaires also compel an obligation to pass on a posted questionnaire alongside other mails addressed to the CEO. On the other hand, questionnaires sent online through a website that is intended for commercial enquiries would not be answered, similarly a questionnaire sent as an unsolicited e-mail could easily be deleted or filtered (Faught et al., 2004).

A major limitation of postal questionnaires is that they suffer from low response rates. However, good questionnaire design in terms of layout, formatting and question styling all go to improve response rate. Therefore the mail questionnaire was adopted in this study. To mitigate the problem of response rate, reminder phone calls were made and letters sent. Additionally, the covering letter to the questionnaire carried the name of Director of Logistics Institute at the University of Hull to stimulate the interest of respondents.

A major consideration in this research was efficiency due to constraints in terms of time and funds. Efficiency refers to completing many questionnaires within a period of time. Moreover the relative advantages of the postal over the telephone or Internet questionnaire have been discussed (Nachmias and Nachmias, 1992). The post is not too expensive and perhaps, it compels an obligation to pass a posted questionnaire

alongside other mails addressed to the CEO. This is quite unlike passing a questionnaire through a website, which was intended mainly for commercial enquiries or sending a questionnaire, as unsolicited e-mails that could be easily deleted. In addition to the inexpensive nature of the postal questionnaire, the nature of the proposed research did not require collection of sensitive data; hence a mail administered survey was deemed adequate and adopted.

However, as stated above postal questionnaires often suffer from problems of low response rate, perhaps due to pressure of work or lack of interest. In this study of a new and poorly understood concept of agility, several methods were applied to boost the response rate. The "*funnel approach"* of starting survey questions from wider issues at market and industry levels before narrowing down to company level details was applied. In addition, the "total design method" was deployed. It consists of an 18-step process for avoiding bad formatting, illogical sequence, repetition, threatening, and double barrel questions (Nachmias & Nachmias, 1992). Therefore, attention was paid to good formatting, logical sequence, and simplicity so that respondents could spare the time and interest required to provide accurate information. Additionally, the questions were simple and easy to complete within eight to ten minutes, and without recourse to documents or records. Also, most of the questions required just a tick on a five-point Likert Scale.

In order to further improve on the response rate, reminder questionnaires were sent at the end of the third, fifth and eight week of sending out the questionnaires. Follow up telephone calls were also made. University official letterhead was used for the covering letter while post-paid and self-addressed return envelopes were enclosed. In addition, the researcher hid his identity as a student. The covering letter to the questionnaire and all follow up written contacts carried the name and signature of the Director of Hull University Logistics Institute.

The survey questions captured perceptual data using relative scores on a 1-5 Likert Scale (Oppenheim, 1992). For most of the questions, One (1) stood for “Highly negative”, “Least important” or “Sharp decrease”. As well, Three (3) represented “Neutral” or “Modest” whilst Five (5) meant “Highly positive”, “Most important” or “Sharp increase”. It is evident that relative rather than objective scales were used for capturing data in the study. Although the validity of relative scales in relation to absolute scales has been questioned, their use in the conduct of social and organisation research has, however, become popular. With respect to the debate between relative and

absolute scales, Ward et al. (1998) contend that there is no empirical evidence to assert that objective measures yield better results than measures derived from relative scales. Accordingly, in using relative scales, this study accepts the procedure adopted by Gordon and Sohal (2001) in an empirical study of manufacturing plant competitiveness. As such, this research assumes that every factor, increase or decrease has equal weight or importance and that change in factors had equal impact across companies and over time. It also assumes that direction is as important as magnitude of change and that changes had equal impact regardless of current attainment or base.

Sampling Frame and Sample selection

This study focuses on the oil and gas industry; however as stated previously the oil and gas industry represents companies from diverse backgrounds. Within the oil and gas industry the constituent organisations are diverse in terms of size and activity. For example there are four classifications of companies according to size. These are: Very large, Large, Medium and Small. Classifications in terms of the activities of the organisations are: operators (mostly oil companies), contractors and suppliers. In this classification oil companies are the customers while contractors and suppliers provide goods and services to the operators. Thus the contractors and suppliers represent diverse industries. The diversity of industries which the contractors and suppliers represent is considered important in order to reduce external validity problems, which are often associated with industry specific studies. Accordingly, the respondents were drawn from operators (oil and gas operating firms), integrated contractors and suppliers. Among the three categories the sample were stratified to reflect the size variation (very large, large, medium and small) of the organisations.

Within this, although the organisation was the unit of analysis, the respondents to the study were the chief executive officers (CEOs). CEOs were targeted as respondents because they were deemed to be the source of information required in the study. Research suggests that greater attention to informant selection can help to overcome the common method variance problem when practical considerations require single respondents (Miller and Roth, 1994). Moreover it was suggested that high ranking informants tend to be more reliable sources of information than their lower ranking counterparts. Thus people at the CEO level were targeted to assure that the respondents were knowledgeable of the constructs and issues under investigation, such as the performance of their companies relative to their competitors. The CEOs were mailed research questionnaires accompanied by explanatory letters; subsequently, repeated

follow-up telephone calls were used. In line with prior empirical studies, CEOs of multiple business units were instructed to select one of their Strategic Business Units (SBUs) and to forward the research questionnaire.

The sampling design adopted, in company selection for the study, is the stratified random sampling. The companies were selected from a database of corporations known as Financial Analysis Made Easy (FAME) and other databases; additionally randomly sampling was adopted in selecting the companies from the database for participation in the survey. These databases contain information about financial and mailing address of organisations. Additionally corporations are coded with the standard industry classification code SIC code (2003). Typical SIC codes (2003) for Oil and gas industries are: 1110 which is oil and gas explorations; 1120 is service activities incidental to oil and extraction excluding surveying; 2912 manufacture of pumps and compressors; 5190 wholesale; 7420 architecture and engineering activities related to technical consultancy; and 2941 manufacture of hand held power tools.

Out of the 880 companies sampled and sent a questionnaire, 137 companies completed and returned a copy of the survey questionnaire (see Appendix 1), for a response rate of 15.6% percent. This response rate is considered to be representative of studies on organisations. An earlier empirical survey of organisations achieved a response rate of 6.5% (Ahmed et al., 1996).

4.7 Research hypotheses

In light of the three research questions stated in section 1.4 six hypotheses were proposed in order to investigate the relationships enumerated in the conceptual framework depicted in Figure 4.1. The six hypotheses would study the relationships between the following aspects:

- Geographic proximity of supply chain members by being located in clusters;
- Agility of supply chain;
- Attainment of competitive objectives; and
- Business performance.

However, broadly the study attempted to explore the extent of diffusion of established agility attributes into industrial clusters as well as the relationship the impact of being located in clusters on agility of a supply chain. The six hypotheses were as follows:

1a There is high diffusion of established dimensions of agile supply chains into oil and gas clusters.

1b There is a strong relationship between cluster attributes and dimensions of agile supply chains.

2. Agility dimension is related to attainment of competitive objectives.

3. Being in clusters is related to the attainment of competitive objectives.

4. Agility dimension is related to business performance.

5. Being in clusters is related to business performance.

6. Attainment of competitive objectives is related to business performance.

Hypothesis 1a attempts to present an audit of agile supply chain capabilities in an oil and gas cluster. This was considered necessary as proponents of agility called for the need to assess the implementation of agility in different industries in order to analyse industry effects and other dimensions of the business environment (van Hoek et al., 2001; Vazquez-Bustelo et al., 2007). Furthermore, hypothesis 1b contends that geographical proximity of supply chain members by being located in clusters can affect agility of a supply chain. Agility emphasises customer responsiveness and mastering market turbulence through deploying capabilities (van Hoek et al, 2001). On the other hand clusters are considered as providing capacity for enhanced flexibility to react rapidly to dynamic customer requests (DeWitt et al., 2006) as well as enhanced competition and cooperation (Porter, 1998a; Patti, 2006; Reichhart and Holweg, 2008) which goes to enhance perceived responsiveness of the suppliers that are located in the clusters (Frigant and Lung, 2002; Lyons et al., 2006). Although Reichhart and Holweg (2008) assert that co-locating suppliers in clusters is primarily to achieve cost efficiency, nevertheless, critical to the agility dimension of customer enrichment is postponed manufacturing. Due to the closeness of companies within the cluster, both in terms of geographic proximity and relationships, companies are able to experiment innovative product at lower cost and delay large commitments until they are more assured that the product will be fruitful (Porter, 1998). Thus, in effect, they achieve postponement far downstream and closer to the customer (van Hoek, 2000; van Hoek et al., 2001) as well as overall competitiveness through increased productivity, quicker pace of innovation and growth of new organisations (Dayasindhu, 2002).

Hypothesis 2 states that there is a relationship between dimensions of agility and the attainment of competitive objectives. Hypothesis 2 derives from the argument that where an organisation has attuned itself internally in terms of:

a. nurturing cooperation within its internal and external resources;

b. leveraging the impact of people and information, so as to

c. master relentless change and uncertainty

the organisation will be able to achieve enhanced customer enrichment capability (Meade and Sarkis, 1999). In effect, the preceding is the principal goal of agility (Goldman et al, 1995). Thus, hypothesis 2 argues that an agile supply chain can lead to attainment of competitive objectives and enhanced competitiveness.

Hypothesis 3 is a complement of hypothesis 2 whereby some researchers posit that clusters is a production model (Carbonara, 2002; Carbonara et al., 2002; Albino et al., 2007) that offers competitive advantage in terms of productivity, cooperation, competition, responsiveness as well as flexibility as result of proximity. Geographic proximity enhances access to labour and suppliers, specialized information, complementarities as well as the motivation to perform better due to peer pressure and rivalry (Porter, 1998a; Porter and Solvell, 1999; Porter, 1994). Thus hypothesis 3 suggests that as a result of the underlying advantages and purpose of industrial clusters, being located in an industrial cluster can lead to attainment of competitive objectives.

Hypotheses 4 and 5 are corollaries of hypotheses 2 and 3 respectively. Hypothesis 4 states that agile supply chain can lead to enhanced business performance and similarly Hypothesis 5 states that being in an industrial cluster can lead to increased business performance. In tracing the route map to agility, Mason-Jones et al (2000) contend that agility maximises profit through enhanced customer enrichment. Although not directly stated the reference to profit by Mason-Jones et al. (2000) indicates the existence of relationship between organisational performance and agile supply chains. Whereas many prior empirical studies on agility have been carried out (Tolone, 2000; Lau and Hurley, 2001; van Hoek, 2001; Ren et al., 2002; Weber, 2002; Cao and Dowlatshahi, 2005; Yusuf et al., 2004; Ismail and Sharifi, 2006; Swafford et al., 2006b; Vonderembse et al., 2006; Masson et al., 2007; Vazquez-Bustelo et al., 2007), this study could only find two studies that tested for impact of agile supply chain on business performance (Yusuf et al, 2004) and impact of virtual enterprise and information technology on business performance (Cao and Dowlatshahi, 2005). Accordingly this study proposes that the dimensions of agile supply chain can influence a firm’s business performance.

Furthermore, most empirical studies on clusters have been case studies (Dayasindhu, 2002; Malmberg and Power, 2005; DeWitt et al., 2006; Patti, 2006; Waxell and Malmberg, 2007), except Lubslinski (2003) and Bengtsson and Solvell (2004) who performed statistical analysis of survey by questionnaire data. However neither of the two studies explicitly measured business performance. Given that implicit in the thesis of clusters is the conferment of competitive advantage of being in proximity (Porter and Solvell, 1999), it follows that competitive advantage can lead to enhanced business performance. Accordingly it was hypothesised that being in clusters can lead to enhanced business performance.

Hypothesis 6 states that attainment of competitive objectives is related to business performance. This hypothesis proposes that, compared to competitors, an organisation that has cumulative competitive capabilities in terms of the best of all or combinations of the following: Cost, Delivery, Dependability, Speed, Innovation, Customisation, Quality, Flexibility and Proacitvity can have enhanced overall performance (Flynn et al., 1995b; Li, 2000; Corbett and Claridge, 2002; Flynn and Flynn, 2004; Gonzalez-Benito, 2005; Li et al., 2006) and consequently will outperform its competitors. Thus, hypothesis 6 affirms strong relationships between competitive objectives and business performance. This means that an organisation that attains more competitive capabilities will out-perform one that attains less of the capabilities.

4.8 Summary

In this chapter, a discussion on the conceptual model of the research was presented. Justification for the conceptual framework was used to give account of the relationships between the research constructs and the factors and dimensions of each of the construct. Thereafter research hypotheses were enacted to reflect the relationships between the constructs. An overview of research methodologies was given and a case was made for the chosen methodology in this research. Finally the method of data collection was also highlighted.

The next chapter reports the result of a survey by questionnaire. The survey was designed to collect responses of top executives in the oil and gas cluster and its supply chain. Top executives were the target respondents due to the fact that they are concerned with decisions on key strategic and operational issues within their organisations. Specifically, the survey elicited perceptual information in respect of implementation of the core dimensions of agile supply chain, location and clusters

issues and attainment of competitive and business performance objectives. Multiple instruments were crafted to collect data, and the data were used to test the validity of the hypotheses proposed earlier with the aim of answering the research questions.

The next chapter will undertake empirical validation of the model through survey by questionnaire. Additionally, in chapter 7 case studies of selected firms that participated in the survey by questionnaire will be presented as part of the validation of the survey results and testing of relevant hypotheses.

CHAPTER 5: SURVEY BY QUESTIONNAIRE

5.1 Introduction

This chapter reports the planning and administration of a survey by questionnaire and the resulting findings. The survey generally gathered data with a view to exploring and testing the relationships specified in the conceptual framework and research hypotheses presented in chapter 4. To test the hypotheses proposed in the previous chapter, correlations and relationships among the four research constructs consisting of agile supply chain attributes, industrial cluster variables, competitive objectives and business performance were determined. Additionally, correlation analysis was evaluated for cluster and non cluster based organisations to test for the impact of proximity on speed, flexibility and responsiveness.

There are two main themes in this study; the first is based on the theory that agility is deployed by organisations to overcome the challenge of a business environment that is characterised by volatile markets as well as dynamic performance requirements to meet the needs of fickle consumers (van Hoek, 2001). The second theme of the research was to assess the impact of being in industrial clusters on the agility of organisations. As such a survey design was adopted to undertake the study to gain an understanding of the two themes. The survey was carried out to determine the extent of adoption of agility as an operations strategy to survive in a changing business environment. Survey method was deemed to be an appropriate research methodology as means of investigating practitioners' opinions on emerging concepts and practices of agility (Malhotra and Grover, 1998; Curkovic et al., 2000). Also survey, being a deductive research method as opposed to the inductive method typical of qualitative methodology, was deemed appropriate in order to test the relationships between the agile supply chain attributes and industrial cluster factors. The survey is extensive, as agility as a topic is only recently being subjected to empirical study. Thus, the limited study on the topic of agility necessitates complementing the survey with case studies (in chapter 6) to mitigate the limitations of a single method, as well as gain further insight through the in-depth study of limited sample of cases.

Although numerous studies on agile manufacturing (Elkins et al., 2004; Vazquez-Bustelo and Avella, 2006; Zhang and Sharifi, 2007) and agile supply chains (Ismail and Sharifi, 2006; Vonderembse et al., 2006; Masson et al., 2007) have been carried out, to date there is no research that have been carried out to assess the impact of being in

industrial clusters on the agility of an organisation. Thus, this research is exploratory in nature as it attempts to investigate the impact of cluster location attributes on agility, attainment of competitive objectives and business performance of organisations.

Generally, agility is the ability of the firm to respond and adapt to a business environment characterised by dynamic and continuous change. The framework for assessing the agility is the dimensions of agile manufacturing proposed by Goldman et al (1995) which are Enriching the customer, Cooperating to compete, Mastering change and uncertainty, and Leveraging the impact of people and information.

The survey data was designed to provide the basis for answering research questions and testing the research hypotheses. In order to reduce error and enhance validity of results, formal procedures of survey design, administration and data analyses were applied (Nachmias and Nachmias, 1992; Creswell, 1994).

5.2 Questionnaire design

The literature on questionnaire design emphasizes the need for a comprehensive approach to questionnaire design. This is sometimes known as the Total Design Method (TDM) (Nachmias and Nachmias, 1992). TDM entails a broad set of questions to be asked, taking into account data types, analysis and research questions to be addressed.

The survey instrument (questionnaire) attached in Appendix 1 is divided into eleven sections consisting of 26 main questions. The sections are:

A. Company background

B. Business performance

C. Creating customer value

D. Cooperating to enhance competitiveness

E. Role and importance of alliance

F. Mastering change and uncertainty

G. Leveraging the impact of people and information

H. Cluster location attributes

I. Strategic distinctive competence

J. Competitive objectives and finally

K. Impact of adopted practices on responsiveness

A covering letter soliciting for participation also accompanies the questionnaire.

The first part of the questionnaire, section A, concerns the demographic characteristics of the company. The background information includes information on the name and address of the responding company, the length of time the firm has been operating in Aberdeen, estimates of the number of employees and annual turnover. Thus in this section both textual and numeric data are generated.

The second part of the questionnaire, section B, obtains information concerning business performance based on financial and marketing based performance indices. Part 3 of the survey instrument concerns the implementation of general agile supply chain attributes followed by more specific agility enablers. Questions about agility implementation are divided into five sections. Sections C to G elicited information concerning the implementation of the four general dimensions of agility. Questions 13-17 were used to elicit information in respect of the implementation of the four agility dimensions namely: Enriching the customer, Co-operating to compete (including alliances), Master change and Uncertainty and Leveraging People and Information. The specific information sought is as follows:

Section C is about the critical output of agility which is Enriching the customer (Meade and Sarkis, 1999). The focus on the need to enrich the customer through the object of exchange but mainly in terms of providing solutions not just products. Indeed, where there is customer delight, the products of the enterprise will be perceived by the customer as constituting solutions to a problem. This is important because it indicates the focus of the company in terms of the product or service it sells. Sustained customer enrichment is attained through building long-term stable relationships based on selling solutions which involve products, information and services. Moreover supplier – customer relationships evolve in response to changes in the dynamic business environment. Equally, a customer-enriched business environment is opportune for products to be designed by the end user, as well as upgraded and reconfigured instead of being replaced (Meade and Sarkis 1999; 243). Essentially, customer enrichment includes market understanding, customisation, and proactive response (van Hoek et al, 2001). Thus Section C (consisting of 14 questions) measures the level of customer enrichment perceived by the customer, as well as the effort of the supplier to enrich the customer.

In light of the customer enrichment being the output of agility, Sections D to G reflect the input dimensions of agility that ensure enhanced output of customer delight. These inputs are Cooperating to compete (section D), Role and importance of Alliances (section E), Mastering change and uncertainty (section F) and Leveraging the impact of people and information (section F).

Section D, Cooperating to compete (consisting of 19 questions) measures cooperation within the organisation as well as among different organisations. Thus Section E of the questionnaire (consisting of 8 questions) measures the roles and importance of partnering and alliances within the supply chain. Indeed an agile enterprise needs to utilise existing resources regardless of location in order to bring the product to market as rapidly and cost effectively as possible (Goldman et al, 1995).

Section F (11 questions) concerning Mastering change and uncertainty, measures the business environment of the survey. An organisation that wants to survive in an environment that is characterised by turbulence needs to be organised in such a way that it can thrive on change and uncertainty. Being organised to master change and uncertainty requires a skilled workforce that has autonomy and self management in tasks as well as fostering an entrepreneurial company culture. An entrepreneurial culture supports innovation and authority to respond to changing market opportunities.

Section G (12 questions) measures Leveraging the impact of people and information. Leveraging the impact of people and information is the mechanism that utilises cooperative relationships for customer enrichment. People's skills, knowledge and information are the most valued assets of an organisation. Main attributes are: organised around competencies and processes; employee motivation through trust and empowerment. Overall, an agile organisation sells its ability to convert knowledge, skills and information embodied in its personnel into solution products for the customer (Goldman et al, 1995, Meade and Sarkis, 1999).

Section H of the questionnaire elicits information concerning cluster and location factors. The section contains four main questions on the importance of location in clusters:

1. In sourcing for labour

2. On transportation and transaction cost factors

3. Sourcing for intermediate goods and services

4. Importance of localized networks as sources of knowledge and information

Section I is composed of two main questions (22 and 23). Question 22 elicits information on the distinctive competence (based on Miles and Snow's strategic typology (Hambrick, 1983)) that is at play in the surveyed firms as well as in the cluster, while question 23 determines the emerging competence required to meet the challenges of the business environment.

Section J elicits information, through Q24, on the operations and logistics characteristics that respondents consider to be critical to attainment of their competitive objectives. Section K (Q25) determines the significance of adopted factors and practices on the overall responsiveness of respondents and finally Q26 solicited for participation in the case study phase of the study.

5.2.1 Pilot-testing the questionnaire

Pilot study entails testing the questionnaire instrument to be used to collect data during the survey. Pilot study often reveals and highlight potential problems associated with the questionnaire wording and clarity as well as the survey administrative processes (Oppenheim, 1992; Forza, 2002).

Forza (2002) suggests that to pilot-test the survey instrument prior to commencing the full field study, the questionnaire should be submitted to three types of people: colleagues, industry experts and target respondents. Colleagues test whether the questionnaire accomplishes the study objectives, while industry experts prevent inclusion of some obvious questions that might reveal avoidable ignorance of the researcher in some specific area. Finally target respondents provide feedback on things that can affect response as well as intent to respond. Additionally, Forza (2002) propose a two phase strategy to carry out the pilot-test. In the first phase the researcher fills in the questionnaire with a group of potential respondents who fill the questionnaire as if they are part of the planned survey. The researcher should be present to observe the respondents filling the questionnaire and also record their feedback. Subsequently the researcher determines from the respondents whether:

- the instructions accompanying the questionnaire were clear
- the questions were clear

- there were problems in understanding the questions or in providing answers to the questions posed; and
- the planned administration procedure would be effective

The second phase of the pilot-test involves administering the questionnaire to a sample to test contact-administration protocol. This phase is aimed at gathering data to perform exploratory analysis to assess the measurement quality of the questionnaire as well as sampling adequacy. The performed with the data from this phase preliminary analysis investigates whether:

- answers to certain questions are too concentrated due to the choice of scale
- the content of answers differs from expected; and
- the context modifies the question (such as question can be manufacturing focussed while industry studied is service based, or question can be suitable for medium-size companies but not for very small or large companies).

Thus in this study, the questionnaire was administered to seven colleagues (PhD students within the University of Hull), two lecturers and two people outside the university. They were asked to complete the questions as if they were potential respondents, and to provide feedback on clarity, flow and time taken to answer the questions. These respondents were also asked to write any comments and observation they have on the questionnaire. Results from this pilot test indicated average of 10 minutes to complete the questionnaire. Furthermore comments expressed on the questionnaire in terms of clarity of instructions from the pilot test were discussed with the supervisors and appropriate changes were incorporated into the final questionnaire.

Furthermore pilot-test was carried out through face-to-face meetings with four industry experts consisting of consultants and industrialists conversant with the industry to be studied. Finally ten questionnaires were sent out by mail to members of the Aberdeen based UK oil and gas industry Supply Chain Management Network. Seven filled questionnaires were returned with detailed comments and suggestions which helped towards improving the contents and format of the final questionnaire for final administration.

Overall the result of pilot-test indicates that the survey instrument was perceived:

- Clear, legible and the items comprehensively measures the issues
- The questionnaire took about 10 minutes to answer
- The instructions on how to complete the questionnaire was clearly understood

5.2.2 Questionnaire administration and response rate

A total of eight hundred and eighty (880) questionnaires were mailed out to the addresses of the respondents taken from Financial Analysis Made Easy (FAME) database of companies and other databases that host business directory of corporations.

Out of the 880 companies sampled and sent a questionnaire, 137 companies completed and returned a copy of the survey questionnaire (see Appendix 1), for a response rate of 15.6% percent. This response rate is considered to be representative of studies on organisations. An earlier empirical survey of organisations Ahmed et al (1996) achieved a response rate of 6.5%. Of the 137 questionnaires returned, 95 were fully completed with the answers being logical. The 95 questionnaires were deemed as valid and usable for the study while 42 questionnaires were excluded from further analysis. Although poorly completed questionnaires still provide some data, researchers often exclude such questionnaires in order to reduce the incidence of missing data in statistical analysis as well as improve the reliability of results (Hair et al., 2006; Tabachnick and Fidell, 2007; Gill and Johnson, 2002). Also one questionnaire was returned not completed, with a comment that the type of business does not fit the survey. Twenty envelopes were returned with the questionnaires due to inability to the addressees, as the companies had moved. In another case, an email was received stating that the organisation is in receivership and will not be able to participate in the study, while a phone call was received to the same effect from another organisation. Table 5.1 reports the sample, response and usable percentage rates per product group of the 880 companies studied. From the general spread of the response among the business sectors or product groups it can be inferred that there is no bias in demographic composition of the responses.

Table 5.1: Analysis of response rates across product groups

Business sectors/Product groups	Sample	Rate (%)	Response	Rate (%)	Usable	Rate (%)
Exploration and production	112	12.7	18	16.1	12	10.7
Business services (incl. consultancy)	64	7.3	6	9.4	6	9.4
Marine and Allied Transport services	122	13.9	19	15.6	14	11.5
Engineering services and Offshore construction	140	15.9	21	15.0	15	10.7
Computer and allied equipment	62	7.0	9	14.5	6	9.7
Supply and rental of equipment	40	4.5	4	10.0	4	10.0
Automotive and automotive accessories	50	5.7	10	20.0	5	10.0
Electrical and electronic products	110	12.5	17	15.5	12	10.9
Food chemical and pharmaceutical products	80	9.1	11	13.8	8	10.0
Industrial equipment	100	11.4	20	20.0	11	11.0
Any other			2	2.3	2	2.3
Total	880	100	137	15.6	95	10.8

After looking at the spread of the responses among the business sectors and product groups the following section will give an account of the statistical analysis carried out on the data. The analysis forms the basis for hypotheses testing and validation carried out to answer the research questions.

5.3 Statistical results

The responses to the survey were input into SPSS® version 15 for windows in order to carry out statistical analysis of the data collected from the study. The SPSS software tool enables the computation of frequency, means, standard deviation of the data collected from the study. It also enables detailed statistical analysis such as performing comparative analysis of the data between the various classification of the research theme to test for association or differences among the responding organisations to the study.

5.3.1 Assessing normality

Prior to performing inferential statistical analysis there is the need to assess the characteristics of the distribution of the data to determine whether the variables are normally distributed. Indeed, the assumption of normality is a prerequisite for carrying out multivariate analysis. There are a number of graphical methods of exploring the assumption of normal distribution in a dataset, which are: Histogram, Stem-and-leaf plot, Boxplot, Normal distribution plot and Detrended normal plot. Furthermore, a number of statistics are also available to test for normality including:

- Kolmogrov – Smirnov (K-S) statistics with a Lilliefors significance level and the Shapiro-Wilk statistic.
- Skewness and
- Kurtosis

Within this study the tests of normality considered were the normal probability plots, Shapiro-Wilks and the K-S (Lilliefors) tests.

There are several procedures available in the SPSS software tool to obtain these graphs and statistics. Two of these procedures are the ANALYZE and EXPLORE menu, but the EXPLORE procedure is the most convenient, especially when graphs and statistics are required simultaneously. Accordingly using the EXPLORE analysis procedure test for normality of each dimensions of the construct shown in chapter four (Figure 4.1) was carried out. Figures 5.1 – 5.5 show histogram, stem and leaf plots, normal and detrended plots for a normally distributed sample of data for enriching the customer and cluster and location variables. Additionally Table 5.2 shows the results of the K-S test statistics with Lilliefors significance level and Sharpiro-Wilks test statistics for normal distribution relating to location factors and enriching the customer.

Histogram is a statistical chart that is used to assess the distribution of a dataset. In this regard, Figure 5.1 shows the histogram of cluster and locations factors and agility attribute of enriching the customer. It can be seen from histogram reported in Figure 5.1 that the two variables have distributions that will be considered normal. Nevertheless, assessment of the other characteristics is necessary to be able to conclude on the nature of the distribution. Information about the shape of the distribution for some of the variables is also provided by the stem and leaf plot. The result of the stem and leaf for

two variables: Enriching the customer and Cluster location factors is shown in Figures 5.2 and 5.3 respectively. The two distributions as seen in Figures 5.2 and 5.3 demonstrate that the dataset comes from a population that is normally distributed. Furthermore, Figures 5.4 and 5.5 show the normal probability and detrended plots for enriching the customer and cluster and location factors respectively.

The aim of a normal probability plot (NPP) is to aid in indicating the nature of distribution of a data, that is, whether it is normally distributed or not. Utilisation of NPP is predicated on the fact that detecting normality from a histogram can be difficult especially if the data set is not large. The plot of the dataset is compared with an expected normally distributed one. If the two are similar, then the dataset is consistent with expected sampling from a normal distribution. Accordingly the normal probability plots shown in Figures 5.4 and 5.5 indicate that the dataset is normally distributed.

The detrended normal plots the actual deviation of the dataset from a straight line. If the dataset represents a sample from a normal distribution then there is no pattern to the clustering of the points; the points should assemble around a horizontal line (Coakes et al., 2006).

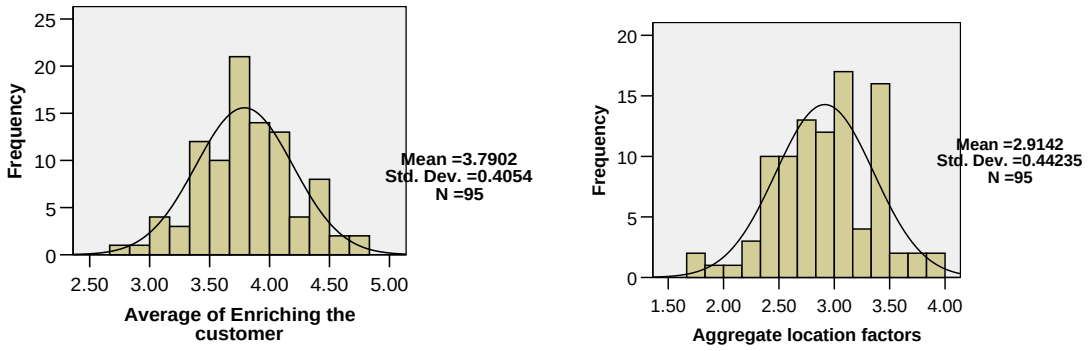

Figure 5.1: Histogram plot of enriching the customer and cluster and location factors

Average of Enriching the customer Stem-and-Leaf Plot

Frequency	Stem & Leaf plot	
1.00	Extremes	(=<2.7)
1.00	2.	8
19.00	3.	0000222344444444444
45.00	3.	555566666666666666667777778888888889999999999
25.00	4.	000000000111122223334444
3.00	4.	566
1.00	Extremes	(>=4.7)

Stem width: 1.00
Each leaf: 1 case(s)

Figure 5.2: Stem and Leaf plot of enriching the customer

Aggregate location factors Stem-and-Leaf Plot

Frequency	Stem & Leaf	
3.00	1.	888
14.00	2.	11223344444444
35.00	2.	55555555666666777777778888889999999
37.00	3.	00000000000001111122233344444444444444
6.00	3.	567888

Stem width: 1.00
Each leaf: 1 case(s)

Figure 5.3: Stem and leaf plot of aggregate location factors and enriching the customer

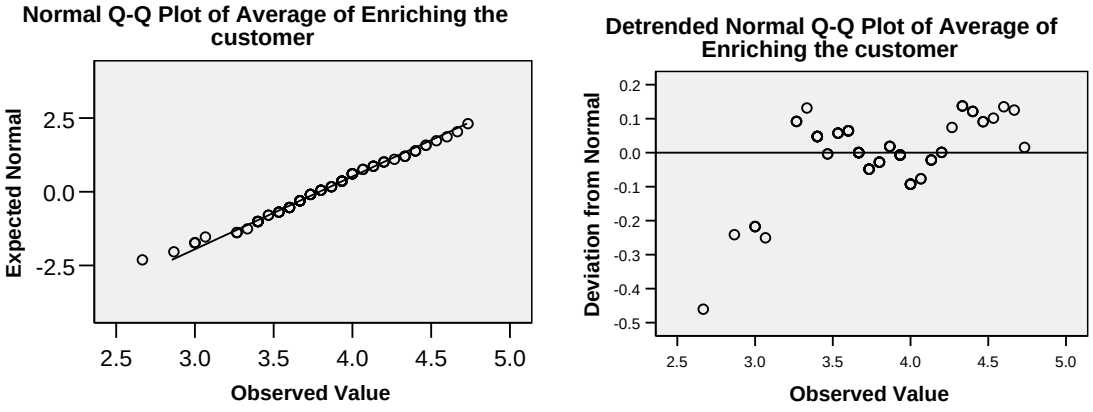

Figure 5.4: Normal probability and detrended plot for enriching the customer

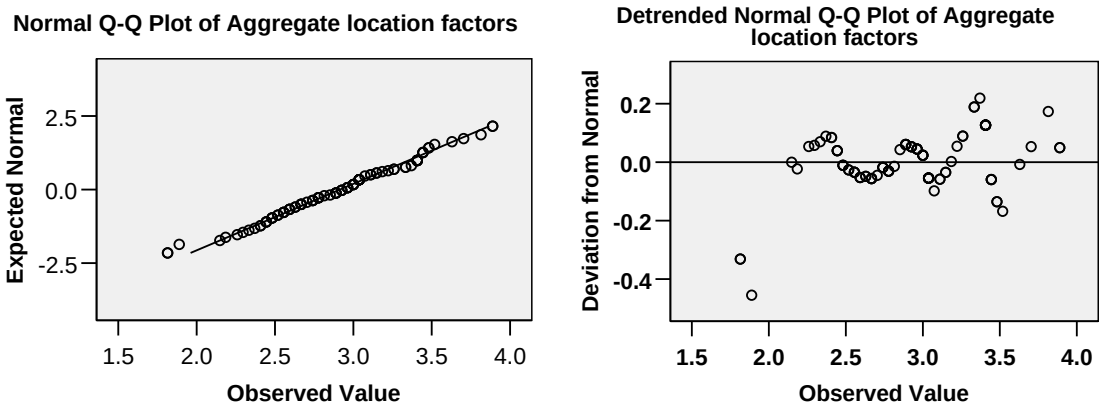

Figure 5.5: Normal probability and detrended plot for cluster and location factors

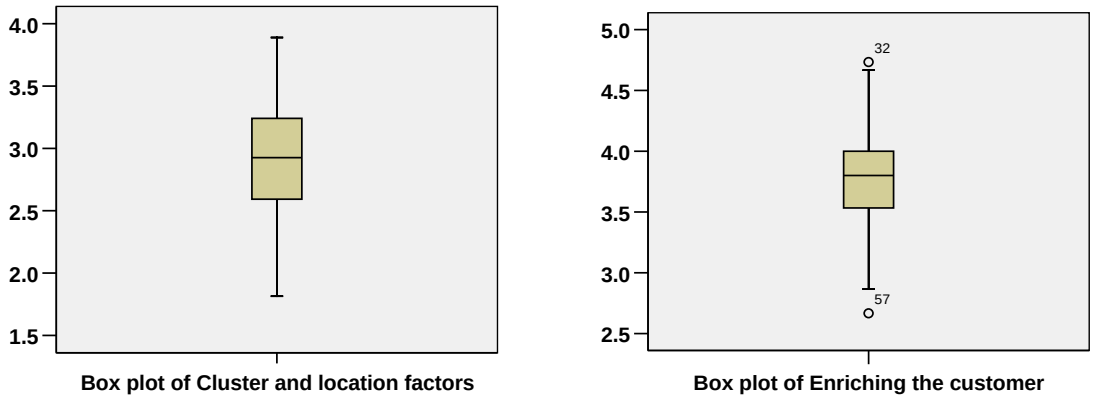

Figure 5.6: Box plot of cluster and location factors and enriching the customer

Figure 5.6 shows the boxplots of some of the variables studied. These variables are Enriching the customer on the right hand side and Cluster and location factors on the left hand side. The boxplots of the two variables show that the Cluster and location factors is normally distributed about the mean, while Enriching the customer, although two variables are outside the upper and lower quartiles, is also normally distributed about the mean. Hence the variable is normally distributed based on the observation that a variable is an outlier if it lies at 3 box lengths from the upper or lower quartiles. Table 5.2 shows the KS statistics with Lilliefors significance test statistics computed for agility attribute of enriching the customer and Industrial cluster factors. Additionally, the Shapiro Wilks statistics was computed since the data was less than 100. Coakes et al. (2006) state that if the significance of the KS statistics is greater than 0.05 then normality is assumed. Hence, the null hypothesis that there is no significant difference between the distribution of the data from which the statistics in Table 5.2 were computed and normal distribution cannot be rejected. Accordingly, the tests of normality presented in Table 5.2 and Figures 5.1-5.6 demonstrates that the data set

satisfies the requirement for normal distribution from the study. Thus it can be concluded that the sample is drawn from a population that is normally distributed.

Table 5.2**:** Kolmogorov-Smirnov (KS) statistics tests of Normality

	KS statistics			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Enriching the customer	0.071	95	0.289(*)	0.989	95	0.619
Industrial Clusters factors	0.068	95	0.245(*)	0.987	95	0.453

Although two results of assessment of normality are presented here, this is not to suggest that only two variables were assessed. The two reported results are just for parsimony as all the variables were assessed for all the dimensions and they all met the requirements of normality which needed to be satisfied before further analysis such as correlation and regression analysis could be carried out. Indeed Table 5.5 shows the skewness and kurtosis, which is another statistical tool that assesses normality, for all the variables studied. The skewness and kurtosis reported in Table 5.5 demonstrate that the data set is normally distributed since they do not depart significantly from between zero and one. Moreover, the dataset contains a mix of positive and negative values within the range of values for the two variables. An exceptional value for kurtosis of 2.688 was reported for Flexibility (ability to deliver any quantity); nevertheless kurtosis values of 3 represent normal distribution (Tabachnick and Fidell, 2007).

5.3.2 Non-response bias analysis

A variety of ways exists to deal with the potential problem of non response bias. One method as reported in Lambert and Harrington (1990) involves summarising the original questionnaire and sending to the non respondents to complete. On receiving the result of their response, one way analysis of variance (ANOVA) is carried out to test for variance between respondents to the full questionnaire and respondents to the abridged questionnaire. This approach was not adopted in this study, due to the fact that there was no guarantee that this group would respond to the research, given that they refused to participate in the first study. The second approach involves testing for the possibility of non-response bias in the data, which constitutes a test for statistically significant differences in the responses of early and late waves of returned surveys. The last wave of the surveys received was considered to be representative of the non – respondents. Then, t-tests were carried out on the responses of the two waves and the result of the t-test is shown in Table 5.4. The t-test result yielded no statistically significant differences

among the survey items tested. Therefore Table 5.4 suggests that non-response bias did not significantly impact the study.

Creswell (1984) contends that absence of non-response bias indicates that the findings from the survey can be generalised to other settings. A research that satisfies the non-response bias requirement by being representative of all the surveyed organisations can be generalised to different research set-ups from the one originally studied. This implies that when the same research instrument is administered to a different sample from the same population it should give identical results (Wisner, 2003).

In organisational research there is debate in respect of the form of data resulting from research carried out. The contention about the data form is between subjective perceptual data and objective data. Dess and Robinson Jr. (2002) and Ward et al (1994) performed empirical evaluation of the two data forms and found strong correlation between subjective perceptions of relative improvement in organisational performance with objective measures of the absolute changes in business performance over the same period. Thus the study indicates that top managements' perception about the performance of their organisations (measured in subjective and relative terms) conforms to the actual performance of their organisation. Accordingly, where objective data is inaccessible or unavailable, perceptual subjective data offers a viable alternative. Therefore in this study perceptual data was used, in part because of the difficulty of access. Since respondents were also aware that their competitors might participate in the survey, they were not willing to divulge objective data of their operations even though they were assured the information would be used for academic purpose only and strict confidentiality would be maintained during use.

5.3.3 Validity and reliability analysis

Forza (2002) points to the importance of assessing the quality of a research instrument by noting that without assessing reliability and validity it will be impossible to account for the effects of measurement errors on theoretical relationships that are being measured.

Reliability

Since the data for this research was derived from scaled responses it is necessary to assess the reliability of the scales (Tracey et al., 2005; Curkovic et al., 2000). Moreover

Having confirmed statistically that the questionnaire data are devoid of random effects, reliability tests were conducted as a measure of the internal consistency of instruments employed to measure concepts. For instruments measuring a concept to be reliable, they should be highly correlated. Cronbach's coefficient alpha, which computes an average of all possible split-half estimates, is the most widely used test of internal consistency (Flynn et al., 1990; Ngai and Cheng, 1997). Moreover, data reliability requires that instruments measuring the same concept should be sufficiently different from other instruments. As such they should load separately in a factor analysis (Swafford et al., 2006a).

Reliability tests were conducted for the main elements of the research instruments, that is, demographic characteristics, agility attributes, cluster and location attributes, competitive objectives, business performance as well as the entire questionnaire. The reliability test result for the research instrument is reported in Table 5.3, which shows that the Cronbach's alpha for the overall scale of the survey instrument consisting of one hundred and thirty five (135) variables was found to be 0.849**.** In addition, for each of the sub items the scale reliabilities were also computed again. The results of this analysis indicate that for all the sub-items of the research instrument the coefficient alphas exceed 0.70, and the interrater reliabilities exceed 0.80; thus the scales demonstrate both strong internal consistency and strong interrater reliability. The figure for the reliability of the constructs shown in Table 5.3 is within the acceptable value of 0.70. Using results of earlier empirical studies, Swafford et al. (2006) report that while Cronbach's alpha at 0.70 or higher is typically used to establish reliability of a construct, through there are situations in which values of 0.6 are acceptable (Forza, 2002), especially for broadly defined constructs like agility attributes.

Table 5.3: The reliability of test results

Focus of test	Cronbach's Alpha	Number of Items
The entire questionnaire	0.849	135
Demographic characteristics construct	0.717	6
Agile supply chain dimension construct	0.854	65
Cluster and location construct	0.796	27
Distinctive competence construct	0.744	11
Competitive priorities construct	0.727	9
Business performance construct	0.825	5

Validity

Generally the validity of a research instrument assesses the extent to which the instrument measures what it is designed to measure (Collis and Hussey, 2003). Validity requires that the research instrument (that is items in the questionnaire) should correctly measure the concepts under study. It also means that identical results should emanate if research processes were repeated. Thus a measurement scale should have external validity. In this study, multidimensional measures were used to assess the impact of agile supply chain attributes and industrial cluster dimensions on competitive capabilities and business performance. First, to enhance the validity of the research instrument, the scales were derived from exhaustive literature review of the core issues addressed in the research. Subsequently, a guiding conceptual framework was proposed on which research hypotheses were specified. In addition, some control questions were put in the questionnaire; moreover, just as responses to some questions such as sales turnover were compared against published data. Above all, completed questionnaires were scrutinised for consistency and fullness prior to data analysis. Accordingly the instrument can be judged to be of sound construct validity (O'Leary-Kelly and Vokurka, 1998).

In this study wave analysis was also used to analyse the validity of the survey instrument. The questionnaire was divided into two groups. Based on the two groups of the questionnaires, validity analysis is carried out by comparing the variance of the attributes of the questionnaire as part of wave analysis is shown in Table 5.4. The principle of wave analysis is that the first group of the returned questionnaires are representative of those willing to participate in the study while the last batch of the returned questionnaires are representative of the non responding organisations. The wave analysis is premised on the fact that the actual non respondents will still not respond to a condensed questionnaire, so as to get some demographic information about them to enable carrying out a validity analysis of the survey instrument.

Table 5.4: Wave analysis to test external validity for non-response bias of the questionnaire

	1st Wave	2nd Wave	2 tail sig.	df	Levene's test
Turnover	3.92	4.13	0.267 0.266	93.00 91.546	0.387
Employees	4.13	4.66	0.401 0.402	93.00 90.628	0.031
Customer sensitivity	4.23	4.02	0.168 0.168	93.00 92.835	0.134
Network integration	3.69	3.74	0.728 0.728	93.00 91.123	0.592
Process integration	3.81	3.83	0.907 0.907	93.00 92.047	0.609
People and Technology	3.79	4.00	0.201 0.201	93.000 93.000	0.069
Cluster and location	2.94	3.21	0.192 0.191	93.000 91.117	0.272
Distinctive competence	3.85	3.94	0.665 0.665	93.000 92.973	0.904

Table 5.4 shows the results of the wave analysis between the early and late respondents to the survey as a proxy of non-response bias associated with the study respondents. The attributes that were measured in the wave analysis were demographic characteristics, dimensions of agile supply chains, cluster and location attributes and distinctive competence. As shown in Table 5.4 the two tailed significance values are all greater than 0.1 for all the characteristics measured. Thus, the null hypothesis that there is no significant difference between mean values of the two waves of responses cannot be rejected. Additionally Levene's test for the equality of variance of the measured characteristics between the early and late respondents is presented in Table 5.4. Levene's test also tests the assumption of equality of variance between two groups. If Levene's test is significant (for example at significance level of 0.05 or less), it indicates that the two variances are significantly different, whereas if it is not significant (for example at significance level greater than 0.05), then the two variances are not

significantly different; meaning that the two variances are approximately equal. Thus from Table 5.4 it can be seen that for all the measured characteristics except the demographic characteristic of number of employees the null hypothesis that there is no significant differences between mean values of the two waves of responses cannot be rejected. Thus, based on the two tailed significance and the Levene's T test as shown in Table 5.4 the instrument can be adjudged to have a high level of validity. Therefore the null hypothesis, that there is no significant difference between the non-respondents and those that responded to the study in terms of size of the organisations measured by turnover and number of employees cannot be rejected.

5.3.4 Descriptive statistics of respondents

In the foregoing sub-sections statistical tests for reliability, validity and normality were reported as part of data examination as well as to ascertain that the data set satisfies the assumptions for parametric analysis. Additionally, the data was analysed for descriptive statistics. The descriptive and distribution statistics including the mean and standard deviation of the research constructs are shown in Table 5.5. The first two columns in Table 5.5 show the main construct as well as the variables respectively. The next two columns consisting of the minimum and maximum scores are the responses to the questionnaire (shown in Appendix 1) received. Then the last four columns consisting of the mean, standard deviation, skewness and kurtosis respectively were computed from the maximum and minimum scores. It can be seen from the table that the standard deviations show that there is a measure of dispersion in the constructs measured. Looking at the skewness and kurtosis, neither of them has high values and there is an even spread of positive and negative values for the nature of distribution of the data. Skewness and kurtosis enable the determination of the nature of the distribution of the constructs based on the responses to the survey responses.

Although the mean, standard deviation and correlation are the most basic tools for statistical analysis, they are inadequate for measuring the behaviour and determinants of a multi-dimensional concept such as agility. For this reason, parametric techniques like the t-test, regression analysis, analysis of variance (ANOVA), and factor analysis offer a more powerful and rigorous tool for exploring the nature and the competitive impacts of the agility enablers. Additionally there is a debate on the appropriateness of ordinal data for parametric analysis (Hair et al., 2006); nevertheless parametric techniques are now widely used to analyse ordinal data. Thus, in this study the view that ordinal data can be used for parametric analysis was adopted.

Table 5.5: Descriptive and distribution statistics of research variables

RESEARCH VARIABLES			Min	Max	Mean	Std Dev.	Skewness	Kurtosis
Business performance	Turnover		1	5	4.02	.922	-1.123	1.456
	Net profit		1	5	3.83	1.02	-1.139	1.061
	Market share		1	5	3.61	.76	-.088	.517
	Customer loyalty/retention		1	5	3.59	.751	-.235	.672
	Performance relative to competitors		2	5	3.76	.782	-.226	-.278
Cluster and Location issues	Labour source	Universities	1	5	2.73	1.22	.223	-.951
		Competitors	1	5	2.72	1.14	.005	-.904
		Other firms	1	5	3.08	.90	-.441	.691
		Supplier	1	5	2.91	1.97	-.072	-.493
		Customers	1	5	2.31	1.07	.680	-.037
		Headhunting	1	5	2.46	1.10	.120	-.737
	Transportation and Transaction cost	Transportation cost	1	5	2.69	1.20	.202	-.895
		Labour availability	1	5	3.11	1.01	.042	-.519
		Infrastructure	1	5	3.25	1.03	-.469	-.378
		Raw materials	1	5	2.55	1.23	.541	-.609
		Proximity to Suppliers	1	5	2.58	1.02	.246	-.426
		Proximity to markets/customers	1	5	3.54	1.26	-.588	-.736
		Proximity to parent company facilities	1	3	1.67	.76	.634	-1.008
		Proximity to competitors	1	5	2.06	.99	.752	.208
		Quality of life	1	5	2.96	1.16	-.085	-.652
		Regulatory framework	1	5	2.69	1.26	.008	-1.222
		Economic factors	1	5	3.22	1.20	-.513	-.739
		Political stability	1	5	2.75	1.29	-.001	-1.196
		Social and cultural factors	1	5	2.75	1.16	.049	-.632
		Characteristics of the location	1	5	3.18	1.09	-.365	-.375
	Inputs	Basic inputs (2.89, -.159, -1.570)	1	11	6.12	3.36	-.288	-1.468
		Specialist input (2.41, .435, -1.336)	1	11	4.99	3.20	.328	-1.23
	Information source	Trade press	1	5	3.71	1.00	-.618	-.116
		Conference/Fairs	1	5	3.47	1.02	-.574	-.151
		Business press	1	5	3.22	.87	-.146	-.147
		Internet	1	5	3.80	.93	-.481	-.166
		Informal contact	1	5	3.98	.97	-.534	-.456
Enriching the customer	Reconfigurable products		1	5	3.43	1.01	-.384	.138
	Customer satisfaction focus		3	5	4.43	.63	-.649	-.521
	Measure customer satisfaction		2	5	3.98	.89	-.612	-.268
	Ontime delivery		1	5	3.37	1.11	-.111	-.917
	Stock availability focus		1	5	3.32	1.28	-.182	-1.104
	Flexible to customer needs		2	5	4.13	.69	-.569	.665
	Customization of products		1	5	3.27	.93	-.087	-.003
	Providing standard products		1	5	3.09	1.10	-.142	-.826
	Offer solutions rather than products		1	5	3.85	1.09	-.855	.189
	Products ready for use		1	5	3.74	.85	-.092	-.175
	Customer driven products		1	5	3.76	.87	-.193	-.189
	Fat delivery of products		1	5	3.45	.95	-.05	-.263
	Increase customer value		2	5	4.24	.68	-.550	.131
	Retain and grow customer relationships		3	5	4.53	.62	-.938	-.115
	Value added products		2	5	4.26	.75	-.786	.273
Mastering changer and uncertainty	Concurrent engineering/operations		1	5	3.69	.88	-.327	-.035
	Encourage environment of risk taking		1	5	3.15	1.03	.114	-.950
	Discourage risk taking		1	5	2.44	.93	.213	--.424
	People think and take initiatives		2	5	4.05	.75	-1.017	1.672
	Infrastructure to encourage innovation		2	5	3.74	.89	-.378	-.496
	Proactive response to changing markets		1	5	3.77	.83	-.677	1.272
	New processes to follow market trends		2	5	3.80	.75	-.263	-.131
	Organizational boundaries non existent		1	5	2.93	.91	-.023	-.301
	Our company respond rapidly to changes in product		1	5	3.73	.89	-.620	.608
	Productivity and quality are measures of operations		2	5	3.92	.79	-.367	-.258
	Integrated broad measures of capabilities are used		1	5	3.76	.86	-.432	.182

Table 5.5 (continued): Descriptive and distribution statistics of research variables

RESEARCH VARIABLES		Min	Max	Mean	Std. Dev.	Skewness	Kurtosis
Cooperating to compete	Organised along functions and departments	1	5	3.51	1.18	-.406	-.944
	Organised along business processes	1	5	3.56	1.03	-.399	-.553
	Reward based on team performance	1	5	3.78	1.03	-.723	-.129
	Reward based on individual performance	1	5	3.14	1.10	-.327	-.910
	Information available enterprise-wide	2	5	3.82	.85	-.388	-.362
	Information difficult to find	1	4	2.22	.88	.129	-.792
	Matrix project team is utilized	1	4	3.86	.85	-1.027	1.827
	We adopt Partnering is a first choice	1	5	3.25	.97	-.170	-.115
	We adopt Partnering is a last resort	1	5	2.52	.91	-.004	-.364
	Alliances benefit our company	1	5	3.71	.98	-.911	.861
	Temporary alliance formation is easy for our company	1	5	3.55	.97	-1.008	.518
	Actively share intellectual property	1	5	2.94	.84	-.327	-.027
	Protect intellectual property	1	5	3.00	.97	-.216	-.562
	supply chain members are regarded as network associates	1	5	3.63	.98	-.587	-.121
	supply chain *are 'fixed' set of formal, long-term partners*	2	5	3.47	.87	.082	-.638
	We cooperate with our suppliers	1	5	3.15	.97	.130	-.920
	Suppliers part of product development	2	5	4.05	.71	-.446	.262
	We use cross functional customer teams	1	5	3.63	1.00	-.632	.056
	Alliances due to difficult conditions	1	5	3.26	1.10	-.348	-.539
Importance of partnering and alliances	Interaction with competitors	1	5	2.69	1.14	.276	-.279
	Customer involvement	1	5	3.76	.98	-1.18	1.583
	Supplier integration	1	5	3.52	.91	-.872	.893
	Exchange of core competencies	1	5	2.98	.89	-.612	.171
	Alliances motivated by difficult operating conditions	1	5	2.99	.86	-.394	-.151
	Collaboration with complementary equals	1	5	3.07	.94	-.308	.306
	Computer-based data exchange with other companies	1	5	2.91	1.12	.051	-.463
	Knowledge sharing on design, engineering and manufacture	1	5	2.77	1.10	-.020	-.401
Leveraging the importance of people and technology	Employee autonomy over routine operations	2	5	3.49	.71	.019	-.200
	Team spirit among workers and departments	3	5	3.95	.63	.036	-.384
	Team-based performance	2	5	3.87	.72	-.511	.505
	Individual performance	2	5	3.69	.81	-.473	-.118
	Reward based on acquired competencies not seniority	1	5	3.55	.81	-.218	.239
	Employees' involvement in decision making	2	5	3.60	.78	.006	-.383
	Skills development and training	2	5	3.83	.79	-.468	.015
	Managing core skills and competencies	1	5	3.71	.77	-.578	.951
	Capture demand information immediately	2	5	3.53	.89	.060	-.695
	Prefer to keep information on file	1	5	2.73	.97	-.131	-.722
	Information accessible supply chain-wide	1	5	3.27	.96	-.285	-.126
	Intelligent interpretation of customer needs	2	5	3.93	.73	-.381	.097
compete ncies	Employees' knowledge and skills management	3	5	4.56	.63	-1.13	.208
	Concurrent or simultaneous conduct of operations	2	5	3.84	.79	-.107	-.618
	Effective adaptation of facilities and systems	1	5	3.78	.80	-.083	.081
	Networking for exchange of knowledge.	1	5	3.63	.84	-.206	.087
Competitive objectives	Product customisation (Engineer -to-order)	1	5	3.63	1.07	-.747	.317
	Flexibility (ability to deliver any quantity)	1	5	3.96	.874	-1.284	2.688
	Low cost	1	5	3.36	1.00	-.121	-.091
	Innovation	1	5	3.74	.97	-.589	.051
	Speed	2	5	3.91	.81	-.216	-.651
	Quality	3	5	4.41	.63	-.578	-.575
	Dependability (order fulfillment)	3	5	4.25	.76	-.460	-1.116
	Proactivity	2	5	4.00	.74	-.317	-.282
	Delivery (on time and on schedule) reliability	2	5	4.28	.71	-.655	-.060

The data presented in Table 5.5 also shows the perception of the surveyed organisations on the competitive objects that guide their operations. The competitive dimensions were assessed on a five point scale ranging from very low to very high. The mean and standard deviation of the responses are also shown in the same table. It can be inferred that quality is perceived as the highest competitive objective; equally the responding organisations indicated competing on cost is the least among the competitive objectives they were asked about. Indeed the result of the response shows that the competitive objectives were ranked as follows; Quality, delivery reliability, Dependability, Proactivity, Flexibility, Speed, Innovation, Customisation and Cost. However Customisation and cost have the highest deviations in the mean of the responses.

Within the cluster location attributes, four main factors were studied. These are Labour source, Transaction and transportation costs, Source of inputs and Information source. Three of the factors were measured on a 5-point Likert scale while Source of inputs was measured on an 11 point Likert scale that tried to capture the percentage of inputs sourced locally or outside the cluster. However, prior to subsequent analysis, the variable measured on an 11 point Likert scale was re-corded to a 5 point scale. The three factors that were assessed on a 5-point Likert scale were, Source of information, Source of labour, and Transaction and transportation cost. Of the three factors that were measured on the 5-likert scale, the survey revealed source of information to be the highest factor that was derived from the cluster. After Source of information, Transaction and transaction cost advantage was perceived as the next benefit derived from being in the cluster. Finally, source of labour and source of inputs were respectively judged as of less importance, suggesting that being in proximity does not confer any advantage in those two factors. The finding that being in proximity is important as a source of information is instructive because past studies asserted that advancement in communication technologies renders face-to-face communication less important and that virtual integration (Carrie, 2000; Pawar and Sharifi, 2000; Tolone, 2000) will supplant the need for geographic concentration of industry (Colotla et al., 2003). Indeed Belussi and Arcangeli (1998, 426) point to the importance of proximity by stating that “While it is true that face-to-face communication will be partially substituted by multimedia technologies, the existence of tacit knowledge (dispersed among firms and manpower) will still require physical proximity.” Perhaps the importance of the cluster as a source of information reported from this study could be due to the need for solutions rather than standard one off products within the oil and gas industry.

Demographic characteristics of respondents

Descriptive statistics were used to analyse the distribution of the demographic and socio-economic characteristics of the response to the survey. In Table 5.6 some basic demographic characteristics of the survey respondents are depicted including Size of organisations measured by number of employees, Designation of respondents, Size of organisations by turnover (in terms of million's of pounds), Production Process flow and Principal Business Sectors of the respondents to the survey. Examination of the result in Table 5.6 reveals that the survey is representative in terms of size, production process employed and the designation of respondents. Additionally, the industries to which the respondents belong as revealed by the principal business sectors of Table 5.6, supports the view that the oil and gas industry supply chain is served by organisations from diverse industrial sectors.

A detailed account of the demographic characteristics of the respondents enumerated above will be given in the following sections.

5.3.4.1 Designation

The designation of the respondents to the survey is depicted in Table 5.6. A significant problem with organisational-level research is that senior and executive level managers receive many requests to participate; additionally these are the people who have very limited time due to tight schedules. Nevertheless, among the respondents, heads of organisation, i.e. those with the designation of MD, CEO and Director constitute the majority at 57% of the respondents. Supply chain managers and Procurement/Purchasing managers each constitute 19% of the respondents. Within this study the most sought after respondents were the CEOs; where the CEOs were indisposed then supply chain managers sufficed. The feeling in the study is that the key information solicited in the study is held by top managers, as they possess better overview of the issues that the study hopes to address.

5.3.4.2 Size of company

Size of company was indicated by number of employees in the company as well as the total turnover reported by the survey respondents. In Table 5.6 the two indicators of company size and related demographic characteristics of the survey respondents are shown. It can be observed from table that out of the sample respondents about 42% of the organisations have 50 or fewer employees while about 17% of the organisations

have more than 2000 workers. About 8% have a workforce in the range of 201 to 500 employees.

Table 5.6: Demographic characteristics of respondents

Total number of respondents = 95	**Frequency**	**Percentage (%)**
Size by number of employees		
Up to 50	40	42.1
51 - 200	16	16.8
201 - 500	8	8.5
501 - 2000	15	15.8
Above 2000	16	16.8
Designation of respondents		
MD, CEO, Director	54	56.8
Supply chain Manager/Director	18	18.9
Procurement/Purchasing Manager	18	18.9
Others	5	5.3
Company annual turnover (£ million)		
Up to 10	41	43.2
11-50	16	16.8
51-100	6	6.3
101-500	15	15.8
501-1,000	7	7.4
Above 1,000	10	10.5
Production process		
Project	46	48.4
Jobbing	5	5.3
Batch	8	8.4
Mass production	5	5.3
Continuous production	11	11.6
Two or more processes	20	21.1
Principal business sectors		
Exploration and production	26	27.4
Consultancy	6	6.3
Marine and allied Transport services	2	2.1
Engineering services and Offshore Construction	15	15.8
Computer and communication equipment	4	4.2
Supply and rental of equipment	1	1.1
Automotive and automotive accessories	2	2.1
Electrical and electronic products	2	2.1
Food, drink and chemical and products	17	17.9
Industrial, Hospital and Agric products	4	4.2
Any other	16	16.8

Thus, the spectrum of the respondents to the survey cut across large companies, as well as small and medium size enterprises (SMEs), but the majority of the respondents to the survey are SMEs or organisations with a number of employees less than 500. This is in

line with an earlier study of the oil industry by Cumbers et al, (2003) where they found 75% of respondents to their survey of the Aberdeen oil and gas industry to be SMEs.

Furthermore, Table 5.6 describes size by annual turnover of the organisations that responded to the survey. The table shows that there are six categories of the company annual turnover. As the table depicts, the largest category of the firms (about 43%) are small and medium enterprises with turnover of less than 10 million pounds. However there are large and very large organisations, with turnovers of 500 million and over 1,000 million respectively that responded to the survey as well. The company size in terms of number of employees and turnover, as shown in Table 5.6, indicates that a significant percentage (over 40%) of the respondents to the survey are small and medium scale enterprises (Porter, 2003; McCann, 2006).

5.3.4.3 Production process

Table 5.6 shows the following production processes as dominant among the respondents: Project, Jobbing, Batch, Mass production and Continuous production. Equally, a number of organisations utilise a combination of two or more production process in their organisation, signifying that a number of respondents have a wide range of capabilities in their bid to supply the requirements of the industry for highly customised products to meet individual customer requirements. The table indicates that Project set up is the dominant production process, constituting 48%. The next production process most used by the responding organisations is combination of production processes whereby an organisation utilises Batch production as well as Project set up or a similar combination of processes. Finally Jobbing and Mass production are the least used production processes.

The overall pattern of production process reported from this study conforms with the pattern of the production process of engineer-to-order manufacturing reported by Hicks et al. (2000) who found Project as well as Jobbing to be the dominant process capabilities of organisations involved with complex products and systems.

5.3.4.4 Business sectors of respondents

Table 5.6 also summarises the companies in terms of the principal business sectors in which the respondents were involved. A major characteristic of sample respondents is that organisations in the exploration and production sector are the most represented at 27%. This is followed companies operating in food, drink and chemical products at

about 18%. Additionally, organisations involved with engineering services and construction constitute about 16%. There are also several organisations that are undertaking activities not classified under the business sectors reported in the table, thus underscoring the extensively subcontracted nature of the oil and gas industry, which draws companies from varied industrial backgrounds to meet its demand for goods and services. This reinforces the assertion that the oil and gas industry is a nexus of companies from diverse industrial sectors (Bower and Young, 1995; Crabtree et al., 1997; Crabtree et al., 2000). It is instructive that within the category of respondents with two or more processes, four respondents had more three processes flows, while of the four organisations with three process flows, all had project process flows among the three processes within the organisation. Two organisations stated the following process flow: Project, Jobbing and Batch, while the other two stated Project, Batch, Continuous as well as Project, Mass production, Continuous respectively. Sixteen organisations reported that two process flows were used within their organisation. Among the organisations with two process flows, six reported: Project and Jobbing, while four others reported Project and Batch process flows. Another four organisations reported Batch and Continuous as their process flows.

5.3.5 Identified sources and forms of networking within industrial clusters

It has been observed that industrial clusters confer benefits from scale economy and efficiency arising from the geographic concentration of firms in an industry (McCann, 2006). Furthermore, it is contended that networking among the members of an industrial cluster is high and depending on the level of the networking existing, there will be enhanced business performance. Recognising the importance of networking Colotla et al.(2001) argue that networked companies may derive competitive advantage through the mobility of either or all of the following: product/process between plants; or from managerial skill to accelerate acquisition of valuable skills such as knowledge or culture. Competitive advantage may also be expressed in terms of operational performance dimensions such as cost, quality, dependability, flexibility, and innovation. However efficiency consideration within organisations often leads to the need to address the inherent trade–off of integration as well as the requirement for responsiveness. Porter (2004) referred to the factor conditions focussing on competitive advantage stemming from the economic, social and natural resources available to a given location. This could be manifested in the firm with access to low cost labour, proximity to markets as well as use of local technological resources. In this respect the

sources of information within the cluster firms were assessed by requesting respondents to rate the importance of the following five sources of information: Trade press, Conference/fairs, Internet, Business press and Informal contact. The result of the response is as follows:

5.3.5.1 Labour market pooling

Firms need to access qualified and specialized workforce to manage and operate the activities of the organisation. The appropriate workforce can be recruited from diverse sources, which include institutions that are almost exclusively for the training for manpower, as well as other firms. According to Lublinski (2003), labour market pooling is among the most important advantages of being in clusters. This is because cluster based firms may access good quality labour at low recruitment and training costs as well as access the pool of specialized and experienced skills and labour force that is present in all clusters (Porter, 1994; Porter and Solvell, 1999; McCann, 2006). The availability of manpower means that when workers are made redundant in one firm they are easily absorbed by other local firms possibly in a different industry (Lublinski, 2003). Thus, in this study, firms were asked to evaluate the degree of importance of the following six sources of labour: universities, other firms, Competitors, Suppliers, Customers, or Headhunting. These sources of labour were derived from a study by Lublinski (2003) of the impact of proximity of clustered and non-clustered German aeronautic firms.

Using a five point likert scale ranging from 1 (very high importance) to 5 (very low importance) organisations were asked to assess the degree of importance of the above six sources of labour to themselves. Figures 5.7 to 5.12 present the results of the assessment of the above six factors as sources of labour. Specifically Figure 5.7 shows that competitors were perceived as being of moderate to high importance as a source of labour. Equally, Figure 5.8 depicts proximate universities as highly important sources of labour for the surveyed firms. Sourcing for labour from universities and competitors could be due to the need to access innovative products and solutions by organisations within the industry, such that people with potential to come with new culture are targeted. Generally, Figures 5.7 and 5.8 display a similar trend by which there is a high level of sourcing of labour from competitors and universities respectively. However Figure 5.9 shows moderate to low sourcing of labour from other firms. Here, Other firms are those in which, due to downturn in an organisation, workers are made redundant in one firm; on the other hand they may be absorbed by other local firms,

because business shocks are not necessarily correlated between firms. The bad times in one firm, in which people are fired, may coincide with the good times in other local firms, in which people are hired. Thus, there is a clear incentive for both firms and workers to move into clusters. Therefore, sourcing from other firms as shown in Figure 5.9, follows a different trend from the other two sources of labour, that is, Competitors and Universities. The reason for the lower intake from "other firms" could be due to the specialised nature of the oil and gas industry, which makes it not cost effective to recruit from other firms.

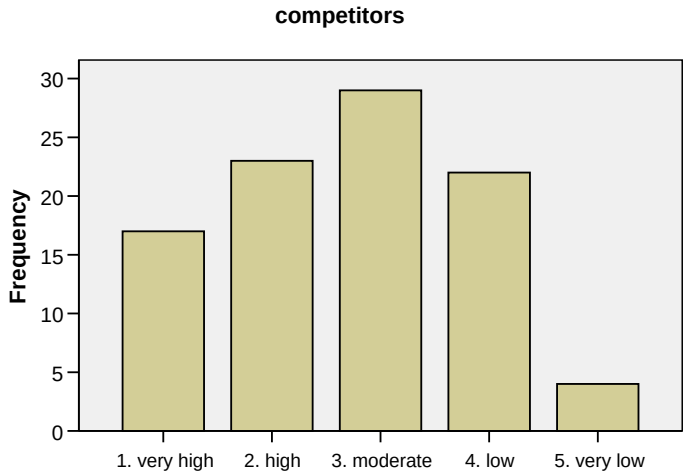

Figure 5.7: Competitors as source of labour for promixate organisations

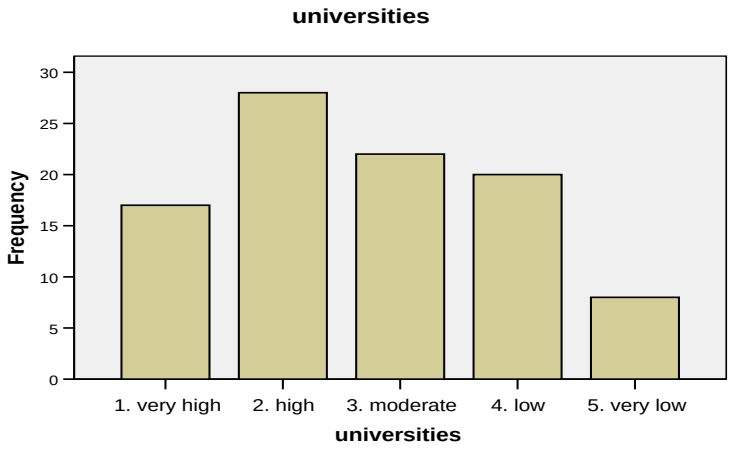

Figure 5.8: Proximate universities as sources of labour for organisation

Figure 5.9: Other firms as source of labour

In line with the above six sources of labour enumerated, the effort by organisations to source for labour is also indicated by the amount of labour sourced from suppliers as well as customers. Figures 5.10 and 5.11 show the result of the extent of sourcing for labour from cluster based suppliers and customers respectively. The two figures indicate that the respondents have a moderate level of sourcing of staff from suppliers as shown in Figure 5.10; on the other hand there is a high tendency for sourcing for labour from customers as Figure 5.11 shows.

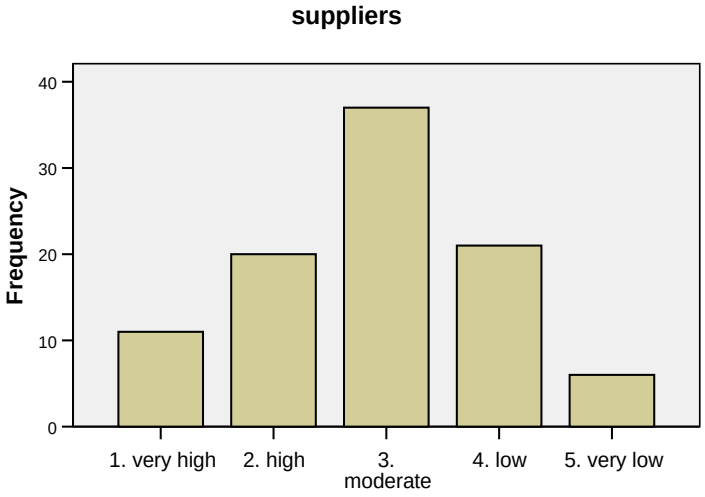

Figure 5.10: Suppliers as source of labour

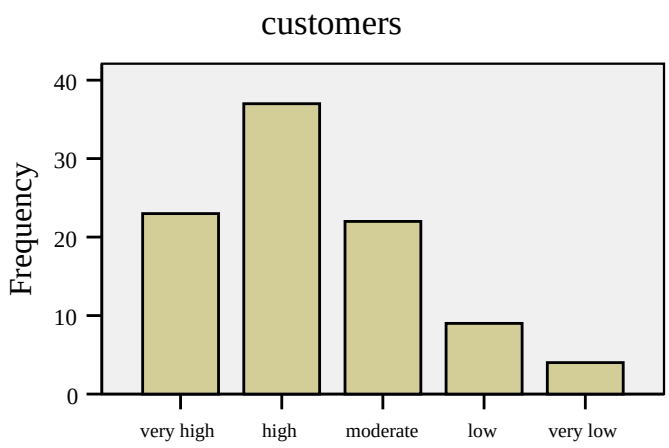

Figure 5.11: Customers as source of labour

Finally, headhunting workforce from proximate firms generally provided a high source of labour within the firms surveyed, as depicted in Figure 5.12. Report on manpower needs of the industry point to the acute shortage of experienced, quality and specialized manpower within the industry. Thus, the increased pressure for manpower could be the reason that firms resort to headhunting to acquire critical manpower needs. Equally, for firms within the cluster, the high level of labour sourcing through headhunting in a way expresses the perceived danger, felt by organisations, of their staff being headhunted by potential competitors in close proximity. So in a way this expresses the negative effects of being in a cluster.

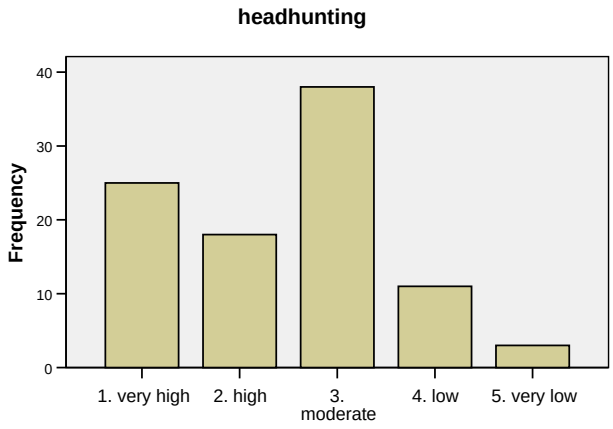

Figure 5.12: Headhunting for labour from whichever sources

There is the presumption that within the cluster, firms could access information through a number of sources. Equally information sources can be used either solely or in combination. Table 5.5 provides insight into the sources of information that are prevalent among the organisations within the UK North Sea oil and gas supply chain. It is indicative from Table 5.5 that informal contact is the most widely used source of information among the surveyed organisations. Informal contact source of information is deemed to be the highest among the five sources of information since it posted the highest mean of 3.98 out of the sources. Furthermore the data on the sources of information was segregated into the cluster and non-cluster based organisations and it was found that both categories stated that informal contacts was the main source of information, but the cluster-based response at 4.01 mean was higher than the non cluster-based at 3.80, thus signifying that between the categories of respondents – that is cluster and non-cluster based – the cluster based respondents use informal contact as a source of information more than the non-cluster based organisations.

5.4 Inferential statistics

In order to increase our understanding of pertinent factors associated with the subject of agility and the impact of industrial clusters on agility, business performance and competitive objectives correlation analysis was carried out to test and explore the relationship between the factors investigated. Also regression analysis was carried out to establish cause effect relationships between factors and combinations of factors. Correlation and regression are related but they serve different purposes. Correlation measures the strength of relationships between variables with the strength of the relationship represented measured by the Pearson's correlation coefficient denoted as *r,* while regression in contrast determines the form of the relationship which correlation established, by predicting/estimating the value of one variable (termed the dependent variable) based on a given value of the independent variable.

In order to present the result of the statistical tests in a structured pattern firstly the results of correlation analysis will be presented, followed by the results of the regression analysis. Included in the regression analysis is the assessment of the conceptual model using a structure equation model (SEM). SEM was used to undertake path analysis of the conceptual model which was presented in Figure 4.1 of Chapter 4.

Correlation Analysis

Correlation coefficient is a statistical measure of the extent to which two variables are associated (or vary together). The coefficient of correlation denoted by the letter *r* ranges from -1 to +1 with the value signifying the strength of the relationship while the sign (- or +) indicates the direction of association. Thus a value of correlation coefficient close to -1 or +1 denotes strong negative or positive association respectively which in practical terms it connotes indirect or direct linear relationship respectively between the variables. Correlation, however, does not enable the manipulation of the research variables to allow causal analysis of relationship between the variables. Indeed the existence of a correlation does not prove causality but it denotes a necessary precondition for it. On the other hand, the absence of correlation demonstrates that no causality is present, hence precluding the need for undertaking regression analysis.

5.4.1 Correlation analysis of the main research constructs

To explore the relationship between agility attributes and competitive objectives, bivariate correlation analysis of the dimensions of agile supply chains and the nine capabilities defining competitive objectives was carried out (see Appendix 1 for the questionnaire containing agility dimensions, cluster attributes, competitive objectives and business performance). This hypothesis tests the validity of the most basic assertion underpinning agility, which is that it is needed to be able to compete in a business environment that is characterised by dynamic change and uncertainty. Indeed, some researchers contend that agile supply chains is the dominant competitive tool that is capable of supplanting the sub optimisation of prior systems such as mass production and lean manufacturing. In order to test the impact of agility as a competitive tool as well as its effect on business performance, companies' individual scores on agility attributes, clusters and location issues, competitive objectives and business performance measures were aggregated and tested for correlation. The result of the correlation analysis is shown in Table 5.7. The correlation is between aggregate agility attributes, industrial cluster factors, competitive objectives, business performance and distinctive competence. It is apparent from the correlation coefficients that there is a significant correlation between agility attributes and industrial clusters, competitive objectives, business performance and distinctive competence. However, there is a non significant correlation between the industrial clusters factors and competitive objectives as well as business performance. Similarly being in industrial cluster does not lead to any significant impact on distinctive competencies as revealed by the correlation

analysis in Table 5.7. This result is instructive in that the literature on clusters contends that there are productivity gains as result of being in clusters and industrial districts. Indeed, a number of case studies (Patti, 2006; DeWitt et al., 2006) point to the cost reduction and responsiveness derived from the cluster effect. However, although the result from this study shows that being in clusters correlates with agility attributes, indicating that being in clusters enhances the agility of the supply chain, there is no correlation between clusters and competitive objectives as well as business performance. Further statistical analysis will be carried out between the two variables.

Table 5.7: Correlations between main constructs of the study

	Agility attributes	Cluster factors	Competitive Priorities	Business Performance	Distinctive competence
Aggregate agility attributes	1				
Industrial cluster factors	**0.216***	1			
Aggregate Competitive priorities	**0.551****	NS	1		
Aggregate Business performance	**0.407****	NS	**0.270****	1	
Distinctive competence	**0.374****	NS	**0.268****	**0.284****	1
*Significance at 5% level indicated by *, at 1% level by *****					

The analysis carried out in Table 5.8 is based on the partitioning of the data into two; the first set representing the respondents based in Aberdeen, with the second consisting of those based in Yorkshire. The Aberdeen group proxies the cluster based response, while the Yorkshire group is indicative of non-cluster based respondents. As seen from the result of the analysis, the cluster based organisations felt that being in clusters enhances the agility of their organisations, as shown by the strong positive correlation coefficient between the agility attributes and the industrial cluster factors. Equally, there is strong positive correlation between agility attributes and competitive objectives and business performance. However, for the Yorkshire based firms (that is non-cluster based); there is a non significant correlation between the agility attributes and industrial clusters. Nevertheless, the non-cluster based respondents posted a strong positive correlation between agility attributes and competitive objectives as well as business performance. In comparing the strength of the correlations between the cluster based and the non cluster-based firms, it is apparent that the strength of the correlations

between the agility attributes and competitive objectives for the non-cluster based respondents is greater than the correlation coefficient between agility attributes and business performance.

Table 5.8: Correlation coefficients for cluster and non-cluster based respondents

Location of company		Aggregate Agility attributes	Industrial cluster factors	Aggregate Competitive Priorities	Aggregate Business Performance
Aberdeen (Cluster based) N=55	Aggregate agility attributes	1			
	Industrial cluster factors	**0.440****	1		
	Aggregate Competitive priorities	**0.407****	-0.068 (ns)	1	
	Aggregate Business performance	**0.439****	0.123 (ns)	0.184 (ns)	1
Yorkshire (Non-cluster based) N=40	Aggregate agility attributes	1			
	Industrial cluster factors	0.030 (ns)	1		
	Aggregate Competitive priorities	**0.693****	-0.001 (ns)	1	
	Aggregate Business performance	**0.383***	-0.073 (ns)	**0.378***	1
*Significance at 5% level indicated by *, at 1% level by **, ns=not significant*					

Table 5.9 shows the correlations between the four agility dimensions and business performance, competitive objectives and industrial clusters. In the correlation analysis the aim was to test for the relationship between competitive agility attributes and competitive basis and performance with the four dimensions of agility rather than the composite score of the dimensions. Equally relationships between the clusters and location issues were tested with the four agility dimensions.

From Table 5.9 it is apparent that the highest level of correlation was recorded between customer sensitivity (that is enriching the customer) and leveraging the impact of people and information. A more detailed account of the relations between agility dimensions and business performance indices are shown in Table 5.13.

Table 5.9: Correlations of agility to competitive business performance

	Business performance	Competitive objectives	Industrial cluster factors	Distinctive competence
Enriching the customer	**0.355****	**0.417****	ns	**0.308****
Cooperating to compete	**0.236***	ns	**0.397****	**0.214***
Mastering change and uncertainty	**0.284****	**0.534****	ns	**0.259***
Leveraging the impact of people and information	**0.335****	**0.523****	**0.229***	**0.333****
*Significance at 5% level indicated by *, at 1% level by **, ns = not significant*				

Aggregate location was used in a correlation analysis with business performance. The result of the correlation analysis shows that there is no relationship between aggregate location issues with business performance. However when four of the constituent location issues were correlated with performance, a positive significant correlation was found between sources of labour and financial performance of turnover and net profit at 0.33 (0.001) and 0.23 (0.02). Although from the table it is apparent that agility attributes correlate with the competitive objectives and business performance, we will need to know what dominant characteristics of each of the dimensions of the agility are responsible for the correlation. Hence, Table 5.9 shows the correlation coefficients of the dimensions of agility. It is apparent from the table that Process integration has the highest correlation at 0.534 (*p<0.01)* to Competitive objectives. This is followed by leveraging the impact of people and technology at 0.523 (*p<0.01) and* finally customer sensitivity at 0.417 (*p<0.01).* However, and surprisingly, Network Integration is not significantly correlated to competitive objectives but is significantly correlated to business performance at 0.236 *(p<0.021).*

The results of the relationships reported above denote that, in an organisation that is integrated with its supply chain -both upstream and downstream of the organisation - there would not be any enhancement in its competitiveness in terms of cost, speed, flexibility or responsiveness with respect to its rivals in any way whatsoever. However, for the organisation, being integrated with its supply chain will lead to better business performance.

After computing the mean scores of the questionnaire items and computation of distribution and correlation statistics that were presented in Tables 5.1-5.7, in the

following section inferential statistical analysis will be used in testing the six hypotheses proposed. The six hypotheses are restated as follows:

Hypothesis 1a: There is high level of diffusion of dimensions of agile supply chains into oil and gas clusters.

Hypothesis 1b: There is a strong relationship between cluster location attributes and level of adoption of agility dimensions. The null hypothesis states there is no significant difference between implementation of agility by cluster and non-cluster based organisations.

Hypothesis 2: Agility dimensions can lead to enhanced attainment of competitive objectives. Thus agility dimension is positively related to competitive objectives

Hypothesis 3: Being in clusters is related to the attainment of competitive objectives

Hypothesis 4: Agility dimension is related to business performance

Hypothesis 5: Being in clusters is related to business performance

Hypothesis 6: Attainment of competitive objectives is related to business performance

5.4.1.1 Adoption and diffusion of dimensions of agile supply chain into oil and gas industrial cluster

Extant literature argued that adoption of the four main dimensions of agility impacts on the speed, flexibility and responsiveness of an organisation. Although most of the past studies have looked at agile manufacturing (CRINE Network, 1999), a number of studies have tried to point to the applicability of agility as a supply chain wide operations strategy (Barlow, 2000; Davies, 1999). However a cursory study of the earlier works revealed that none of the prior studies have attempted to empirically test the impact of the four dimensions of agility espoused by the earlier proponents (Goldman et al., 1995) on competitiveness and business performance, as well as assess the extent of the adoption of agility attributes within an established industry cluster. Indeed Vazquez-Bustelo et al (2007) state that there is paucity of empirical studies on agility generally and this researcher has yet to see any studies on agility within the oil and gas industry. Furthermore there are as yet no studies on impact of being in clusters on agility, apart from the following studies that chararcterised supply chains within industrial districts (Carbonara et al., 2002) as well inventory management within industrial districts (Carbonara et al., 2001) and supply chain cooperation within

industrial districts (Albino et al., 2007). Additionally it is evident from prior study on agility that most empirical research was carried out on the discrete manufacturing industry, with the automotive sector accounting for most of the studies.

Therefore, this study set out to test systematically the level of implementation of the dimensions of agility empirically, with the aim of determining the attributes of the four dimensions of agility that impact on overall responsiveness of organisations. The data was sourced from the oil and gas industry with the aim of documenting agility implementation in an industry other than discrete manufacture generally and automotive specifically. Moreover, early researchers on the subject of agility such as van Hoek et al (2001) contend that agility implementation will have industry based as well as regional specifics that need exploration. Equally, the study also assessed the impact of being in industrial clusters on the agility of a supply chain. The result from the survey is as shown in Table 5.10. As Table 5.10 shows, there are different levels of adoption of the dimensions of agile supply chains. The table indicates the percentage adoption of customer enrichment, cooperating to compete, mastering change and uncertainty, leveraging the impact of people and information, perception of being in an industrial cluster and the impact of strategic distinctive competence on the responsiveness of the surveyed organisations. Equally, the perceived emerging core competencies for effective and responsive operations in light of the need for agility are also reported. It can be deduced from the table that most of the organisations consider all the agility dimensions to be of very high importance to their responsiveness, as shown by the percentage of respondents within this category, ranging between 63-76%. However, most of the organisations expressed that being located in an industry cluster is of moderate importance to their responsiveness. Consistent with the high percentage of respondents attaching very high importance to Customer sensitivity; Customer enriching attributes are manifested in the form of incorporating the changing customer needs into design and development of products, even as the project progresses. Accordingly, an organisation that is customer sensitive will be willing to accept the changes in customer specifications, take them on board and incorporate them into the design and production of the product. For a project set up this is a very difficult situation because with progress of the project incorporating any subsequent changes or change in specification tends to be difficult, due to the potential disruption in the scope of the project that the change in specification normally entails. This adds to overall cost and tends to prolong the lead time of project completion.

Furthermore, the data in Table 5.10 shows the level of adoption of cooperating to compete (network integration) dimension of agility within the surveyed firms. As the table shows 63 percent of the firms indicated high and very high adoption of the Cooperating to compete dimension of agility. It is interesting to note that, although cooperating to compete is the least adopted among the attributes, none of the firms indicated that they have very low adoption of the attribute of network integration. The respondents also indicated adoption of process integration and leveraging impact of people and information at about 68% and 71% respectively. Overall, it is apparent from the responses that there is a very high adoption of agility within the oil and gas supply chains.

The emerging core competencies in support of agility that impacts on effective and responsive operations are also indicated in Table 5.10. The core competencies include employees' knowledge and skills; networking for exchange of knowledge; adaptable facilities and systems; and concurrent engineering of operations. The extent and perceived importance of the core competencies indicates that employee knowledge and skills is rated the most important by 93% of the respondents. Networking for exchange of knowledge and concurrent engineering are next in importance as 66% of the respondents indicated. The trend of the extent of diffusion of agility within the oil and gas cluster as shown in Table 5.10 is consistent with the assertion by McCullen and Towill (2001; 532) that agility is achieved through a "…highly skilled, knowledgeable and empowered workforce…" Thus the high percentage of perceived impact of agility attributes and attendant core competencies on effective and responsive operations indicate the level of implementation of agility within the studied industrial cluster. However and ironically there is some perception, indicated by 24% of the respondents, that being located in a cluster in close geographic proximity to the supply chain does not account for enhanced effectiveness and responsive operations. The context of the respondents that perceived low influence of being in clusters on their operations can be explained by an earlier study of the oil and gas industry (Hallwood, 1991b). In that study Hallwood (1991) found that geographic proximity of is contingent on the area of activity of the organisations. For example, organisations connected to operational activities such as Drilling or Oil well data collection considered proximity to be essential, while firms in data analysis, tools manufacture or structure construction thought it was not necessary to be located in close proximity to their customers the oil companies.

Table 5.10: Diffusion of agility inn industrial clusters within oil and gas supply chains

Factors	Percentage of respondents stating factor adoption is (%):		
	Low - Very Low	Moderate	High - Very high
Customer enrichment/sensitivity	2	12	76
Cooperating to compete(Network integration)	6	31	63
Master change and uncertainty (process integrations)	2	30	68
Leveraging the impact of people and information	2	27	71
Distinctive competence	5	28	67
Being in cluster or industrial district	24	46	30
Emerging core competencies			
Networking for exchange of knowledge	6	38	66
Adaptable facilities and systems	1	39	60
Concurrent engineering of operations	3	31	66
Employees knowledge and skills	0	7	93

In light of the above account of implementation of agile supply chain attributes in the oil and gas industrial cluster, it can be stated that there is high diffusion of agility attributes within the industrial cluster.

5.4.1.2 Relationship between cluster locations and dimensions of agile supply chain

However in order to elucidate the adoption and implementation further a robust statistical analysis through One way analysis of variance (ANOVA) was carried out to assess the difference between the cluster based and non-cluster based respondents. The ANOVA test result validates the result in Table 5.10 by indicating whether there is significant difference between the implementation between the implementation of the agility attributes between the different groups of respondents. In order to perform the statistical analysis the data was partitioned into three groups. The three groups are cluster based, non-cluster based and multinational corporations (MNC). The MNC group was created out of the cluster based respondents. This third group constitute respondents whose activities span many locations and impact their host location in terms of the improved productivity and spillover effects. To test the null hypothesis that there is no significant difference in implementation of agility attributes between the three groups of respondents a One-way ANOVA was used, where cluster location attributes is the dependent variable while agility attributes and the corresponding emergent distinctive core competencies constitute the independent variables. The result of One-way ANOVA test is depicted in Table 5.11. At a probability (p) of significance of 0.001 which is less than 0.05, the null hypothesis stated above is therefore rejected.

Thus, the result of the one-way ANOVA reveals that differences are evident between the three groups in the implementation of agility attributes, $F(2,92) = 7.706$, $p<.05$.

In order to determine the nature of the difference between the three groups, a review of Table 5.12, which is the result of the Tukey post-hoc tests, is necessary. To compute the Tukey HSD multiple comparisons, for every variable being tested for significant difference, contrast statistics are computed equal to the number of sub-samples. As shown in Table 5.12 the first 2 columns are the variables. Contrasts values and their standard errors are reported in columns 3 and 4 respectively. This is followed by their probability (p) of significance in column 5 and column 6 partitioned into two shows the upper and lower bound of the confidence interval. Accordingly, a review of the Tukey post-hoc tests reveal that the difference in implementation of agility attributes lies between Aberdeen and Yorkshire as well between Multi National Corporations (MNC) and Yorkshire, with respondents based in Aberdeen and MNCs having higher levels of implementation of agility attributes than those based in Yorkshire.

Table 5.11: One-way ANOVA results for agility attribute: Leveraging the impact of people and information

	Sum of Squares	df	Mean Squares	F	Sig.
Between groups	9.026	2	4.513	8.317	.000
Within groups	49.921	92	.543		
Total	58.947	94			

Table 5.12: Tukey HSD multiple comparisons for agility attribute

Cluster (I)	Cluster (J)	Mean difference (I-J)	Std. Error	Sig.	95% Confidence interval	
					Lower Bound	Upper Bound
Aberdeen	Yorkshire	.553*	.167	.004	.16	.95
	MNC	-.147	.220	.781	-.67	.38
Yorkshire	Aberdeen	-.553*	.167	.004	-.95	-.16
	MNC	-.700*	.219	.005	-1.22	-.18
MNC	Aberdeen	.147	.220	.781	-.38	.67
	Yorkshire	.700*	.219	.005	.18	1.22
*. The mean difference is significant at the 0.05 level						

Within the ANOVA statistical test procedure of the SPSS, there is a provision that generates a mean scores plot. For example, a plot of the mean scores for agility dimension of leveraging the impact of people and information for the groups of cluster

location attributes was generated as shown in Figure 5.13. The groups based on which the plot was generated comprise Aberdeen, MNC Aberdeen and Yorkshire. As revealed in the figure, it is evident that the Aberdeen based respondents have the highest mean score, while Yorkshire corporations posted the lowest score on the agility dimension.

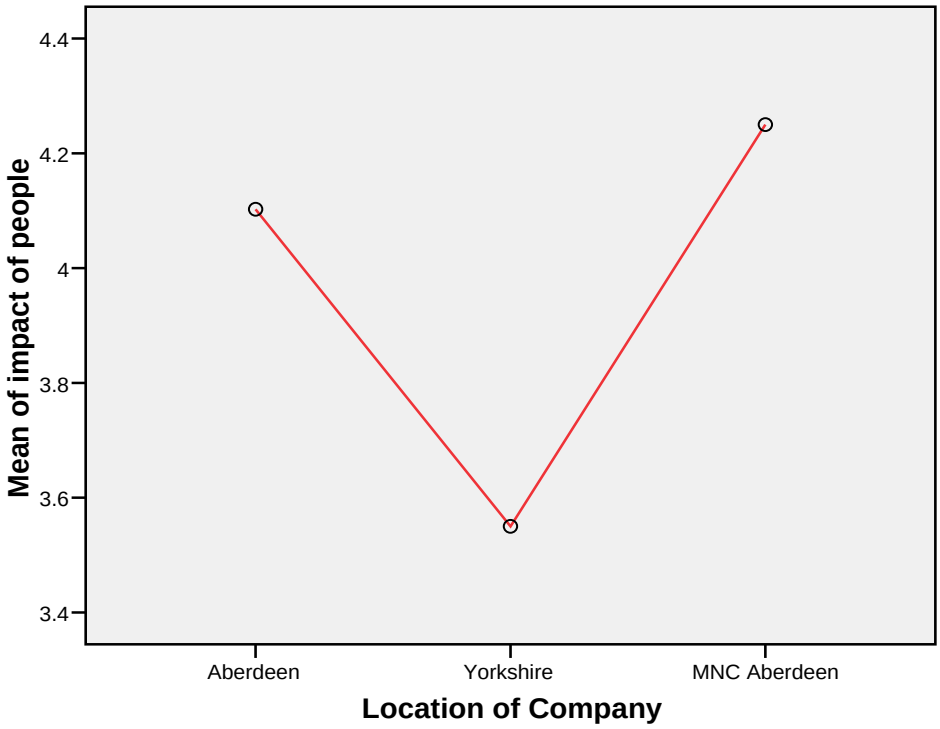

Figure 5.13: ANOVA mean scores plot of differences in leveraging the impact of people

In light of the results of the frequency analysis of Table 5.7 it was revealed that there is high level of implementation of the dimensions of agile supply chains. Additionally the one-way ANOVA and Tukey multiple comparisons tests of robust statistics depicted in Tables 5.8 and 5.9 show that there is a significant difference between the cluster based and non-cluster based respondents in terms of the implementation of the agility attributes. This led to the conclusion that the null hypothesis that there is no significant difference between the different groups of respondents is rejected. Finally Figure 5.13 depicts the distribution of the mean scores on the agility attribute between the three groups of respondents demonstrating the significant difference between the three groups.

5.4.1.3 Relationship between agile supply chain attributes and business performance

In order to validate hypothesis 2, correlation analysis of the dimensions of agile supply chain attributes and business performance was carried out. In assessing the perceived correlation between agility attributes with business performance SPSS bivariate correlation analysis was performed between the two variables. The result of the analysis depicted in Table 5.13 indicates that only three of the agility attributes correlates with business performance. The agility attributes that posted significant relationships with business performance were cooperating to compete, mastering change and uncertainty and Leveraging the impact of people and information. On the other hand none of the correlations between enriching the customer and business performance were significant and so are not reported here.

The result of the analysis reported in Table 5.13 shows that cooperation posted a significant correlation with turnover only, as all the correlations with the other four business performance measures were non-significant. On the other hand, Leveraging the impact of people and information displayed a positive strong correlation with all the business performance measures, with the strongest correlation being with customer loyalty based on repeat orders at *0.339 p<1%,* followed by performance relative to competitors while the least significant correlation was with turnover. The next attribute to post remarkable correlation with business performance, after leveraging the impact of people and information, is mastering change and uncertainty. As seen in Table 5.13, Mastering change and uncertainty also posted a positive significant correlation with all the business performance indices. Unlike Leveraging the impact of people and information, Mastering change and uncertainty posted a strong positive correlation with the financial business performance of turnover, followed by the market based performance measures of customer loyalty and performance relative to competitors.

The correlation perspective presented in Table 5.13 highlights the apparent influence of dimensions of agile supply chains on business performance measures generally. However, specifically it goes to show that agile supply chains have a significant influence on business performance and competitive objectives of the respondents to the study. Moreover, specifically it can be seen that the agility dimension of Cooperating to compete, mastering change and uncertainty, and leveraging the impact of people and information all have positive effect on business performance. On the other hand customer enrichment posted no significant correlation with any of the business

performance measures. Additionally, Leveraging the impact of people and information posted the highest correlation with customer loyalty, while with a correlation of about 31% master change and uncertainty posted the next highest correlation with turnover. Finally, of the total 11 significant positive correlations between the three agility dimensions and five business performance factors, Mastering change and uncertainty posted the lowest correlation coefficient with business performance attribute of market share.

Table 5.13: Correlations between aggregate agility dimension and business performance

	Turnover	Net profit	Market share	Customer loyalty	Performance relative to competitors
Cooperating to compete	**0.223** (0.044)**	ns			
Mastering change and uncertainty	**0.309*** (0.005)**	**0.214* (0.054)**	0.**184* (0.098)**	**0.292*** (0.008)**	**0.287*** (0.009)**
Leveraging people and information	**0.229** (0.038)**	**0.254** (0.021)**	**0.238** (0.031)**	**0.339*** (0.002)**	**0.284** (0.010)**
Significance at 10% level indicated by, 5% level indicated by **, at 1% level by ****					

The following section assesses in detail correlations between the characteristics of dimensions of agility and five business performance indices. The aim of giving the detailed account of the relationships between the variables is to illustrate and deepen the understanding of the relationship between the two variables at a particular rather than aggregate level. This is because the four dimensions of agility (such as enriching the customer etc) will offer little in the form of guidance to Managers and Practitioners that are interested in attainment of agility in their supply chain and its attendant influence on competitiveness and business performance. In other words, if organisations are interested in enhancing financial or marketing growth, what specific variable of the agility dimension do they need to focus on? The analysis given in the following section will attempt to answer the preceding question by highlighting the relationships between the variables of the four dimensions of agility and business performance.

5.4.1.4 Assessing the relationship between the factors of each of the dimensions of agility and business performance

In a dynamic business environment in which non-price based competition dominates competitive basis tends to change from cost based factors to attribute based factors such as quality advantages and factors that enhance customer delight. Thus, for those types of

market situations, an organisation focuses on quality and enriching the customer in an effort to create more value for the customer enhances its competitiveness. Creating customer value is one of the dimensions of agile supply chains, and a correlation analysis was carried out to determine the impact of creating customer value on business performance.

The correlation coefficients between business performance and the agility dimension of enriching the customer are presented in Table 5.14. In the questionnaire, there were nineteen variables that were used to elicit perception about the attribute (shown in Appendix 1). From Table 5.14 it can be seen that among the attributes of enriching the customer, ten out of the nineteen variables have a significant correlation with aspects of business performance. Of the ten attributes that are significantly correlated to business performance, the highest correlation of about 34% is recorded between *Reconfigurable products* and *Market share*. This means that organisations that possess the ability to deliver reconfigurable products could have an increased market share through encroachment on the market of competitors. Equally and expectedly, ability to provide reconfigurable products has a significant correlation with customer loyalty based on repeat orders and performance relative to competitors. Thus, this result indicates that being able to provide reconfigurable products correlates significantly with the non-financial performance measures rather than financial measures of net profit or turnover. This denotes that ability to provide reconfigurable products leads to enhanced competitiveness rather than financial performance. Similarly, of the fourteen variables used to measure the Customer enrichment dimension of agile supply chain, the ten variables that recorded significant correlation to business performance are: Customer satisfaction focus, ontime delivery, Stock availability focus, Customization of products, Providing standard products, Fast delivery of products, Increase customer value, Value-added products and Reconfigurable products.

Table 5.14: Correlation coefficient of enriching the customer with business performance

	Turnover	Net profit	Market share	Customer loyalty	Performance relative to competitors
Customer satisfaction focus	NS			**0.266*** (0.009)**	NS
Ontime delivery	0.211 (0.057)*		**0.242 (0.028)****	**0.222 (0.045)****	**0.251 (0.023)****
Stock availability focus			.198 (.075)*		
Customization of products	NS	0.207 (0.062)*	0.203 (0.067)*	NS	0.191 (0.086)*
Providing standard products	NS	**0.232 (0.036)****	**0.222 (0.045)****	NS	
Fast delivery of products	NS		**0.272 (0.013)****	NS	
Increase customer value	NS			0.217 (0.050)*	NS
Customer relationships	NS	0.201 (0.070)*	NS	0.190 (0.087)*	**0.230 (0.038)****
Value added products	NS	0.205 (0.064)*	NS		
Reconfigurable products	0.207 (0.062)*	NS	**0.337 (0.002)*****	**0.285 (0.009)*****	**0.314 (0.004)*****
*Significance at 10% level indicated by *, at 5% level indicated by **, at 1% level by ******					

It is instructive that both customization of products and providing standard products were significantly correlated to customer enrichment. This is due to the fact that customization and standardisation of products are contending variables in the customer enriching dimension. This means that organisations could be competing on the mass production paradigm; whereby organisations would want to provide standard products, with cost being the competitive focus, or organisations could adopt customer enrichment through the provision mass customisation of products or service in line with customer needs aimed at attaining higher customer satisfaction. Thus, in the case of mass customisation attaining customer delight is the competitive objective. This result, in which both the contending competitive objectives are at play, point to the diversity of competitive focus of members of the oil and gas supply chain whereby some firms supply standard products while others supply more customised products and services. A study of the organisational arrangement of the UK oil and gas industry by Finch (2002; 72) found that the industry place "an emphasis on rent-seeking contracting rather than value-creating activities" such that oil Operators seek for "commodities rather than specialised and bespoke solutions from services companies" (Finch 2002; 72).

Accordingly there is industry initiatives targeted at standardisation of processes and technologies in line with such a way of thinking. Thus initiatives have been launched for standard well designs, drilling solutions, contracts, and assessments of components suppliers and services suppliers (Finch, 2002).

Table 5.15 shows the correlation coefficient and relationships between leveraging the impact of people and information and business performance. From the table it is apparent that of the 40 correlations between the variables, 18 of the variables have significant positive correlations between leveraging the impact of people and information and business performance. Of the variables that correlated with business performance, capture demand recorded positive significant correlations with all the variables of business performance. The correlations between capture demand and business performance are as follows: 0.411, 0.377, 0.328, 0.324 and 0.323 with performance relative to competitors, Net profit, Market share, Customer loyalty and Turnover respectively. Additionally, of all the business performance variables, Performance relative to competitors recorded significant positive correlations with all the variables of the agility attribute of Leveraging the impact of people and information.

Table 5.15: Leveraging the impact of people and information with business performance

	Turnover	Net profit	Market share	Customer loyalty	Performance relative to competitors
Team spirit	NS			**0.258** (0.019)**	**0.245** (0.027)**
Team-based performance	**NS**			**0.255** (0.021)**	**0.275** (0.012)**
Reward based on competencies	NS			0.190* (0.087)	**0.223** (0.044)**
Involvement in decision making	NS			**0.278 (0.011)****	**0.301*** (0.006)**
Managing core competencies	NS				**0.228** (0.039)**
Capture demand information	**0.323*** (0.003)**	**0.377*** (0.000)**	**0.328*** (0.003)**	**0.324*** (0.003)**	**0.411*** (0.000)**
Information accessible	NS				**0.275** (0.012)**
Intelligent interpretation of customer needs	NS	**0.218** (0.049)**	NS	**0.258** (0.019)**	**0.269** (0.015)**
*Significance at 10% level indicated by *, at 5% level by **, at 1% level by ******					

Table 5.16 reports the correlations between cooperating to compete and business performance. The strongest significant correlation at about 42% was recorded between

Turnover and Organised along functions and department. The next highest correlation for business performance of Turnover was recorded with Rewards based on individual performance. Furthermore, Alliances and Supply chains as network associates were all perceived to have influence on Turnover. On the other hand, Net profit correlates only with Organised along functional lines. The result of the relationships between financial business performance and agility dimension of Cooperating to compete posted a lower level of correlation than that between market based non-financial indices. This is in line with the general perception that cooperative relations within and across organisations takes time and needs to be nurtured. For example, it can be seen from Table 5.16 that when Supply chains are considered as long term partners, this leads to Enhanced customer loyalty a with correlation coefficient of 0.389. This could be due to the fact that more time is dedicated to creating the right product to meet the customer requirement such that customer delight is achieved in the product or service. This customer delight then translates into repeat orders. This finding corroborates an earlier study (Swafford et al., 2006b) in which it was found that supplier relations enable improved responsiveness and customer satisfaction.

Table 5.16: Correlations of cooperating to compete and business performance

	Turnover	Net profit	Market share	Customer loyalty	Performance relative to competitors
Organised along functional lines	**0.415*** (0.000)**	**0.198 (0.075)***			**0.199 (0.073)***
Organised along business processes				**0.186 (0.094)***	
Reward based on team performance				**0.222 (0.045)****	**0.254 (0.022)****
Reward based on individual performance	**0.246 (0.026)** ***		**0.280 (0.011)****		
Information available enterprise wide					**0.272** (0.013)**
Information difficult to find					**-0.192 (0.084)***
Matrix project team			**0.209* (0.060)**		**0.270 (0.014)****
Partnering is first choice				**0.255 (0.021)****	**0.206 (0.063)***
Supply chains as network associates	**0.215 (0.052)***		**0.193 (0.082)**		
Supply chains as long-term partners				**0.389*** (.000)**	
Use cross-functional customer teams			**0.315*** (0.004)**	**0.317*** (.004)**	**0.276 (0.012)****
Alliances due to difficult operating conditions	**0.226 (0.041)** ***	0.183 (ns)	**0.274 (0.013)****		**0.187 (0.092)***
*Significance at 10% level indicated by *, at 5% level indicated by **, at 1% level by ****					

Also, using cross-customer teams leads to enhancing all the marketing performance indices of Market share, Customer loyalty and Performance relative competitors. This supports the hypothesis that acquiring the agility attribute of Cooperating to compete enhances Business performance.

Table 5.17**:** Correlation of mastering change and uncertainty with business performance

	Turnover	Net profit	Market Share	Customer loyalty	Performance relative to competitors
Rapid Decision making				**0.212* (0.039)**	**0.279** (0.006)**
Encourage risk taking			**0.318* (0.002)**	**0.285** (0.005)**	**0.414** (0.000)**
Discourage risk taking			**-0.295** (0.004)**	**0.225* (0.029)**	**-0.305** (0.003)**
Take initiatives					**0.204* (0.048)**
Encourage innovation	**0.331** (0.001)**	**0.315** (0.002)**	**.287** (0.005)**	**.314** (0.002)**	**0.320** (0.002)**
Proactive response			**.226* (0.028)**	**.255* (0.013)**	**0.273** (0.007)**
Rapid response to customer changes	0.**227* (0.027)**				**0.255* (0.013)**
*Significance at 10% level indicated by *, at 5% level indicated by **, at 1% level by ******					

5.4.1.5 Assessing relationship between agile supply chain attributes and competitive objectives

In order to validate hypothesis 2 a bivariate correlation analysis between the main dimensions of agility and competitive objectives was carried out. The results of the bivariate correlation analysis between the two variables are presented in six tables (Tables 5.18-5.23). These report only the result of significant correlation coefficients at the 10%, 5% and 1% levels of significance between the two variables. The data shown in the six tables can be summarised as follows:

Table 5.18 shows the result of the correlations between the principal dimensions of agility and the competitive objectives, while Tables 5.19 -5.23 gives a detailed analysis of correlations of the characteristics of each of the principal dimensions of agility, given in Table 5.18 and their corresponding correlations with individual competitive objectives.

Table 5.18 shows that all the four dimensions of agility registered some level of positive significant correlation with all the competitive objectives except customisation. This means that the surveyed organisations do not perceive customisation as a competitive tool that will enable them to outperform their rivals. This finding is ironic in that the UK oil and gas industry has been perceived as an industry that requires a high level of innovation, especially due to the need to produce from the deep offshore fields (Bower

and Young, 1995; Crabtree et al., 2000; Cumbers et al., 2003). Clearly, the findings from this research point to less incidence of customisation within the industry, to such an extent that ability to deliver customised products is not perceived as a competitive advantage. Indeed, in Table 5.19 it can be seen that the result of correlation coefficient between customisation and providing standard products is significant negative correlation. This means that where the need for standard products is high, there is low level of customisation and vice versa. This goes to show that there is high preference for standard products within the industry rather than customised products. This finding is in line with the current drive within the industry for cost reduction occasioned by government and industry, in which product standardisation is encouraged by using standard products to build modules for oil and gas production platforms (CRINE Network, 1999).

Customer enrichment posted the highest significant positive correlation with dependability and delivery, followed by proactivity and flexibility. Cooperating to compete correlates positively with Quality, Proactivity and Speed. Mastering change and uncertainty posted the highest correlation with Innovation and Speed followed by Quality and Proactivity. Finally, Leveraging the impact of people and information posted significant positive correlation with Innovation and Speed, followed by Quality and Proactivity. Among the four dimensions of agility, Mastering change and uncertainty posted the highest correlation followed by Leveraging the impact of people and information.

From Table 5.18, it is apparent that an organisation that masters change and uncertainty can derive the competitive advantage of innovation, competing on time through speed as well as being proactive. Similarly the organisation is considered to have delivery reliability as well as competing without compromising on quality. Moreover, the organisations surveyed considered a significant level of dependability as a competitive advantage.

Table 5.18: Correlations coefficient of agility dimensions and competitive objectives

	Customer enrichment	Cooperation	Master change and uncertainty	Impact of people and information
Delivery	**0.289*** (0.009)**	**0.211* (0.057)**	**0.270** (0.014)**	
Proactivity	**0.233** (0.044)**	**0.279** (0.011)**	**0.289*** (0.008)**	**0.239** (0.030)**
Dependability	**0.291*** (0.008)**		**0.184* (0.098)**	
Quality		**0.284* (0.040)**	**0.321*** (0.003)**	**0.233** (0.035)**
Flexibility	**0.230** (0.038)**			
Cost	**0.203* (0.067)**			
Innovation		**0.262** (0.017)**	**0.487*** (0.000)**	**0.433*** (0.000)**
Speed	**0.234** (0.034)**	**0.269** (0.015)**	**0.439*** (0.000)**	**0.356*** (0.001)**
*Significance at 10% level indicated by *, at 5% level indicated by **, at 1% level by ****				

Tables 5.19 and 5.20 present a detailed analysis of the relationships between two of the dimensions of agility and the Competitive objective. This is aimed at identifying the factor within each of the agility dimensions that has the most impact on the speed and flexibility. As shown in Table 5.19, enriching the customer by adding value posted significant correlations with the following Competitive objectives: Speed, Quality, Innovation, Dependability, Delivery reliability and Proactivity.

The correlation coefficients indicate significant positive correlations between the Competitive objective of Speed and agility dimension of Enriching the customer variables of: Increase customer value through customer driven products as well as being flexible to customer needs. This shows that ability to compete on speed is contingent on customer relationships, as the positive correlation coefficient between Speed and customer relationship focus shows.

Table 5.20 shows the correlations between the agility dimension of Leveraging the impact of people and information with Competitive objectives. The main conclusion to draw from this analysis is that all the Competitive objectives posted significant positive correlations with most of the variables of this agility dimension. In particular it is interesting that ability to capture demand information quickly enhances speed of response. Furthermore, the two variables of ability to capture demand and managing core competencies correlate positively with all the Competitive objectives. Equally, Training enhances Delivery, Proactivity, Cost reduction and Flexibility.

Table 5.19: Correlations coefficient of agility dimension of customer enriching the customer and competitive objectives

	Customisation	Flexibility	Cost	Speed	Innovation	Quality	Dependability	Proactivity	Delivery
Customer satisfaction focus		0.206* (0.063)		0.201* (0.070)			**0.352*** (0.001)**	**0.233** (0.035)**	**0.254** (0.021)**
Measure customer satisfaction						0.194* (0.081)	**0.229** (0.039)**		
Ontime delivery					0.204* (0.066)		**0.346*** (0.001)**		**0.376*** (0.001)**
Flexible to customer needs		**0.399*** (0.000)**	**0.305*** (0.005)**	**0.383*** (0.000)**			**0.245** (0.026)**		**0.247** (0.025)**
Providing standard products	**-0.303*** (0.002)**								
Customer driven products	**0.297*** (0.007)**	**0.369*** (0.001)**	0.213* (0.055)	**0.232** (0.036)**		**0.275** (0.012)**			
Fast delivery of products		**0.257** (0.020)**		0.208* (0.060)	**0.217** (0.050)**				
Increase customer value		0.188* (0.092)	0.191* (0.086)	**0.385*** (0.000)**	**0.318*** (0.004)**	**0.341*** (0.002)**	**0.290*** (0.008)**	**0.247** (0.025)**	**0.255** (0.021)**
Customer relationships		0.185* (0.096)		**0.315*** (0.004)**	0.185* (0.096)	0.197* (0.076)	**0.222** (0.045)**	**0.327*** (0.003)**	**0.223** (0.044)**
Value added products						**0.241** (0.029)**		0.205* (0.065)	
*Significance at 10% level indicated by *, at 5% level indicated by **, at 1% level indicated by ****									

Table 5.20: Correlations coefficient of agility dimension of leveraging the impact of people and information with competitive objectives

	Flexibility	Cost	Speed	Innovation	Quality	Dependability	Proactivity	Delivery
Autonomy						**0.234** (.035)**		
Team spirit	0.201* (0.071)	0.195* (0.079)	0.208)* (0.061		**0.231** (0.037)**	**0.261** (0.018)**		
Team-based performance	**0.288*** (0.009)**	**0.269** (0.015)**	**0.276** (0.012)**			0.193* (0.083)	**0.266** (0.016)**	
Individual performance		0.207* (0.062)			0.187* (0.097)		**0.226** (0.041)**	0.194* (0.080)
Reward based on competencies						**0.235** (0.022)**	**0.237** (0.032)**	**0.287*** (0.009)**
Involvement in decision making			0.231* (0.055)	0.271** (0.014)	**0.245** (0.026)**	0.209* (0.060)	0.183* (0.100)	**0.225** (0.043)**
Training	**0.256** (0.020)**	**0.360*** (0.001)**	0.194* (0.081)		**0.262** (0.017)**	**0.287*** (0.009)**	**0.350*** (0.001)**	**0.376*** (0.000)**
Managing core competencies	**0.255** (0.021)**	0.216* (0.052)	**0.253** (0.022)**	**0.285*** (0.009)**	0.203* (0.067)	0.201* (0.070)	**0.397*** (0.000)**	**0.327*** (0.003)**
Capture demand	**0.312 *** (0.004)**	**0.246 ** (0.026)**	**0.443*** (0.000)**	0.195* (0.080)	**0.290*** (0.008)**	**0.248** (0.025)**	**0.326*** (0.003)**	**0.378*** (0.000)**
Information accessible				**0.195* (0.079)**	**0.227** (0.040)**			
Intelligent interpretation of customer needs		0.201* (0.069)	**0.207* (0.062)**	**0.428*** (0.000)**	**0.217* (0.050)**	**0.255** (0.021)**	**0.274** (0.013)**	**0.380*** (0.000)**
*Significance at 10% level indicated by *, at 5% level indicated by **, at 1% level indicated by ****								

Table 5.21: Correlations coefficient of agility dimension of mastering change and uncertainty with competitive objectives

	Customisation	Flexibility	Cost	Speed	Innovation	Quality	Dependability	Proactivity	Delivery
Concurrency for rapid decision making				**0.279*** (0.006)**			**0.230** (0.025)**		
Encourage risk taking					**0.245** (0.027)**		**0.292*** (0.004)**	**0.268** (0.015)**	
Discourage risk taking					**-0.222 (0.045)****		**-0.236** (0.022)**	**-0.290*** (0.008)**	
Take initiatives		**0.248** (0.025)**	**0.364*** (0.001)**	**0.296*** (0.007)**			**0.276*** (0.009)**		**0.232** (0.024)**
Encourage innovation		**0.375*** (0.001)**		**0.457*** (0.000)**	**0.662*** (0.000)**	**0.304 (0.005)*****	0.201* (0.071)	**0.389*** (0.000)**	**0.262** (0.017)**
Proactive response		**0.250** (0.024)**	0.209* (0.059)	**0.231** (0.037)**	**0.355*** (0.001)**			**0.345*** (0.001)**	**0.280** (0.011)**
New supplier process		**0.206* (0.063)**	**0.207* (0.062)**	**0.382*** (0.000)**	**0.280** (0.011)**	**0.290 (0.008)*****	**0.268** (0.015)**	**0.216* (0.051)**	**0.301*** (0.006)**
Organisational boundaries non existent					**0.245** (0.026)**				
Rapid response to customer changes	**0.342*** (0.002)**	**0.261** (0.018)**			**0.301*** (0.006)**	**0.297 (0.007)*****			
Productivity and quality measures of operations		**0.334*** (0.002)**				**0.311 (0.004)*****	**0.253** (0.022)**		0.212 (0.056)*
Broad based measures of capability used					0.207* (0.062)	**0.203* (0.067)**	**0.239** (0.031)**	**0.249** (0.024)**	**0.241** (0.029)**
*Significance at 10% level indicated by *, at 5% level indicated by **, at 1% level indicated by ******									

Table 5.22: Correlations coefficient of agility dimension of cooperation to enhance competitiveness with competitive objectives

	Customisation	Flexibility	Cost	Speed	Innovation	Quality	Dependability	Proactivity	Delivery
Organised along functions and departments				**0.255** (0.021)**					
Organised along business processes					**0.255** (0.012)**			**0.209** (0.042)**	
Reward based on team performance		**0.310*** (0.005)**							
Reward based on individual performance	**-0.382*** (0.000)**							**0.195*. (0.058)**	
Information available enterprise wide		**0.204** (0.047))**				**0.277** (0.012)**			
Information difficult to find				**-0.304** (0.003)**		**-0.244* (0.017)**	**-0.341** (0.001)**		
Matrix project team					**0.228** (0.026)**				
Partnering is first choice			**0.225** (0.029)**		**0.219** (0.033)**				
Partnering is a last resort		**-0.377*** (0.000)**							
Alliance benefits our company							**-0.286*** (0.009)**		**-0.257** (0.016)**
Easy for my company to form temporary alliances				**-0.240** (0.019)**		**-0.217** (0.035)**	**-0.249** (0.015)**		**-0.276*** (0.007)**
Supplier involvement in NPD				**0.225** (0.042)**		**0.237** (0.032)**	**0.236** (0.033)**	**0.234** (0.035)**	**0.204** (0.048)**
Use cross-functional customer teams				**0.246** (0.026)**		**0.245** (0.026)**		**0.225* (0.042)**	**0.209** (0.042)**
Alliances due to difficult operating conditions					**0.237** (0.013)**			**0.331*** (0.002)**	
*Significance at 10% level indicated by *, at 5% level indicated by **, at 1% level indicated by ******									

Table 5.23: Correlations of alliances with competitive objectives

Variable	Customisation	Cost	Innovation	Speed	Dependability
Interaction with competitors		**-0.221* (0.032)**		**-0.259* (0.011)**	**-0.292** (0.004)**
Customer involvement	**0.270** (0.008)**		**0.292** (0.004)**		
Exchange core competencies					**-0.245* (0.017)**
Alliances due to difficult operating conditions				**-0.232* (0.024)**	**-0.225* (0.028)**
Collaboration with complementary equals			**0.279** (0.006)**		
*Significance at 5% level indicated by *, at 1% level indicated by ** *					

The following section will discuss the relationships between the cluster location factors and agile supply chain attributes with the aim of ascertaining the impact of being in clusters on the agility of a supply chain.

5.4.1.6 Testing for the relationships between cluster characteristics and agility attributes

In a bid to determine and enhance the agility of organisations it is postulated that location is an antecedent of agile supply chains. The proposition is based on the idea that being in industrial clusters will lead to enhanced agility of an organisation. Subsequently the consequence of the enhanced agility of an organisation will be indicated in terms of business performance and competitive objectives. Thus, this section will attempt to verify the proposition linking clusters with agility of a supply chain.

However in testing this hypothesis, first a t-test was carried out to determine if there is a difference between the cluster based and the non cluster based firms in terms of the attributes that are measured. Thus, a systematic assessment of the equality of variance was carried out. Table 5.24 shows the result of the t-test of the business performance and competitive objectives between the cluster based and non-cluster based firms. The results of the T-test for all the variables is placed in Appendix 3. Account of the result shown in Table 5.24 will be given as follows:

Turnover: T = 1.553, $p < 0.10$. This is significant at the 10% level. Hence, it can be stated that there is a difference in terms of the turnover between the cluster based and non-cluster based firms.

Net profit: T = 2.136, $p = 0.372$. Thus, with a probability level more than 10% it indicates that there is a non significant difference in variance between the clusters based and non -cluster based firms. Hence, there is no difference in net profit between the cluster and non-cluster based respondents.

The other three variables constituting business performance, that is, Market share, Customer loyalty based on repeat orders and Performance relative to competitors all report values of probability greater than 10% level and hence there is no significant difference in variances between the cluster based and the non - cluster based firms. Accordingly it is only the turnover that showed significant difference between the cluster and non-cluster based organisations. The result of the t-test for Competitive objectives also shown in Table 5.24, indicates that only cost and dependability were considered to be of significance as a competitive weapon by the respondents. Incidentally, in both situations it is the non-cluster based firms that reported these two as of moderate to high importance. This could be due to the fact that for the cluster based firms Quality, Delivery reliability and Dependability and Proactivity are the most important, but none of these four variables significantly differ from the non-cluster based organisations.

Table 5.24: T-test of business performance and competitive objectives

Effect	Proximate M	Proximate SD	Distance M	Distance SD	t-value	P-Value
Business performance						
Turnover	4.15	0 .803	3.85	1.051	1.553	**0.051**
Net profit	4.02	1.009	3.58	0.984	2.136	0.372
Market share	3.49	0.742	3.78	0.768	-1.816	0.799
Customer loyalty	3.55	0.789	3.65	0.700	-0.668	0.353
Performance relative to competitors	3.69	0.791	3.85	0.770	-0.979	0.329
Competitive objectives						
Effect	Proximate M	Proximate SD	Distance M	Distance SD	t-value	P-Value
Customisation	3.49	1.169	3.83	0.903	-1.571	0.135
Flexibility	3.91	0.928	4.30	0.800	-0.636	0.526
Cost	3.20	1.026	3.58	0.931	**-1.829**	**0.067**
Innovation	3.87	0.883	3.55	1.061	1.615	0.110
Speed	3.93	0.790	3.90	0.841	0.776	0.872
Quality	4.38	0.593	4.45	0.677	-0.521	0.604
Dependability	4.13	0.771	4.43	0.712	**-1.918**	**0.055**
Proactivity	4.04	0.693	3.95	0.815	0.557	0.579
Delivery	4.20	0.704	4.40	0.709	-1.363	0.176

The rest of this section will present the results of correlation analysis carried out in order to test the hypothesis that there is a relationship between industrial cluster dimensions and agile supply chain attributes. Tables 5.25-5.39 show the correlations established between the dimensions of the two constructs.

A correlation analysis of agility attributes of Leveraging the impact of people and information and Transaction and transportation cost was carried out to test for significant relationships between the two variables. Table 5.25 reports the results of significant correlation coefficients between the two variables; cluster factor of Sources of labour and agility dimension of Cooperating to compete. Tables 5.26 and 5.27 show the correlations between Alliances with Sources of labour. Table 5.25 shows that Labour sourcing through Head-hunting correlates with Reward based on individual performance. This indicates that organisations that recruit through Head-hunting could end up with less internal cooperation due to preference for individual work rather than team based performance. Equally, head-hunting indicates a negative effect with external cooperation with the supply chain, as well as suppliers involved with new product development.

Table 5.25: Correlations of sources of labour and cooperating to compete

	Universities	Competitors	Other firms	Suppliers	Customers	Head-hunting
Organised along departments	**0.280** (0.006)**				**0.204* (0.047)**	
Organised along business processes				**0.212* (0.039)**		
Reward based on individual performance	**0.274** (0.007)**				**0.253* (0.013)**	**0.308** (0.002)**
Information hard to find	**0.225* (0.028)**					
Projects run in a matrix teams		**0.291** (0.004)**	**0.268** (0.009)**			
Benefits from forming alliances					**0.229* (0.026)**	
We easily enter into alliance		**0.240* (0.019)**				
Alliances due to difficulty			**0.311** (0.002)**		**0.228* (0.026)**	
Share intellectual property (IP)				**0.219* (0.033)**		
We protect Int. property (IP)	**0.296** (0.004)**				**0.205* (0.046)**	
Supply chain are 'fixed' partners						**-0.253* (0.013)**
Suppliers involved in NPD						**-0.210* (0.041)**
*Significance at 5% level indicated by *, at 1% level by *****						

Table 5.26: Correlations of alliances and source of labour in clusters

	Universities	Competitors	Other firms	Suppliers	Customers
Interaction with competitors		**0.327** (0.001)**			
Supplier integration				**0.247* (0.016)**	
Exchange of core competencies	**0.249* (0.015)**	**0.279** (0.006)**	**0.297** (0.003)**		**0.376** (0.000)**
Collaboration with complementary equals		**0.360** (0.000)**		**0.420** (0.000)**	
Computer-based data exchange with other companies				**0.258* (0.012)**	
Knowledge sharing on design, engineering and manufacture	**0.325** (0.001)**	**0.340** (0.001)**	**0.237* (0.021)**		
*Significance at 5% level indicated by *, at 1% level by *****					

Table 5.27: Correlations of alliances and sources of inputs in clusters

	Basic Inputs	Specialist inputs
Supplier integration	**0.287** (0.005)**	
Alliances motivated by difficult operating conditions	**0.318** (0.002)**	**0.357** (0.000)**
Collaboration with complementary equals	**0.284** (0.005)**	**0.203* (0.049)**
Computer-based data exchange with other companies	**0.212* (0.039)**	**0.243* (0.018)**
Knowledge sharing on design, engineering and manufacture	**0.247* (0.016)**	**0.260* (0.011)**
*Significance at 5% level indicated by *, at 1% level by *****		

Table 5.28: Correlations of alliances and sources of information in cluster based firms.

	Business press	Internet
Alliances motivated by change drivers		**-0.283** (0.005)**
Collaboration with complementary equals	**0.282** (0.006)**	
*Significance at 5% level indicated by *, at 1% level by *****		

Table 5.28 shows the correlations of partnering and alliances and sources of information in cluster based firms. However, only two of the variables correlated. Among the correlated variables, Alliances motivated by environmental change drivers had a significant ($p<.01$) negative correlation with Sourcing for information on the internet. Collaboration with complementary equals has a significant ($p<.01$) positive correlation with sourcing of information from business press. For both of these established relationships the correlation coefficient is weak at 0.28.

Table 5.29: Correlations of mastering change and uncertainty with source of labour

	Universities	Other firms	Suppliers	Customers	Head-hunting
Encourage environment of risk taking	**-0.204* (0.048)**				
People asked to think and take initiatives			**-0.259* (0.011)**		
Develop new supplier processes to follow market trends			**0.214* (0.038)**	**0.248* (0.015)**	
Our company respond rapidly to changes in product by customer		0.**256* (0.012)**			
Operations measured in terms of productivity and quality			0.**215* (0.036)**		
Integrated broad based set of measures of capabilities are used					**0.210* (0.041)**
*Significance at 5% level indicated by *, at 1% level by **					

Table 5.30 shows the correlations between ability to master change and uncertainty and particular sources of information from which firms derive information. It is apparent that proactive response in supplier networks has a significant positive correlation with sourcing information from the business press as well as informal contacts and the internet. What this indicates is that proactive organisations improve their ability to master change and uncertainty by paying attention to informal contacts within the industry and also focusing on the business press to glean information within the industry. This information can then be used to convert the perturbing influence of change and uncertainty on their activities and stay ahead of competitors.

Table 5.30: Correlations of mastering change and uncertainty and source of information

	Trade press	Conference/ Fairs	Business press	Internet	Informal contact
Concurrent conduct of operations facilitate rapid decision making	**-0.238* (0.020)**				**0.256* (0.012)**
People asked to think and take initiatives		**-0.242* (0.018)**		**0.229* (0.025)**	
Proactive response within supplier network to changing markets			**0.250* (0.015)**		**0.245* (0.017)**
Integrated broad based set of measures of capabilities are used			**0.244* (0.017)**		**0.224* (0.029)**
*Significance at 5% level indicated by *, at 1% level by ** *					

Correlations between sources of inputs and Mastering change and uncertainty are all non significant. Thus, sourcing of both basic and specialist inputs within clusters or industrial districts does not augment the capability of an organisation to attenuate the effect of change and uncertainty on an organisation.

Table 5.31: Correlations of sources of labour for organisations and leveraging the impact of people and information

	Universities	Other firms	Suppliers	Customers	Head-hunting
Rapid response to customer changes		**0.255* (0.013)**			
Productivity and quality are measures of operations		**0.215* (0.036)**	**0.260* (0.011)**		
Broad based measures of capability are used			**-0.241* (0.019)**	**0.230* (0.025)**	
Involvement in decision making	**0.230* (0.025)**			**0.237* (0.021)**	
Managing core competencies	**0.241* (0.019)**				
Capture demand information quickly		**0.225* (0.028)**	**0.221* (0.031)**		
Keep information on files		**-0.254* (0.013)**	**-0.239* (0.020)**		
Information accessible	**0.227* (0.027)**	**0.282** (0.006)**	**0.273** (0.007)**		**0.261* (0.011)**
*Significance at 5% level indicated by *, at 1% level by ** *					

Table 5.32: Correlations of sources of information for organisations and leveraging the impact of people and information

	Trade press	Conference /Fairs	Business press	Internet	Informal contact
Employee Autonomy over routine operations				0.**279** **(0.006)**	
Individual performance		**-0.209*** **(0.042)**			
Reward-based on acquired competencies	**-0.246*** **(0.016)**				**0.260*** **(0.011)**
Involvement in decision making			**0.307**** **(0.002)**		
Skills development and Training			**0.210*** **(0.042)**		
Managing core skills competencies			**0.322**** **(0.001)**		
Capture demand information immediately					**0.237*** **(0.021)**
Keep information on file					**-0.289**** **(0.005)**
Intelligent interpretation of Customer needs					**0.253*** **(0.013)**
*Significance at 5% level indicated by *, at 1% level by *****					

5.4.1.7 Assessing relationships between cluster attributes and attainment of competitive objectives

The argument for locating members of a supply chain in close geographic proximity, as in clusters, is the need to exploit intense interaction and communication that arises between as a result of the face-to-face contact between firms and other actors (Waxell and Malmberg, 2007) to enhance innovation and productivity (Patti, 2006; DeWitt et al., 2006). Thus, it is hypothesised that there will be positive relationships between cluster location attributes and competitiveness. Here competitiveness was operationalised by the nine competitive objectives of cost, quality, delivery, innovation, dependability, flexibility, customisation,speed and proactivity.

In order to test for this hypothesis, correlation analysis was carried out between industrial clusters and location attributes with competitive objectives. Two forms of correlations were carried out. The first was the correlations of the aggregate constructs shown in Tables 5.7 and 5.8, and the second was detailed correlations of the individual variables of the constructs. Accordingly, Tables 5.7 and 5.8 indicate that the correlations between aggregate cluster location attributes and competitive objectives are non-significant, though the direction of the correlation conforms with the theoretical

postulation that the when distance between the supply chain members is low competitiveness will be high. Equally, Table 5.8 shows the data divided between the cluster based and non-cluster based respondents and the test of hypothesis carried. The result from Table 5.8 corresponds with Table 5.7.

Further correlation analysis between the variables, location attributes of Sources of labour, inputs and information with Competitive objectives is shown in Table 5.33, while Table 5.34 also shows the result of the correlations between location factors of transportation and transaction costs with competitive objectives. It is apparent that there are various levels of interrelationships between competitive objectives and the sources of inputs, as well as transaction and transportation costs, as revealed by the two tables. For example Table 5.33 reveals negative effects between the sources of labour and some Competitive objectives. Whereas sourcing labour through Head-hunting and Customers posted negative significant correlations with Customisation and Cost respectively, a positive correlation was found between sourcing for labour from other firms and Quality capability.

Table 5.34 shows that overall, out of a 10 by 7 matrix of correlations, there were sixteen significant correlations. For example, being located to source of raw materials and characteristics of the location positively correlated with innovation. Equally, product customisation negatively correlated with economic factors and political stability characteristics of the location. Competing on cost negatively correlated with regulatory frameworks, political stability and being located close to suppliers. The highest number of correlations was recorded by dependability. It correlated negatively with regulatory frameworks, political stability, and location close to suppliers as well as competitors and parent company facilities. Furthermore characteristics of location have a positive and significant correlation with innovation and delivery reliability. This could be as a result of easy access to knowledge and information available to firms in a supply network (Cumbers et al., 2003; Lublinski, 2003) that enhances the innovative capability of the firms. Similarly, characteristics of location in terms of accessibility by customers and locations of suppliers and physical characteristics of the location (MacCarthy and Atthirawong, 2003) can enhance Delivery reliability.

Table 5.33: Correlations of labour, inputs and information with competitive objectives

		Customisation	Cost	Innovation	Quality	Dependability	Delivery
Labour	Universities					**-0.223* (0.030)**	
	Competitors		**-0.219* (0.033)**				
	Other firms				**0.203* (0.048)**		
	Customers		**-0.272** (0.008)**				
	Head-hunting	**-0.269** (0.008)**					
Inputs	Basic					**-0.267** (0.009)**	**-0.250* (0.014)**
	Specialist		**-0.205* (0.046)**			**-0.284** (0.005)**	**-0.270** (0.008)**
Information	Trade press				**0.212* (0.039)**		
	Conference/Fairs			**0.246* (0.016)**			
	Internet				**.234* (.023)**		
	Informal contact					**0.298** (0.003)**	
*Significance at 5% level indicated by *, at 1% level by **							

Table 5.34: Correlations transportation costs and competitive objectives

	Customisation	Flexibility	Cost	Innovation	Quality	Dependability	Delivery reliability
Raw materials				**.230* (.025)**			
Suppliers			**-0.206* (0.045)**			**-0.220* (0.033)**	
Parent company facilities		**-0.228* (0.026)**				**-.371** (.000)**	
Competitors						**-0.221* (0.032)**	
Quality of life					**0.273** (0.007)**		
Regulatory framework			**-0.260* (0.011)**			**-0.242* (0.018)**	
Economic factors	**-0.233* (0.023)**						
Political stability	**-0.253* (0.013)**		**-0.235* (0.022)**			**-0.261* (0.011)**	
Social and cultural factors					**.218* (.034)**		
Characteristics of location				**0.286** (0.005)**			**0.250* (0.015)**
*Significance at 5% level indicated by *, at 1% level by **							

5.4.1.8 Assessing correlations between clusters and location attributes with business performance

In order to test the impact of cluster and location attributes on business performance, a hypothesis was proposed that being in clusters and industrial districts leads to enhanced business performance, as the extant literature argues. In testing for this hypothesis, all the variables that constitute the cluster location attributes were correlated with the business performance and Tables 5.35 and 5.36 were used to validate this hypothesis. The two tables display the variables that returned significant correlations from the statistical analysis carried out.

Table 5.35: Correlations of source of information, labour and business performance

	Turnover	Net profit	Customer loyalty	Performance relative to competitors
Informal contact			**0.208* (0.043)**	
Universities	**0.250* (0.014)**	**0.262* (0.010)**		
Competitors	**0.249* (0.015)**			
Other firms	**0.268** (0.009)**			**0.212* (0.039)**
*Significance at 5% level indicated by *, at 1% level by ** *				

Table 5.36: Correlations between transportation and transaction costs with business performance

	Turnover	Net profit	Market share	Customer loyalty	Performance relative to competitors
Transportation cost	**-0.358** (0.000)**	**-0.208* (0.044)**		**-0.223* (0.030)**	**-0.226* (0.027)**
Suppliers		**0.239* (0.020)**			
Markets/customers					**-0.341** (0.001)**
Parent company facilities		**0.230* (0.025)**			
Competitors			**-0.207* (0.044)**	**-0.209* (0.042)**	
Regulatory framework	**0.208* (0.043)**	**0.259* (0.011)**			
*Significance at 5% level indicated by *, at 1% level by ** *					

Tables 5.35 and 5.36 show the correlations between the attributes of clusters and location and business performance. Table 5.35 shows the correlations between sources of information and labour with business performance. Overall, as seen from Table 5.35 there is an association between cluster location attributes of source of labour and information and business performance. It can also be inferred from Table 5.35 that where labour is sourced from universities, competitors and other firms, there is a significant positive correlation with turnover. On the other hand, as a source of information, informal contacts have a significant positive correlation with customer loyalty. While performance relative to competitors has a significant positive correlation with other firms as source of labour, however for the same source of labour there is no significant correlation with sourcing of labour from competitors. It can be inferred that

perhaps the respondents while completing the questionnaire, considered other firms to be representative of all the other options provided in the questionnaire, such as competitors, suppliers, customers and head hunting from other organisations.

In Table 5.36, Transportation and transaction costs were correlated with business performance. The results of the correlation analysis between the two variables indicate that there is high incidence of negative effect between the two variables. For example there is an inverse relationship between transportation cost and turnover, meaning that as the transportation costs increase turnover reduces and vice versa. Similarly, net profit posted a significant negative correlation with transportation cost. However, market share does not return a significant correlation with transportation cost, as all the other four variables have inverse relations with transportation cost. The direction of correlation between transportation costs and business performance supports the hypothesis that being in clusters can reduce operations cost.

5.5 Regression and path analysis of research constructs

Multiple regression analysis provides a simplified method for investigating relationships between several variables. It is also one of the most widely used statistical tools for analysing data composed of several factors. Regression analysis is among the multivariate statistical techniques used to test relationships between a single dependent and a set of independent variables. It is different from correlation analysis in that it provides prediction and explanation among research variables, thus assisting managers in making decisions concerning the variables that affect their activities the most.

There are three major types of multiple regression analysis; these are: standard regression, Simple/stepwise and hierarchical regression. The main difference between these regression analysis procedures is in the manner of specifying the entry of the variables in the regression equation. In the case of the standard regression, all the independent variables are entered into the equation simultaneously. For the simple regression model the researcher specifies the method of entry of variables into the regression model. For the simple regression procedure the researcher provides the software with a set of independent variables and the software determine the sequence of entering the variables. For the hierarchical regression, the researcher manually enters the variables into the regression. Normally, the pattern of entering the variables is dependent on the theoretical conceptualisation of the problem. Thus, the main difference between simple and hierarchical regression is that in the former, the pattern

of inputting the variables is dependent on the correlations between the variables, which in effect defines the strength of the variables and it is the strength of the variable that determines the entry into the regression analysis. Accordingly, a variable with a high correlation coefficient will enter first, before variables with a lower correlation. On the other hand, in hierarchical regression, the manner of entry of the variables into the regressions analysis is dependent on the model and entry into the regression is done manually, while in the simple regression the entry into the regression is accomplished by the software automatically.

The basic procedure of regression analysis involves computing a model of an estimate of the proposed relationship in a sample of data.

In the result of regression analysis, three things are the most important. These are:

1. The model summary

2. The table of coefficients and

3. The table of ANOVA

The fit of the model to the data is evaluated using summary statistics such as t, F and R^2. These variables are defined as follows:

β = is the slope of the regression line that approximates the data

t = is the t-test that is done to measure the difference between the variables in the study.

F = F-statistics measures of the ratio between the least squares of the numerator to the least square of the denominator.

R^2 = the proportion of variability which is explained by the regression equation.

Prior to undertaking multiple regression analysis there are a number of assumptions and criteria that needs to be met. As part of the requirement of multiple regression analysis there is the need for the variables to be of normal distribution and there should be no multicollinearity among the variables. Multicollinearity is the case in which there is high correlation between the variables in the regression model. The test for normality undertaken earlier in section 5.5 shows no significant departure from normality by the variables.

Agarwal et al. (2007) observed that in formulating strategies for building an agile supply chain, there is the need for management to understand the characteristics and interdependencies among the variables that enable and inhibit the attainment of agility within the supply chain. Accordingly, regression analysis of the main variables was carried out to determine the nature of relationships between the drivers of agility (which are the dependent variables in this case) and the independent variables, which are competitive bases and organisational performance. Sample results of the regression analysis are reported in Tables 5.37 and 5.38, while Table 5.39 shows the summarised result of the analysis on the Competitive objectives, Business performance as well as Cluster agility.

Prior to performing the regression analysis, the correlation matrix of the independent variables was verified. The results of the correlation coefficients between the pairs of variables were all very low, being less than 0.5. Thus, multicollinearity is not a problem in the regression analysis. A number of researchers have made suggestions with respect to multicollinearity. For example Tabachnick and Fidell (2007) suggest that for correlation with coefficients less than 0.7 there is no problem of multicollienarity in the regression analysis. They state that multicollinearity becomes a problem when there is correlation in the region of 0.7 to 0.9 between the variables. Additionally, it has been suggested that a stronger indicator of multicollinearity is high values of R^2 combined with statistically insignificant coefficients when all the independent variables are regressed against each other (Flynn and Flynn, 2004). Accordingly the two independent variables of agility attributes and industrial clusters were regressed against each other. The result of the regression analysis shown as follows: $R^2 = 0.047$, F statistics = 4.560 (0.035), $\beta = 0.216$, $t = 2.135$ (0.035) all being significant at the 5% level indicates that there is no multicollinearity in the data. Thus, the results of the regression analysis shown in Tables 5.37 and 5.38 suggest the absence of multicollinearity as none of the conditions stated by Flynn and Flynn (2004) are satisfied.

As the models in Tables 5.37 and 5.38 shows, there are hypothesised relationships between the agile supply chain attributes and industrial clusters on the competitiveness and performance of organisations. Hence, multiple regression analysis used to verify the model. The model is based on the premise that agile supply chains and industrial clusters are the exogenous variables which impact on the performance of organisations, with competitive objectives being an intervening variable that acts on the causal flow

between the two exogenous variables on the performance of organisations. Accordingly, simple regression was performed to test the relationships in the model.

The first model, shown in Table 5.37, is the regression analysis of agility attributes and business performance, while Table 5.38 is the regression model of the Agility dimensions, Competitive objectives and Business performance. Table 5.37 indicates that the characteristics of the regression model are as follows: $R^2 = 0.304$, while the F change is significant at the 1% level. Similarly regression analysis of Agility dimension and competitive objectives and Business performance was undertaken with the result of the analysis shown in Table 5.38. Table 5.38 shows that the R squared is 0.166, this means that competitive objectives account for 16.6 percent of changes in business performance. Whilst as Table 5.37 shows agility explains 30.4 percent variation in business performance.

Table 5.37: Model summary for agility attributes and business performance

			Change Statistics				
Model	R	R Square	R Square Change	F Change	df1	df2	Sig. F Change
1	.551(a)	0.304	0.304	40.576	1	93	0.000

a Predictors: (Constant), Aggregate Agility
R squared of the model is = 0.304

Table 5.38: Model for agility business performance and competitive objectives

			Change Statistics				
Model	R	R Square	R Square Change	F Change	df1	df2	Sig. F Change
1	.407(a)	0.166	0.166	18.469	1	93	0.000
2	.411(b)	0.169	0.003	0.333	1	92	0.565

a Predictors: (Constant), Aggregate Agility
b Predictors: (Constant), Aggregate Agility, Average of competitive priorities
R Squared of the model is = 0.166

Table 5.39 summarise the regression results showing the relations between the dependent and independent variables, while Table 5.40 shows a decomposed model of the relations between the main variables.

Table 5.39: Regression model of cluster agility attributes competitive objectives and business performance

Dependent Variable	Independent Variable	R	R^2	t-Value	F-Statistics	Beta Path Coef.
Competitive Objectives	Master change and uncertainty	0.534	0.285	6.084 (0.000)	37.017 (0.000)	0.543
	Leverage people and information	0.598	0.357	3.223 (0.002)	25.579 (0.000)	0.326
	Cooperation	0.650	0.422	-3.195 (0.002)	22.155 (0.000)	-0.304
	Enriching customer	0.674	0.454	2.287 (0.025)	18.697 (0.000)	0.197
	Aggregate agility	0.551	0.304	6.370 (0.000)	40.576 (0.000)	0.551
	Cluster agility	0.458	0.210	4.966 (0.000)	24.662 (0.000)	0.458
Business performance	Aggregate agility	0.407	0.166	4.298 (0.000)	18.469 (0.000)	0.407
	Competitive Objectives	0.270	0.073	2.706 (0.008)	7.321 (0.008)	0.270
	Location factors	0.046	0.002	0.448 (0.656)	0.200 (0.656)	0.046
	Cluster agility	0.371	0.168	3.856 (0.000)	14.866 (0.000)	0.371
Aggregate agility	Cluster factors	0.216	0.047	2.135 (0.035)	4.560 (0.035)	0.216

Table 5.39 reveal various levels of dependence between the dimensions of agility with competitive objectives and aggregate agility dimension with competitive objective. Similarly, cluster agility explains variation in the level of attainment of competitive objectives. Table 5.40 reports the detailed regression path analysis between the research constructs. It reveals various competitive objectives are pursued by the supply chain in order to enhance business performance, thus corroborating finding that organisations should aim for cumulative attainment of competitive objectives (Noble, 1995; Vokurka et al., 2002; Flynn and Flynn, 2004) rather than competing on limited number of objectives.

Table 5.40: Path coefficients for cluster agile supply chains

Dependent variable	Independent variable	t-value	F-statistics	Path Coeff (Beta).
Turnover	Quality	1.926* (0.057)	2.076** (0.041)	0.231
Net profit	Dependability	-2.954** (0.004)	2.271** (0.025)	-0.451
Market share	Speed	2.021** (0.047)	2.021 (0.047)	0.315
	Location	-2.685*** (0.009)	6.483 (0.013)	-0.333
Customer loyalty	Flexibility	-2.089** (0.040)	2.004** (0.028)	-0.254
	Speed	2.110** (0.038)	2.004** (0.028)	0.310
Innovation	Master change	2.259** (0.026)	3.958*** (0.000)	0.271
	Impact of people	2.122** (0.037)	3.958*** (0.000)	0.243
Speed	Location	3.636*** (0.000)	4.012*** (0.000)	0.351
	Master change	1.593 (0.115)	2.613* (0.010)	0.189
Performance relative to competitors	Location	-1.834* (0.070)	3.365* (0.070)	-0.213
Significance at10% indicated by*, at 5% level indicated by **, at 1% level by ***				

5.5.1 Structure model of cluster agile supply chains attributes

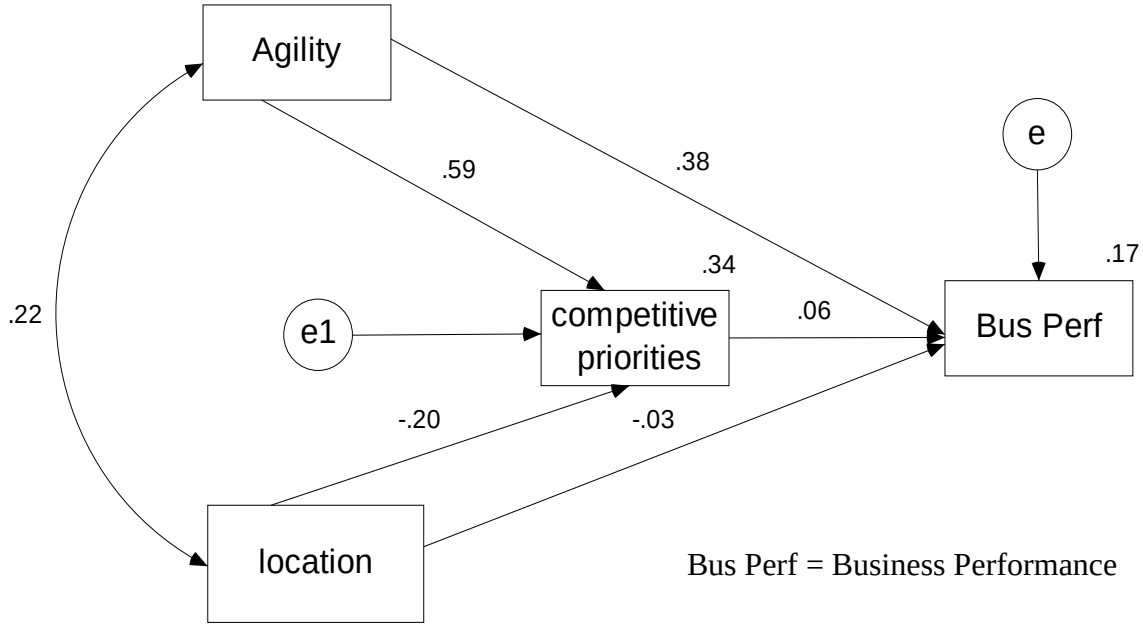

Figure 5.14: Structural Equation Model (SEM) of agility, location, competitive priorities and business performance

Although structural equation modelling provides several fit indexs after running the analysis, to explain and discuss all the indices will be superfluos. Accordingly Hair et al (2006) observe that in reporting a model fit after running a structural equation model it will be adequate based on three to four fit indices to provide evidence of a model fit. Indeed not all of the suggested three or four should be reported due the overlapp between the different indices. Hence only a few of the indices of the model fit will be reported.

The result of the Goodness-of-fit (GOF) for the proposed model shown in Figure 5.14 were acceptable.The Ration for Chi square/degree of freedom (χ^2/degree of freedom) is 1.912 and the Goodnees of fit Index (GFI) is 0.937. Both the normal fir index (NFI) and the comparative fit index (CFI) have values of 0.917 and 0.942 respectively which all exceeded the recommended minimum of 0.9. Though root mean square error of approximation (RMSEA) is 0.09 at $p<0.05$ is lower than the threshold of 0.10 (Ullman, 2006; Bentler and Yuan, 1999; Hair et al., 2006; Tabachnick and Fidell, 2007).

A structural equation model (SEM) of the relationship between agility attributes, industrial cluster dimensions, competitive objectives and business performance is shown in Figure 5.14. It is apparent from the structural model that there is a positive

correlation between location and agility with a path coefficient of 0.22. On the other hand the structure model of the paths indicates that competitive priorities fully mediates the effect of location on business performance, by which the effect of competitive objectives determines the business performance much more than being in an industrial cluster. Thus, the result of the structure model shown in Figure 5.14 genarally supports the proposition of this study, that location or being in an industrial cluster leads to or enhances several competitive objectives and thus affects business performance. Thus, the structural model affirms the conceptual model presented in Figure 4.1. From the path model it is apparent that Agility has a significant positive direct effect on Competitive objectives and Business performance. Equally, for the survey organisations, Competitive objectives have a positive direct effect on Business performance.

The regression model produced by running the structural equation model shows a positive direct relationship between agility and competitive priorities at less than 1% significance level. Equally agility has a significant direct effect on business performance. However, there are weak non significant relationships between both location competitive priorities and business performance.

The result of the model of the structural equation modelling (SEM) analysis shows that there is a moderate fit between data and model (Hair et al, 2006). This may be expected since the concept of Agility is still evolving and its implementation is not widespread within industry. Although within the academic arena there are publications that purport to show the capability of the agility paradigm to overcome some of the problems facing the manufacturing industry, studies like this tend to signpost that there is more work that needs to be done before the goal of disseminating the concept to industry is achieved.

5.5.2 Test for impact of cluster agile supply chain

The statistical tests of Correlation analysis (Table 5.7), Regression analysis (Table 5.39) and Structural equation modelling (Figure 5.14) established relationship between Clusters and Agility dimension. Accordingly a composite variable (Hair et al, 2006) was computed by combining company's scores on Cluster location attribute with Agility dimensions to form a variable termed Cluster agility. Aggregate values of Cluster agility, Competitive objectives and Business performance were computed and bivariate correlation analysis carried out between the three variables. The bivariate correlation coefficient between the three variables is shown in Table 5.41. The result of

the correlation analysis in Table 5.41 provides further empirical validation of direct (hypothetical) link between Cluster attributes and Agility dimensions, and its impact on attainment of Competitive objectives and Business performance. An account of the result shown in Table 5.41 is provided as follows.

Cluster agility significantly correlates with competitive objectives and business performance at 45.8 and 37.1 percent respectively with the probability of 1 percent the correlation is by chance. Similarly, competitive objectives correlates with business performance at 27 percent while there is 1 percent probability the correlation is by chance. Thus the implication of this result is that a cluster based agile supply chain will have a higher level of attainment of competitive objectives and business performance than a non cluster based on. Whereas there is a significant positive correlation coefficient between cluster agility and business performance, it is apparent that the relationship between the cluster agility and competitive objectives is higher. Perhaps the perceived importance of being in clusters on agility can easily be assigned to competitive objectives such as Speed and Innovation. However the link with business performance cannot be easily made due to the fact that not all the advantages of clusters will be quantifiable (Patti, 2006).

Table 5.41: Correlation analysis of cluster agile supply chain

	Cluster agility	Competitive objectives	Business performance
Cluster agility	1		
Competitive objectives	**0.458** (0.000)**	1	
Business performance	**0.371** (0.000)**	**0.270** (0.000)**	1
Significant at 1% level (**)			

5.6 Conclusion

This chapter reported the result of a survey by questionnaire carried out to test and validate the hypotheses on the diffusion of agile supply chain attributes into established industrial clusters. This survey was carried out within oil and gas supply chains; the studied oil industry supply chain operates within a defined geographic location famously known as industrial clusters.

Based on the empirical evidence from the survey the cluster based organisations were seen to have positive significant relationships between the agility of the organisations and being in a cluster. On the other hand, the non-cluster based firms indicated no

significant relationships between the cluster and location attributes and agility, thus demonstrating that not being in a cluster can affect the agility of organisations. Specifically the result from this study revealed the influence of being in a cluster on agility through the significant correlation between the cluster location attributes and the dimensions of agility of Cooperating to compete and Leveraging the impact of people and information (network and process integration). Furthermore and consistent with extant literature, the results from the empirical study support the link between agility and competitive objectives. This means that organisations deploy their agile capabilities to maintain competitive advantage. Similarly, the links between agility attributes and competitive objectives also support the assertion that organisations are aiming at simultaneous deployment of competitive objectives, rather than concentrating on a single competitive capability. This was indicated by the correlation between multiple competitive objectives with a single agility dimension.

Additionally, the result from this study determined the relative impacts of the agility attributes on the competitive objectives and business performance. Although prior studies were carried that showed relationships between agile manufacturing and competitive objectives, this study attempted to show the impact of the dimensions of agile supply chains on Competitive objectives. Thus, the difference espoused here is that the study has proposed a clear link between each of the dimensions and its impacts on specific Competitive objectives, such that managers can be guided in making choice of an intended competitive outcome based on a specific agility dimension. Essentially the study will aid in showing the interplay between the agility dimensions and a given competitive objective and clusters and location attributes.

By showing the impact of location on agility this study has extended the factors that affect agility of organisations and by implication has enriched the knowledge and practice of agility.

CHAPTER 6: CASE STUDY

6.1 Introduction

This section presents six case studies, including five companies and one government department. The five case study companies consist of two oil and gas operating companies, two integrated contractors and one SME supplier. Finally, DTI was included in the case study because it is the government body responsible for monitoring the activities of the industry to ensure adherence for relevant laws as well as sustainable exploitation of the resources within the UK sphere of influence. The case study organisations were chosen with the aim of giving a spread across the whole spectrum of the industry supply chain as well as the regulatory body responsible for monitoring the activities of the industry.

Case study research is among the research methods commonly used in operations management for theory building. It is used most especially in the early phase of a research process where there has been less prior study carried out that will guide subsequent studies. Case study is a phenomenological research method in which the research context is very important, as context is an essential part of the research process. Accordingly, case study can be used as a follow up to a survey by questionnaire to provide the context for the survey findings. There is increasing emphasis on exploiting the synergy within methodologies rather than viewing the different methodologies as mutually exclusive. Some researchers have referred to this idea as methodological fit (Edmondson and McManus, 2007). Indeed it is now understood that methodological triangulation offers better insight rather than purity of methods, such that survey research and qualitative case study type research are seen as two ends of a continuum rather than as a mutually exclusive set of approaches. Accordingly, they should be integrated into the overall research methodology so as to utilise the strengths of the two methods to overcome their weaknesses and improve the quality and validity of the findings.

The method of data collection in case study research often involves, but is not limited to, in-depth structured, semi structured or unstructured interviews. Based on the results of the exploratory survey by questionnaire, studies of six cases were conducted so as to validate the results of the survey through a more detailed qualitative study of the selected organisations.

6.2 Case study protocol

In empirical research case studies have been used as a follow on methodology after an initial survey by questionnaire. Accordingly, in this study the qualitative approach of case study are used to validate the results of the survey findings. The case study also provides the context surrounding the findings that clusters and location variables have effects on the competitiveness and business performance of the organisations. Prior to the study, the respondents were sent a copy of the issues to be covered in the interview. Also they were assured that strict confidentiality would be adhered to in handling and reporting the views they expressed during the case study. Intimation was given of the approximate length of time the interview would take and the type of information to be solicited during the case study. Additionally, they were informed of the method of data collection and the need for recording of the interview for subsequent transcribing. Generally, suggestions of researchers such as Yin (2003) and Eisenhardt (1989) were incorporated in the case study. The interview questions are shown in Appendix 2.

6.2.1 Sample and company selection

Sample selection for a multiple case study is often based on random sampling (Pagell, 2004), though case study samples could also be based on criteria other than random sampling as Voss et al (2002) attest. Thus, cases could be chosen based on purposeful or opportunistic samples. Accordingly, respondents to the case study were solicited using the survey instrument (shown in Appendix 1). At the end of the questionnaire respondents were asked if they were interested in participating in the case study phase of the research, and were asked to indicate their interest in the case study by a selecting ‘yes’ or ‘no’ in the questionnaire. Based on the response to this question a database of all the ‘yes’ respondents was created and they were contacted to thank them for their willingness to participate in the next phase of the research and equally inform them (through the case study protocol) of the issues to be covered in the case study. Indeed Eisenhardt (1989) contends that prior to a site visit for a case study, a researcher should have a developed a protocol. This was corroborated by Voss et al. (2002), who observe that the starting point for any case study is the research framework and the research questions. The case study was set up within oil and gas industrial clusters located at Aberdeen. Within the UK upstream oil and gas industry there is the feeling that the North Sea as an oil region has matured now and most of the future developments to exploit the oil reserves will be small rather than large. For an oil province that has depleted its economically recoverable reserves, the cost of finding and developing the

small fields will be high compared to the oil regions where there are abundant new fields, in which large oil wells will be found and exploited. Accordingly, the government of the UK felt that there is a need for cost reduction by the organisations involved in the business of exploration and production of oil and gas resources. This has therefore fostered the need to seek appropriate organisational arrangements as well as operational strategies to deploy in the UK upstream oil and gas industry, to serve the following three critical needs:

(1) to maximise economic recovery of the UK's oil and gas reserves.

(2) to keep the UK oil and gas province's pre-eminent competitiveness within the global oil and gas industry and finally.

(3) to ensure sustainable returns to the UK in form of Petroleum Revenue Tax (PRT).

Accordingly, in line with the desire to search for an appropriate operations strategy, the survey was used to test the adoption of some of the emergent supply chain management tools and techniques – agile supply chains – within the UK upstream oil and gas industry. Additionally, in a bid to test and extend the theory on industrial clusters, the survey only tested the proposition of relationship between being in industrial clusters and the agility of an organisation.

6.2.2. Data collection procedure and analysis in the case study

Interviews were conducted with top and middle management in the three tiers of the industry, consisting of operators, integrated contractors and suppliers. Additionally interviews were carried out with staff of the Department of Trade and Industry (DTI) and Leading Oil and Gas Industry Competitiveness (LOGIC). DTI is a government body responsible for policy formulation implementation in the industry whilst LOGIC is the organisation formed by collaboration between government and industry to monitor the cost reduction initiative in the industry as well as to implement and monitor initiatives across all tiers of the industry aimed at enhancing industry competitiveness.

Data were collected for the period from June 2000 – May 2005. Thus a period of five years was chosen for investigation. This was in order to study the transition that occurred within the oil and gas industry during that period. In undertaking the case study, many sources of information were utilised. These include semi-structured interviews, company reports and attendance at one of the regular panel discussions carried out from time to time within the industry among its middle and top management, to confront any problem facing the industry, as well as minutes of meetings and

presentations during Share Fairs, Conferences and Workshops. Summaries of the panel discussions were utilised in analysing the themes of the research case study.

6.3 Business environment and the industrial context of the case study

The Aberdeen oil and gas industry is multi-tiered with the operators at the head of the supply chain. The contractors are the tier – 1 suppliers who mostly undertake project management and assembly and testing of the product before it is deployed and commissioned for service to the operator. The supplying tier, which also includes Small and Medium scale Enterprises (SMEs), normally subcontracts jobs from the tier 1 contractors and participates in the supply chain as the lower rung of the chain. Another part of the supply chain is the supporting organisations composed of DTI which is a government body as well as Leading oil and Gas Industry Competitiveness (LOGIC) and Oil and Gas Industry Task Force (OGITF) however OGITF was later changed to PILOT). These three bodies and institutions coordinate issues related to industry competitiveness and are linked to all the three tiers of the industry. In asserting the unique nature of the oil and gas industry, a respondent drawn from among the operators commented as follows:

> "…in a nutshell the oil and gas industry is an inherently conservative sector. The industry is not very close to its customers; it produces products that are dumped into the market place. Organisations operating in the upstream oil and gas industry operate remote from its customers. Accordingly it has none of the normal competitive pressures that you will expect an organisation in other industrial sectors like retail or automotive or anything like that. It is a very interesting sector from those perspectives: huge investments, return on these can be extremely good but the industry tends to be slow in the time it takes to come to marketplace. For example from oil discovery to the oil coming out from the ground is measured in years. So its a something like you know a Fast Moving Consumer Goods market you know where there is product development cycle is very rapid …. I was once working on a project for 6 years before we even got to offshore construction and oil coming out of the ground so it is an industry dominated by huge expenditure, lots of risk management, because you are making investment decisions that ultimately have a lot of uncertainties about price of oil. As soon as it goes up or down they go rapidly, and your revenue is in foreign currencies so all our expenditure is in Sterling in the UK and goods and services and our

revenues come in foreign currencies (usually US Dollars) so it is a very interesting business." (Source: Interview response).

In the preceding response, the respondent alludes to the fact that the oil and gas industry differs markedly from other sectors such as retail, automotive and electronic industries in terms of its operational and strategic focus. Equally, its capital outlay as well as risk exposure is very high in relation to other industrial settings.

Figure 6.1 summarises the nature of networking and relationships within the industry. As shown in Figure 6.1, operators composed of the oil companies are at the top of the supply chain and they constitute the customer class within the supply chain in that all the lower tier organisations are trying to supply the needs of the operators. Moreover the locus of forward movement of goods and services as depicted moves from the suppliers right up to the contractors, while the feedback movement of information, payments and revenues goes from the operators right down to the suppliers. Then Operators are followed by the integrated contractors who are the main sub-contractors to the oil companies, while at the bottom of the supply chain are the suppliers and the SMEs. The integrated contractors and SMEs group consists of contractors such as drilling, completions and service companies as well as suppliers of tangible inputs and consumables. Another peculiarity of the industry is the manifest network with educational and research institutions, industry bodies and government organs. The supporting organisations include government institutions such as DTI, Universities as well as industry bodies represented by LOGIC and OGITF as shown in Figure 6.1.

Additionally, Figure 6.2 shows a representation of the organisational arrangement of the UK oil and gas supply chain as well as the relationship of the members of the supply chain to the type of value they add in the value stream and activities undertaken within the total value stream. Figure 6.2 indicates the delayering within the industry, such that the operators have outsourced a significant part of the activities required in the industry to the supply chain and they are concentrating on their core competence. Frigant and Lung (Frigant and Lung, 2002) report a similar trend in the automotive industry, by which vehicle makers delegate module design and production to the first tier suppliers and in turn focus on their core competencies. The structure of the supply chain illustrated in Figure 6.2 conforms with an earlier exposition of a hierarchical supply pyramid (Nooteboom, 2004) in which the first tier suppliers take control of coordinating the lower tiers activities.

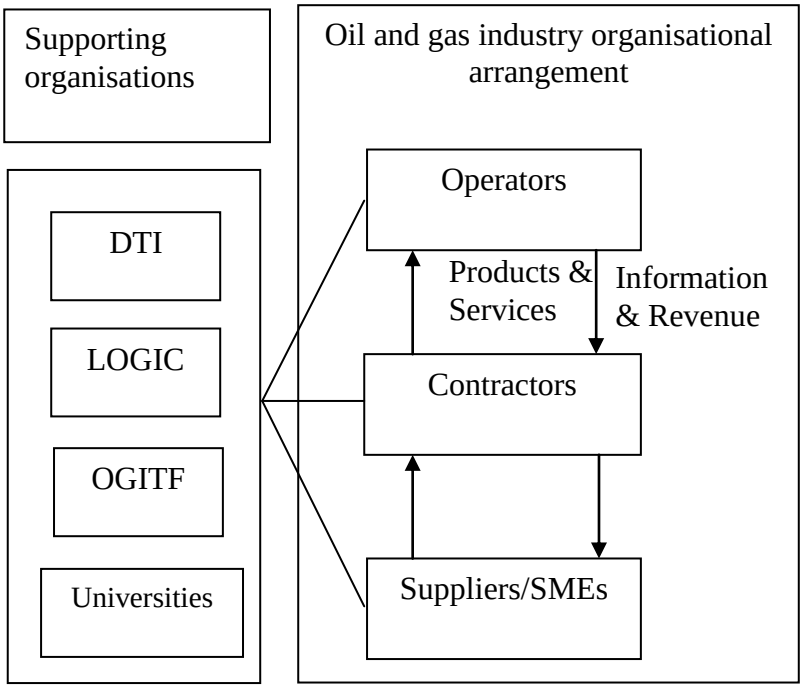

Figure 6.1: The nature of networking within UK oil and gas cluster [Source: Mackinnon, Chapman et al. (2004) and interview materials]

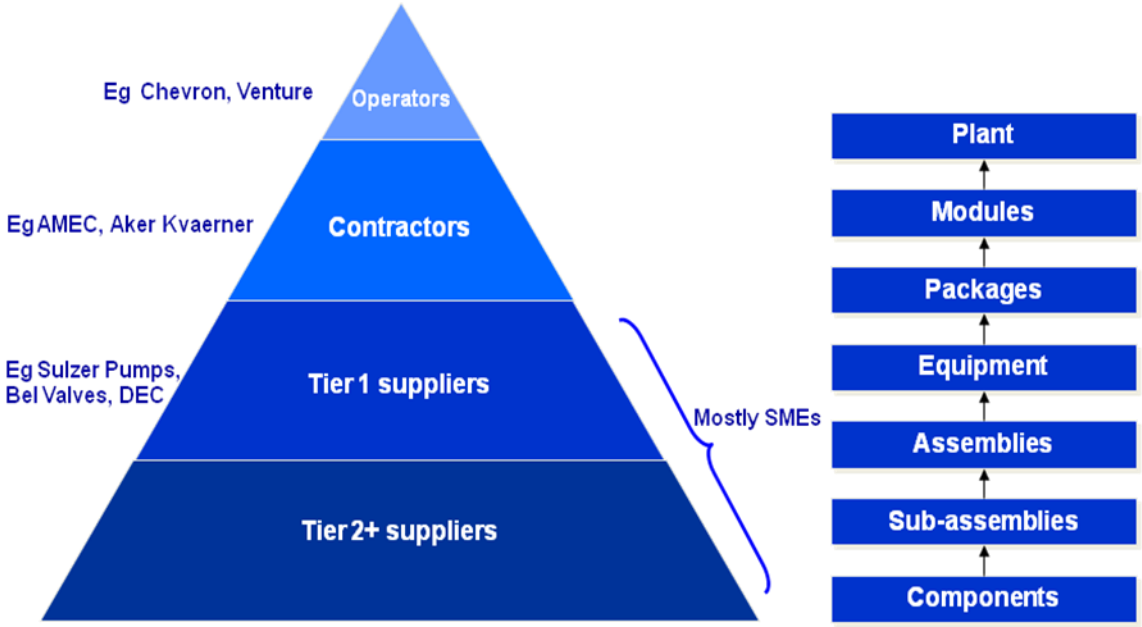

Figure 6.2: The UK oil and gas industry supply chain [Source: PA Consulting & Yorkshire Forward (2004) and Interview materials].

6.4 Case study

6.4.1 Case study organisation 1: Department of Trade and Industry (DTI)

The Department of Trade and Industry (DTI) energy group regulates, promotes, and sponsors all aspects of the UK's energy industry including the oil and gas sector activities. It encourages commercial competitiveness and best practices in all aspects of the industry generally. However it specifically acts in relation to oil and gas exploration, development, production and decommissioning with the aim of ensuring that the UK undertakes sustainable exploitation of the oil and gas reserves as well as undertaking the task of accessing the reserves with minimal destruction to the environment. It also ensures minimum damage to the environment in the course of exploring and producing oil and gas resources and the subsequent decommissioning of facilities at the end of the productive life of an oil reserve.

Indeed, the deputy director of DTI Aberdeen assesses the function of the government body in light of the organisation of the United Kingdom Continental Shelf (UKCS) oil and gas industry as follows:

> "The DTI is the government body that is responsible with leasing the acreage to the operating oil companies to enable them to undertake exploration for the oil and gas resources within the UKCS on discovery of commercial oil and gas reserves then development and production stage is the next."

Furthermore he contends that within DTI efforts have been made,

> "within the last decade since the fall in the price of oil around 1996, through initiatives to change the behaviours of the big buyers, the operators and tier-1 contractors and make the market more accessible for the supply chain and open it up to ensure that everybody such as the potential companies that got product or service to sell have got access to the market."

DTI have done that in a number of ways, such as the Share Fair and Progressing Partnerships. DTI used the Progressing Partnerships initiative and supply chain code of practice initiative to target improvement of the payment terms and prompt payment within the supply chain for jobs executed between organisations. The initiative was predicated on the fact that for an SME, cashflow is very important; hence improved payment terms and prompt payment will enhance their operation markedly. Equally the Share fair concept gives opportunities for the operators and the tier – 1 contractors to share with the contracting community their investment proposals for the following 18

months and they also look at ways to simplify the contracting process and streamline it across all the supply chain so as to reduce duplication in tendering and evaluation. Apart from ensuring that more streamlined and standard contracts were introduced, DTI also introduced the concept of feedback for unsuccessful bidders so that companies whose bid was unsuccessful were given feedback on the reason for the loss of the bid. However, in assessing the bid, whether it was purely based on cost or whether it is on content, the bid, must be both commercially and technically the best. Sometimes it could be commercially aware but technically not the best, which is why an effort falls through.

Furthermore, in trying to improve the environment and for the supply chain, DTI also tried to look at ways to ensure that bids were not selected on purely the lowest bid, and that any bid selected is really best value that was seen in the bid. In that way, DTI also try to ensure that there were opportunities for small innovative companies to add to the bid and to put forward technologies and innovation.

With respect to partnering and alliancing within the industry, the DTI respondent states as follows:

> "I think obviously joint venturing and partnering is quite a good idea because more and more the operators are looking for complete solutions and they don't really want to buy things piecemeal if they can get a good solution that could be ready for adoption."

Furthermore when asked to assess the extent of adoption of partnering and alliances within the industry he contends:

> "Well there is a practical example of that called SIGMA 3 where Wood Group is involved, where the big contractors came together and they call themselves SIGMA 3, so they can offer total solutions and there might be opportunities further down the value chain for companies to feed into that kind of process. So that kind of shows you at a higher level, even the Wood Group, Halliburton and AMEC, companies that you would think who are big enough and fit enough to operate on their own, have come together to develop so I think that is the model and other things which will be good to look at as well."

Another consideration to which DTI points is risk associated with currency convertibility, such as the fall in the value of Dollar against the Pound. This is another area that affects activities in the UK oil and gas industry. For example, since the revenues accrues in dollars (since oil and gas are sold in dollars in the international

market) while the costs associated with the production of oil and gas are in pounds, the strength of the pound relative to the dollar translates into lower returns as the cost of operations is incurred in the stronger currency – the Pound – while the revenue accrues in a weaker currency – in this case the Dollar. So currency convertibility also imposes some risk in the operations of the industry. However, it is noteworthy that currently the reverse is the case, with the Dollar appreciating relative to the Pound, thus supporting the notion of uncertainty associated with fluctuation in currency convertibility.

6.4.2 Case study company 2: Venture production PLC

6.4.2.1 Introduction

Venture is an independent oil and gas production company that is solely focused on exploiting the hydrocarbon resources in the North Sea oil province. Accordingly it is headquartered in Aberdeen with total staff strength of 55 employees. Venture's operations strategy is to acquire and (re)develop proven but 'stranded' oil and gas reserves. As such it is an established operator of production and development projects. It has a Proven and Probable reserve base of about 125 Million barrel equivalent of oil (MMboe) as of the year 2004. Furthermore, its net production rate has risen from 2,250 Barrels of oil equivalent per day (Boepd) in 2000 to around 36,000 (from 2000-2006). Figure 6.8 shows the reserves of the UKCS and the operators and their share of the reserves. In terms of assets Venture Production has 20 oil and gas fields, out of which 18 are fully operational. Finally, Venture was listed on London Stock Exchange in March 2002. With reference to its supply chain, Venture Production asserts that there are five key differences that define its Supply Chain Management, and they are as follows:

- Business Model
- Attractiveness
- Contract Management and relationships management
- Pace and Speed
- Co-operation and competition – co-opetition

Venture has a unique business model as it considers itself as being a niche company. It is not a conventional oil and gas company, in that; it does not have a downstream part of oil and gas business so it actually does not sell petroleum products such as gasoline at the pump station, lubricants and similar goods. Its main business activity has to do with

acquiring and developing mature assets in the upstream part of the oil and gas business. Matured assets are those assets that, for various reasons, other oil companies have not exploited. This could be due to the asset being partially denuded fields that have moved into a more matured phase of their existence. Accordingly Venture buys those assets and rapidly develops them.

6.4.2.2 Adoption of agility

Due to the nature of the assets it develops and subsequently produces from, Venture believes its business model itself will have to be different from those of the larger more conventional organisations. Venture is a company that has very large equity positions on its assets. Typically in the oil business there is risk in the exploration phase, in that of every three wells drilled two will be dry holes, which cost a lot of money. Accordingly, companies spread the risk by going into partnerships with other companies. However, since Venture acquires matured assets they have not got an exploration risk, so what they do is to buy out all their partners that are involved with the asset that they have acquired. Typically Venture hold a large equity position and they have few partners, as they would own 100% of the asset. This is rather different in an industry that has established partnering and alliancing as its mode of operation. In the work of the supply chain those differences are mirrored in the organisation, as Venture does not actually operate its production facilities – that is it does not perform facilities management and does not have a maintenance function in the organisation; it outsources facilities management. However, what Venture does in the course of operating the organisation is projects and drillings, so with a heavy capital investment part of the company, it is looking after the operational expenditures covered by external contracts, that is, the facilities management contracts which it has outsourced. Thus the key differences between Venture and other operators are as follows:

1. They price pace rather than perfection
2. Speed and slickness is seen as very important
3. Attractive propositions to do business with.

To emphasise the differentiation between Venture and its competitors, the Supply chain Manager of Venture states as follows:

> "We actually have a very flexible supply chain strategy. There are some things we do in the buyers market we don't do in the sellers market and

there are some things we do in the sellers market we don't do in the buyers market. At the moment we're in a very deep sellers market so our SC strategy will behave very differently with the kind of things we are doing with our key suppliers than we'll do typically when we would be stronger. These are some of the real defining differences of the SCM in Venture." (interview transcript).

More specifically Venture's Business Model is uniquely characterised by the following:

- It holds large equity positions and has few partners
- Drilling is done in-house but Projects and Operations are heavily outsourced
- It has a high degree of reliance on Contractors
- It values pace and agility – Venture Production considers itself to be fast and flexible
- Perception of risk can be a little different than the norm
- It is prepared to be a little untypical for the industry

To maintain its unique business model, Venture has adopted the following philosophy in the execution of its business:

- Go into long term relationships with the best service provider in the market
- Consider that Venture and its service providers are all in the same business to succeed
- Adopt fair pricing for services offered
- Act as an "Operator" and "Co-operator"
- Venture is: Fast, Flexible and Focused
- Contractors required to offer: Assistance, Anticipation & Alignment
- Compromise rather than compulsion
- Supporting industry initiatives such as Supply Chain Code of Practice (SCCOP) and First Point Assessment Limited (FPAL) industry database.

SCCOP promotes industry standard practices to eliminate waste, save unnecessary cost, add value and increase competitiveness for all parties. The plan covers three main activities which are as follows:

- Plan: by which activity plans and contact are communicated to the supply chain
- Contract: By which FPAL database is used and duplication avoided by using standard Invitation to Tender (ITTs), contracts and adopting fair contracting principles.
- Perform and Pay: the service provider should perform the contracted work to the required Key Performance Indices (KPIs), both the client and contractor use FPAL performance feedbacks, and the client pay the contractor or service provider's invoice within 30 days.

Additionally, part of the business strategy of Venture is the willingness to become a good customer to its suppliers through:

- Striving to gain scale
- Gaining attractiveness
- Low maintenance, and
- Smart behaviour

Indeed, Venture's overall partnering philosophy is that they are only as good as their supply chain partners. This demonstrates their reliance on their supply chain in the execution of their activities and the eventual success in their operations. Thus they show willingness to cooperate with their suppliers to enhance their competitiveness and business performance.

Some of the market challenges experienced by the industry can be highlighted by the data in respect of the Rig Demand for a period of time. Tables 6.1 and 6.2 show the demand for semi-submersibles and jack-ups for the North Sea province for three years. It is apparent based on the demand profile shown in Tables 6.1 and 6.2 that for the period coinciding with the increased price of oil there is a corresponding increase in the demand for drilling facilities. This seems to be the trend in all the inputs for materials and services required in the activity of the offshore oil gathering business. Accordingly,

this undersupply of inputs has caused the players within the industry to be concerned with the potential impact of the insufficient capacity and as such they have adjusted their supply chains to react to the dynamics of the market situation.

The respondent from Venture production contends that there is a need to align the supply chain to the nature of the business environment. For example, the procurement market can either be a buyers' market or a sellers' market. Currently the industry is in a deep sellers' market. A continuum of buyer supplier behavioural patterns was analysed to be either high pressure, cooperation, domination or competition (Dowlatshahi, 1999). The key challenge is to choose the right type of behaviour to suit a particular need. Accordingly, having a very large order may not be an attractive proposition to the service provider if the market is a sellers' market, as factors other than scale will affect the decision making process of a seller.

Table 6.1: Demand for semi-submersible rigs in the UKCS. (Source: Interview)

Semi Submersibles	**2004**	**2005**	**2006**
Demand	140	161	192
Total supply	198	197	196
Marketed supply	169	177	178
Marketed surplus	29	16	-14

Table 6.2: Demand for jack-ups in the UKCS. (Source: Interview)

Jack ups	**2004**	**2005**	**2006**
Demand	317	342	388
Total supply	386	384	385
Marketed supply	357	358	363
Marketed surplus	40	16	-25

Another attribute of the industry as highlighted by the organisation is the need for forward planning to aid in capturing dedicated input from the market. Thus, Figure 6.3 shows the current and projected capital and operating expenditure of venture for the period covering 2003–2009 as well as the historical data on drilling days utilised for three years between the period 2003–2005 and projected annual demand for drilling days for the period 2006–2009. Additionally, actual and forecasted production rate is also indicated. From the production rate trend shown in Figure 6.3, it can be seen that broadly Venture aims to double its size in terms of production and reserves without increasing its staff. Moreover Venture prides itself on its execution capabilities and

attractiveness to its suppliers and contractors such that it confers on it preferred business partner status even in sellers' market.

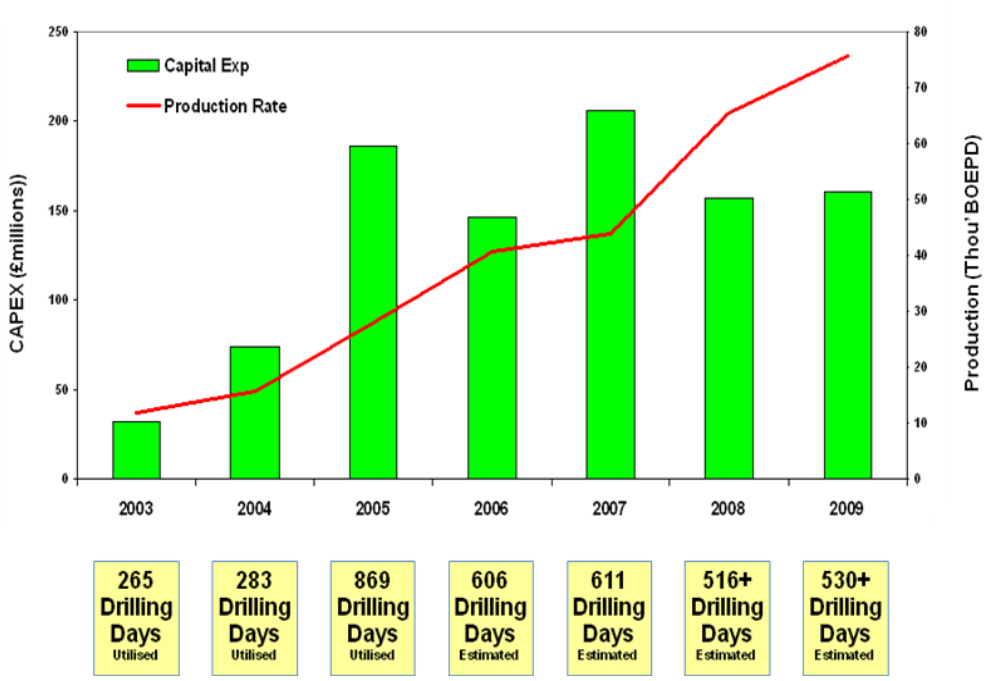

Figure 6.3: Capital and operating expenditure of organisation. (Source: Internal reports)

As an industry, the oil and gas industry is unique and different from other industries in that the members of the supply chain need to benchmark their operations based on the transactions that they are involved in at a particular point in time. In a commercial transaction that involves a supplier and a client, both of them are assessed using a number of performance indicators. Thus, a customer will assess its supplier for the quality of service or product it receives while the supplier assesses the customer for a number of issues including cooperation and relationships. Accordingly, Table 6.3 shows the assessment of Venture's 20 key contractors on the First Point Assessment Limited (FPAL) database. In Table 6.3, columns 2–5 represent the factors that assess the performance of contractors. Typically the three performance indices that are stated include overall performance, commitment and user satisfaction, while the first column represents the number of contractors that are assessed at a particular point in time, with the last column showing the mean score of the three performance indices for the year under review. It is also apparent from Table 6.3 that the contractors are benchmarked against each other. For example the table shows the performance of 20 contractors that performed different activities for the case study company. However the actual identities of the contractors have been masked due to confidentiality. The key information is the assessment of the contractors and the items on which they are assessed. The suppliers

are ranked from 1st to 20th based on their individual score on the performance indices on which they were assessed and their mean total score for the year determines their relative ranking.

Table 6.3: Contractor performance feedback on some KPI's. (Source: interview)

	Key Contractor	Performance Overall (%)	Commitment (%)	User Satisfaction (%)	Total 2005 (%)
1st	Steel supplier	90	95	90	92
2nd	Well services supplier	90	90	90	90
3rd	Umbilical supplier	85	90	90	88
4th	Rig contractor	85	90	85	87
5th	Well services supplier	85	85	85	85
6th	Steel supplier	85	90	80	85
7th	IT contractor	85	85	85	85
8th	Well services supplier	80	80	80	80
9th	Well services supplier	80	80	80	80
10th	Rig contractor	80	75	80	78
11th	Marine contractor	75	80	75	77
12th	Well services supplier	75	75	75	75
13th	Facilities contractor	75	75	70	73
14th	Well services supplier	70	70	75	72
15th	Facilities contractor	70	70	70	70
16th	Systems contractor	70	65	70	68
17th	Well services supplier	65	70	65	67
18th	Well services supplier	65	65	60	63
19th	Facilities contractor	65	65	55	62
20th	Well services supplier	50	45	45	47

Equally within the oil and gas industry the service providers can also assess their customers in terms of the way they find them to do business with. Accordingly a typical assessment of performance of the case study company is shown in Figure 6.4 and 6.5. The customer performance benchmark was carried out by a supplier of well services to the case study company. After the assessment a debrief session follows. The debrief session clarifies aspects of the assessment that the assessed may have issues or disagree with, as well as suggest steps to make improvement in areas with low score.

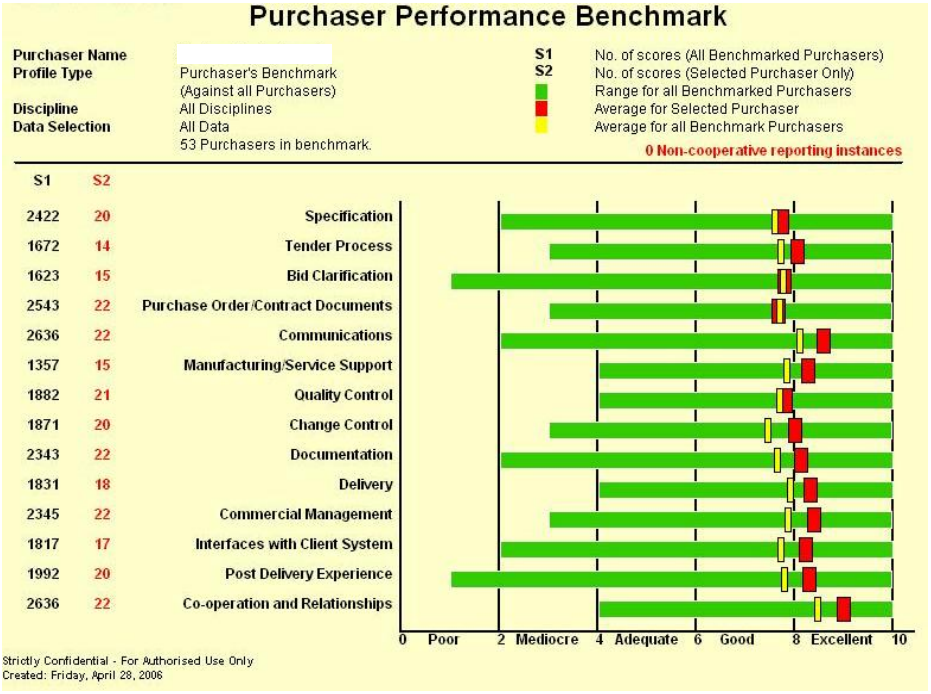

Figure 6.4: Feedback on a customer by a contractor in typical oil and gas project

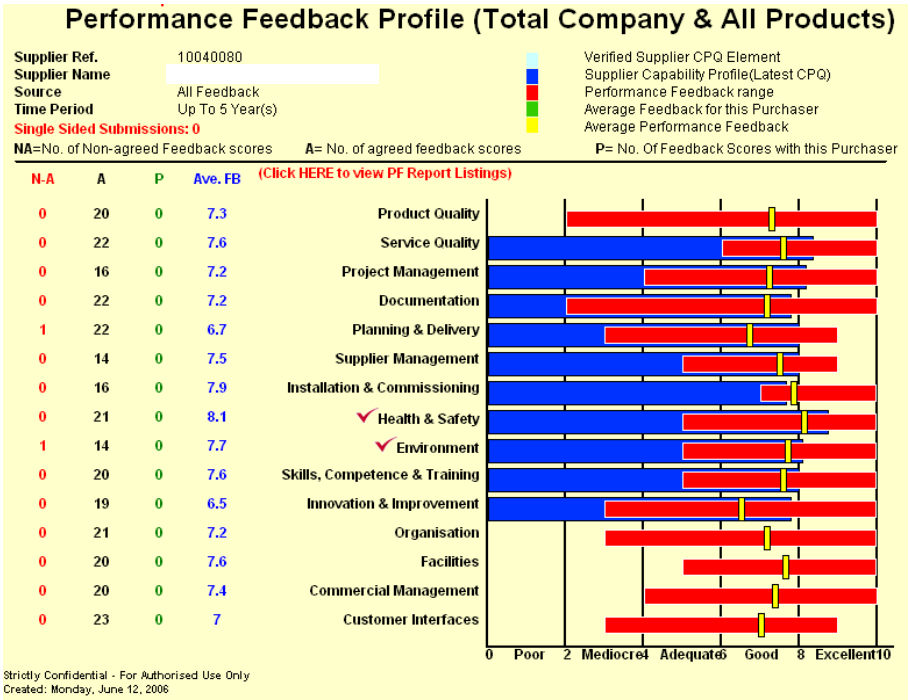

Figure 6.5: Assessment of a contractor for all the products and services by the customer

Table 6.4*:* Well Services Contractors Association assessment of Case Company A

	A	B	C	D	E	F	G	H	I	J	K	L	Venture	N	O	P	Q	R	S	T	U	V	W	X	Y
Number of reports	5	4	3	4	8	9	3	8	1	5	5	7	4	5	2	1	2	2	1	1	1	1	1	1	1
No duplication of FPAL in ITT's	3	3.75	3.33	2.75	2.5	2.78	3	2.75	4	2.6	2.4	2.71	4	2.8	2	3	2.5	4	1	5	5	4	4	2	3
Time given for ITT delivery	3.2	4	3.67	4	3.88	3.78	3	3.88	4	3.4	3.6	4.14	4	3.4	3.5	2	3	3.5	3	4	4	5	3	3	4
Upfront award criteria	3	3.75	3.33	3.5	3.25	3.44	2.67	3.25	4	3.2	3.2	4.29	4	3.2	3.5	2	3.5	3	3	5	5	5	3	3	4
Feedback on lost bids	3.4	2.5	2.5	3.25	3.43	3.56	3.67	3	4	2.75	2.8	3.2	4	2	1.5	3	2.5	3	1	0	0	4	3	4	3
Standard Contract use	2.2	2	2.67	1.75	3.13	3.78	1.67	3.63	3	2.4	1.8	3.71	4.25	3	3	5	2	4.5	0	0	4	5	3	3	0
Use of Special Conditions	2.6	1.75	2.67	2.5	2.38	2.44	2.33	2.5	3	3	1.8	2.43	3.75	2.4	2.5	4	3	3.5	0	3	4	4	2	2	0
MHH	1.6	2	1.67	1	1.88	2.22	1.67	2.5	0	2.4	1.4	2.14	2.5	2.8	3	3	3	3	0	0	0	2	2	2	1
Proximate Third Party Property	2.6	3.5	3.67	1.25	2	2.67	2.67	2.75	3	3.4	1.4	3	2.75	3.6	3	5	3	5	2	3	3	4	3	3	3
Reasonable Limits of Liability	2.8	2.75	3.67	1.75	2.63	2.56	3.33	3.5	3	3.2	1.8	3	4.25	3.4	3	4	3.5	4	2	5	5	5	2	3	2
Defect Correction Periods	3.4	3.75	4	2.75	4	3.67	2.67	3.75	3	4	2.6	3.29	4.25	4.4	4	4	4.5	4.5	4	5	5	5	5	4	1
KPI & contract reviews	3.2	3.25	3	3	3.75	4.22	3	3.43	4	2.6	2.8	1.71	4	3	2	0	3	0	0	0	0	0	1	1	3
Payment <30 days	3	3.5	3.67	3	3.75	3.78	3.33	3.63	4	3	3.4	4	3.5	3.8	3.5	0	3.5	5	3	0	0	0	2	2	4
	2.83	**3.04**	**3.15**	**2.54**	**3.05**	**3.24**	**2.75**	**3.21**	**3.25**	**3.00**	**2.42**	**3.14**	**3.77**	**3.15**	**2.88**	**2.92**	**3.08**	**3.58**	**1.58**	**2.50**	**2.92**	**3.58**	**2.75**	**2.67**	**2.33**

A dominant theme that appears within the case study, especially in the small independent oil companies, is the issue of relationship management between the oil companies and the integrated contractors. Furthermore due to the reliance of the small operating companies on the supply chain to operate their facilities to produce the oil and gas resources, the need for continuous growth by the organisation is met through increased spending on capital and operational activities. Figure 6.4 indicates the present and projected expenditure of the case study organisation for the period up to 2009. It can be seen that the case company aims to double its production with the same number of staff. This is done by outsourcing all the additional activities to the supply chain, rather than expanding its resources. Thus it relies on the supply chain to achieve its target production growth.

6.4.3 Case study company 3: Chevron Upstream Europe

6.4.3.1 Introduction

ChevronTexaco ranks among the world's largest and most competitive global energy companies. ChevronTexaco is engaged in every aspect of the oil and gas industry, including exploration and production; refining, marketing and transportation; chemicals manufacturing and sales; and power generation. The corporation is a fusion of two companies, the Chevron Corporation and Texaco Incorporated, respectively to form the ChevronTexaco. The two companies were both instrumental in transforming a fledgling oil business into today's multifaceted, high-tech energy industry.

Chevron holds interests in nine oil and gas producing fields in the U.K. Continental Shelf. Chevron Upstream Europe's North Sea fields produce 272,000 barrels of oil and 1.2 billion cu. ft. of natural gas per day. Output from the company's Britannia Field in the North Sea meets a significant percentage of the UK's total demand for gas. Chevron Upstream Europe is also developing the North Sea-based Clair Field, in which it holds a 19% interest. The company’s vision is the need for a broader set of skills in production.

One of the issues present in the operations of the organisation is the risk associated with financial exposure. Accordingly within Chevron they have established the following types of financial risks to be of significance to their operations.

- Market risks
- Currency exchange risks
- Interest rates

- Oil, natural gas and power prices
- Credit risks and
- Liquidity risks

6.4.3.2 Adoption of agility and impact of clusters on Chevron

TEAM MARINE: Logistics sharing alliance initiative to take advantage of clusters

ChevronTexaco went into collaboration with its competitors in the case of TEAM Marine. This is an indication of the presence of cooperation in order to enhance competitiveness an aspect of agility attribute of cooperating to compete. The TEAM Marine case is summarised as follows: The case is an example of where a marine logistics initiative resulted in substantial savings for a consortium of North Sea Client Operators. The TEAM Marine (Texaco, Elf & Amerada Marine) was set up as an initiative to get more efficiency out of the oil and gas supply chain arising from falling oil price. At the time all three members of the team were working in close geographic proximity around the Tartan, Piper/Claymore and Scott oil and gas fields. Initially three areas of the supply chain were reviewed, but only the marine went forward successfully. Aviation was a second consideration but as all operators were around the 80 - 85% efficiency mark only a seat sharing agreement was taken forward to share spare seat capacity. Onshore storage and inventory were deemed too large in 2000 and would not be looked at for various reasons, namely, too large to fit into one space. For TEAM a two port operation was developed, Aberdeen and Peterhead, because two of the members of the team were operating from Aberdeen and the other operates from Peterhead. The Team Marine alliance continued successfully with a 26% reduction in operations in the first year 2000/2001. Thereafter the alliance has reduced cost and improved efficiency. The Team members have evolved over time with Chevron acquiring Texaco. Currently TEAM has evolved further by adding new members with the membership currently being Chevron (55% which includes Britannia as an affiliate to Chevron); ConocoPhillips (35%) and Hess (10%). Other oil operators have been part of the sharing concept and include Venture; Total (Elgin, Franklin Fields) and Talisman for the 4th round assets purchased from Elf. All of these additional companies have departed on the basis that they wish to have only one supplier in the supply chain for onshore storage and marine provider.

Clearly, with respect to the Team marine case, it indicates adoption of cooperation and alliancing which are attributes of agile supply chains. The success of the alliance is due to communication, cooperation and commitment by the members of the team. Equally,

the principal factor that prompted the formation of Team Marine was geographic proximity of the assets of the participating members, as members that divested out of the North Sea region subsequently left the alliance.

Additionally, in terms of operational strategy, this company states that "its main tenet of operation is the proactive pursuit of growth in its area of operations." When probed on the previous statement, the respondent stated that "being quick and responsive to the need of the changing nature of the market occasioned by increase in the demand for the product from their customers was the main operating philosophy of the organisation." This also reveals that the dynamics of operating conditions has shaped the strategy adopted by organisations to stay ahead of competition. Perhaps, for the major oil producers like case company 3, the changes in the business environment may also be a result of the competition by the independent oil and gas companies, such as case company 2 above, in sourcing for inputs in a sellers' market; as a result of high oil price.

6.4.4 Case study company 4: AMEC

6.4.4.1 Introduction

AMEC is a global leading international design and services firm offering a wide range of services in the upstream, downstream and distribution parts of the oil and gas industry. It has a total workforce of 8,500 people operating in about three continents, giving it a significant geographic reach. The oil and gas is a multi-tiered industry with the operators at the top of the supply chain and representing the customer. The first tier organisations to which AMEC belongs are essentially system integrators and act as the coordinator of lower tier organisations. Some of the services that AMEC offers include Asset development and support. Under asset development they undertake Program and Project Management, Front End Engineering and Services, while in respect of the Asset Support AMEC performs the following activities; Facilities Engineering and Management, Productions Operations, Brownfield projects, and Operations and Maintenance. It also undertakes most of the Front End project activities such as Concept and Front End, Design and Construct, Hook-up and Commission

6.4.4.2 Adoption of agility within AMEC

Agility encompasses technology and practices; hence its adoption by organisations could be wholesome, such that all aspects of agility are adopted and inform the operations of the organisation or some aspects of it are adopted due to either the

peculiarities of the organisation, or it is on the road to full adoption as is often the case with most organisations. For this reason the supply chain manager, when asked about the adoption of agility within his organisation in particular and the industry in general, responded as follows:

> "It is really being applied in the oil and gas industry, for example AMEC have been working on this for many years in terms of standardisation and there is lots of other words that have been used. There is those kind of skills that doing things more efficiently, quicker and with less rework, that is definitely an issue. For example we took one platform in West Africa and pretty much copy that across to the next one and could deliver it much quicker and at much lower cost and I guess everyone went on that. But also, it means that as a supplier tier 1 or tier 2 people could tell you, "actually I just want the same" or you know you've got so many projects across that you have economies of scale somebody will say, "well I will do three of those because actually I get three of those at the price of two and so, yeah, so that is very important for us."

Furthermore, when asked to enumerate and assess their competitive priorities he went on to state that for AMEC:

> "Time based priority is very much of essence, quality, we've worked various initiatives, typically we have a quality person on projects, and I've been involved in initiatives like first (1^{st}) time right. Cost again key. Furthermore, Innovation, Proactivity and High Flexibility are all necessary"

In terms of flexibility the respondent went on to assert as follows:

> "But High flexibility is at different levels, it is in terms of scope, it is in terms of how you do things, because each plan is different. Each oil company has a different culture, different processes, different procedures and even how they execute projects."

Equally the implementation of attributes of agile supply chain of cycle time reduction was highlighted in AMEC. In AMEC there are three critical factors in any project, these are: Time, Quality and Cost. However other priorities emerge depending on the specific needs of the project. For example there may be the need for Innovation to drive the schedule or Innovation may be needed to reduce cost. In order to achieve the above competitive objectives, the respondent observed that, within AMEC there is a network that allows staff to draw on long experience and learning to provide solutions.

6.4.5 Case study company 5: Aker Kvaerner Offshore Partner Limited

6.4.5.1 Introduction

Aker Kvaerner Offshore Partner Ltd is an integrated oil and gas service company with global operations that enjoys 15% of the UK market and employs more than 800 people. It has a current turnover of £85 million. Its main activities include the Engineering design of structures and modules as well as provision of maintenance, modifications and operation (MMO) services to 55 facilities on the United Kingdom Continental Shelf (UKCS). The company also provides a range of technical support services to operating oil companies in locations other than the UK from its Aberdeen office. Aker Kvaerner Offshore Partner Ltd has a significant client base including many of the major operators in the UK market such as Shell and BP, as well as the independents. It considers the provision of engineering solutions to the offshore oil and gas industry to be its core competence. With both operational and business units in a large number of locations on both sides of the North Sea, AK exploits its strategic advantage of being well positioned in respect of the cross-border markets of the UK and Norway in respect of the North Sea continental shelf. AK attributes its success to leveraging the total MMO resources deployed in support of North Sea activity in respect of office locations, contracts, competent personnel, systems and project capability – through the Aker Kvaerner Offshore Partner and Aker Kvaerner Operations Business units in Stavanger, Bergen and Aberdeen.

Aker Kvaerner's operating structure consists of Field Development; Maintenance, Modifications & Operations (MMO); Subsea; Products & Technology; and Process & Construction. It is the largest maintenance, modifications and operations (MMO) contractor in the North Sea oil and gas operating zone. The organisation also uses a huge variety of products, services and technology in undertaking its activities of satisfying the demands for products and services by the oil companies operating in the North Sea; Logistics services and support, Well operations, Field Development, Project Management, Provision of Drilling and Completion rigs, Wellsite facilities and supervision,, Subsurface products and services, Management of third party inputs and service providers, Knowledge of field, and Wellbore construction engineering.

The demographic and operations characteristics of Aker Kvaerner are as follows:

- 3,200 employees.

- £365 million (turnover 2003).
- 15% UK Continental Shelf (UKCS) + 45% Norwegian Continental Shelf (NCS) Market shares.

With the above demographic and operations characteristics Aker Kvaerner is considered one of the largest integrated contractors operating in the North Sea Continental Shelf (UKCS).

6.4.5.2 Business strategies

Through project performance, understanding of customers' needs and alignment with those customers, Aker Kvaerner has developed integrated engineering services, specialist competence and efficient project execution methodology that enable it to deliver added value to its customers'.

Aker Kvaerner develops a range of solutions for the subsea challenges typical of the North Sea operations. Its diverse range of products and solutions can meet the requirements of the most demanding field development projects, including Front End Engineering and Design (FEED) studies, deepwater exploration and production;

Aker Kvaener believes that profitable growth is at the core of its strategy, as outlined in its vision and core values. Furthermore it believes that its vision and core values would be achieved through the excellent performance of people and teams in and around its work groups. Specifically in the North Sea, Aker Kvaener states that it possesses advanced technology acquired from operating in the North Sea and Gulf of Mexico oil and gas regions. Moreover its track record of ability to execute projects large and small in the world's most important offshore markets is well documented. Through learning networks, its collective expertise is put at the disposal of customers the world over.

6.4.5.3 Agile supply chains in Aker Kvaerner

Being an integrated contractor AK uses the project system of production flow. This is based on the fact that the nature of the product it manufactures is accomplished through teams drawn from organisations that are involved with the manufacture and assembly of the product. In terms of its operations Aker Kvaerner has an increased focus on global sourcing due to its location in almost all of the oil and gas regions.

Being a service provider and sub-contractor that is also involved with equipment supply, construction and fabrication for the oil companies, AK has a strong policy with respect to its human resources. Indeed, it has what it calls a pipeline model that underpins its strategy on its human resources. It states that the pipeline model represents its approach to managing the careers of its employees. The AK pipeline model consists of three tracks, Project, Business and Professional, represented in Figure 6.6.

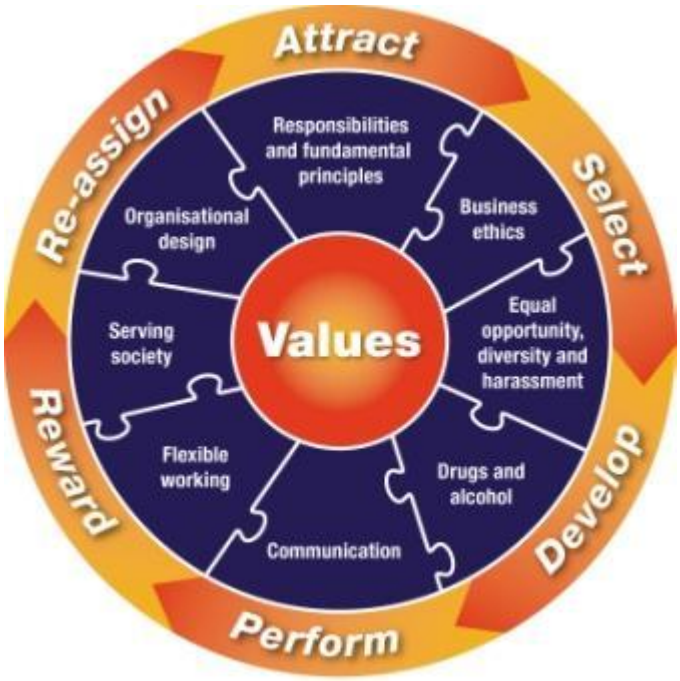

Figure 6.6: Aker Kvaerner's people policy (Source: AK internal document)

Figure 6.6 illustrates the people policy of AK incorporating the main elements of the policy. The key issues underpinning AK's people policy includes recruitment, development and appropriate reward through remuneration of the human resources within the organisation. These are further subdivided into core values which are composed of the following: Attract, Select, Develop, Perform, Reward and Re-assign.

The sub-values of the core values include the following functions and activities such as: Communication, Flexible working and Organisational design stresses the need for responsiveness of the supply chain and enhanced customer enrichment.

The overall core values of the human resources strategy of the AK are underpinned by the above six core values, the 6 core values were sub-divided into corresponding eight sub-values. The essence of the people policy is the underlying belief within the

organisation that its people constitute its most important assets to the extent that its employees are percieved to form the bedrock of its competitive advantage.

The novelty of AK's human reource strategy is the incorporation of re-assiging the manpower from areas of low utilisation to areas of high need whenever necessary. Due to the volatility of the price of oil in the global market, situations in which changes in the business cycle occur are not uncommon. Accordingly AK has also built in the need for flexibility of the workforce so as to cope with changes in the business cycle and its attendant impact on the manpower. Thus through appropriate job rotation and cross-training, the workers can be effectively reassigned from one job to another to reflect movement from areas from low requirement to areas with higher demand for the labour resource.

The process set-up adopted by Aker Kvaerner is the project set-up due to the main actiities of the organisation being Offshore engineering and construction.

Aker Kvaerner Offshore Projects Limited in the North Sea cuts cross the whole spectrum of the region from the Upper Northern North Sea comprising both the Norwegian and the UK Continental Shelf down to the Southern North Sea region. It also has activities in the Atlantic Margin which is the deep offshore area of the exploration and production of oil in the UK. Within the Norwegian Continental Shelf it has activities located at Bergen, Stavanger and Oslo, while in the UK Continental Shelf its activities are located in Aberdeen, Stockton, Immingham, Great Yarmouth and Solent. Figure 6.7 augments the previous information on the site location of the activities of Aker Kvaerner. It shows a map depicting the various sites of Aker Kvaerner's activities within the whole North Sea Continental Shelf, encompassing the two most active parts of the North Sea Continental shelf in terms of exploration and production of the oil and gas resources. Moreover it is apparent from Figure 6.7 that AK is most active in the UK part of the North Sea with five locations at Aberdeen, Stockton, Immingham, Great Yarmouth and Solent. Whilst Bergen, Oslo and Stavanger are the three sites in which AK operates in the Norway side of the North Sea.

In respect of the adoption of agility within its operations, the respondent to the case study, who is the Managing Director of Aker Kvaerner Offshore Partner Limited asserted AK values Speed and Flexibility in its operations. Equally it values responsiveness in its suppliers and the need for speed, flexibility and responsiveness is a major decision point in its sourcing for inputs for its products and services.

Figure 6.7: Map showing the location of Aker Kvaerner's North Sea activities (Source: Company published materials)

In assessing the importance of proximity in Aberdeen as a location in respect of the oil industry operations, the following response was elicited:

> "Even within Aberdeen, the location of a company is important to secure a job by oil contracting company, for example, Total specifically asks contractors and service providers to be located close to its facilities. Therefore for any contracting and service company that is located in a different part of Aberdeen it is impossible for it to win the orders from Total as long as it is not located in close proximity to its facilities"

Furthermore, in responding to the issue of proximity and the location in Aberdeen oil and gas cluster, he stated the following:

> "Generally the UKCS is among the most technically challenging and commercially competitive hydrocarbon provinces in the world. Thus Aker Kvaerner, the Norwegian global oil and gas contractor, has established a major hub here in Aberdeen." (Interview material).

The main drivers of performance in AK are speed, cost, profitability, Quality and innovation. Though in respect of the UKCS being a matured operating region the level of innovation may be at times low, nonetheless innovation within the region also goes to reduce the cost of operations.

To strengthen value creation, AK has adopted the following as the enablers to moderate its effort in value creation. These are empowerment, teamwork, ethical behaviour and transparency.

6.4.6 Case study company 6: Dynamic Equipment Company (DEC) Limited

6.4.6.1 Introduction

Dynamic Equipment Company (DEC) Limited is a UK company based in Aberdeen, Scotland, with annual turnover of £5million. DEC is an SME with a total workforce of 50 people. It was established in 2000, with a mission to supply the energy industry with a range of standard and bespoke mechanical handling equipment to ensure safe working practices, increased drilling efficiency with low maintenance. The company's engineering services are aimed at providing solutions to many of the mechanical handling problems associated with offshore and onshore drilling operations. Accordingly DEC introduces standardised and modular products that offer clients engineered solutions to many of the problems associated with today's demanding offshore drilling environment. A testament to DEC's business model and operation philosophy can be deciphered from its mission statement which is as follows:

> "Dynamic Equipment Company delivers practical solutions to challenging and mechanical handling problems, then they use those opportunities to build long term customer relationships to obtain repeat mechanical handling business" (Interview material).

For example, in order to deliver high quality service, from its beginning in 2000, Dynamic Equipment Company has acquired the latest in terms of technology, such as solid modelling packages to both promote and manufacture the complete "Dyna" range of products. This allows a high degree of flexibility in developing new products in the future with increased capability or functionality.

DEC also provides a wide range of engineering consultancy, design and project management solutions to the ever increasing demands of the industry. Furthermore, DEC asserts that its strength lies in its ability to work as a true partner to its clients and offer genuine "One Off" designs specifically to their requirements.

In respect of the need for flexibility and reliability of delivery as a competitive tool the respondent to the study notes as follows:

> "Our project management team work closely with clients, taking into account of the scope of work, personal safety integration material usage, design constraints, time schedule, delivery and installation deadlines."

As part of its quality achievement DEC achieved registration of its Quality Management System (QMS) to ISO9001:2000. The system will ensure consistency and improvement of their working practices, which will enable the company to provide products and services that meet its customers, requirements. Accordingly, the interview respondent at DEC felt that the registration "further demonstrate to our customers the level of commitment given in order to achieve our promise of quality and meeting deadlines".

6.4.6.2 Adoption of agility and impact of clusters within DEC

The case study reveal that this company leverage it's the knowledge possessed by its workforce in order to provide bespoke solutions to the its customers (mostly the tier 1 contractors). Indeed, according to the respondent who is the Sales Manager, DEC's most important resource and biggest competitive advantage is the highly skilled, knowledgeable and diverse employees of the company.

As an indication of the growth in its activities and due to the success of the company and the attendant increase in demand for its services, it has been necessary to double the size of the workforce to accommodate the scope of work being carried out. Moreover, as part of its commitment to provision of an excellent working environment, DEC gained the membership of the British Safety Council. Thus the Director of International Business Development asserts that:

> "Dynamic Equipment Company (DEC) recognised that the responsibility of its people comes first. Thus it turned to the British Safety Council for guidance. The result is a workforce from Senior Management down all independently showing examples of encouraging best practice in the workspace. They actively promote a positive Health and Safely culture and are implementing a Safety Management System in line with OSHAS 18001."

Since DEC as an organisation provides engineering solutions to its customers in the form of bespoke products and services, then it relies more on leveraging the impact of people aspect of the agility dimension.
The findings from the case study are summarised below in Table 6.5.

Table 6.5: Summary of Case study findings

Company	Supply chain practices	Visibility
1: Venture	Supply chain management implemented in terms of relationship management • Relationship management: supplier – buyer power • Active contract management • Operator & Co-operator • Pace not Perfection • High degree of reliance on contractors • Long-time contract with their contractors • Agility is a part of its operation strategy. • Contractor empowerment • Image management with contracting community	• FPAL database • Share Fair presentations • Benchmark organisation • UK Upstream supply chain management Network (SCMN) • UKOOA (membership). • SCCOP
2. Chevron	Supply chain management implementation • Relationships management • Client attractiveness • Supply chain interdependency • Contract relationship • Procurement and supplier relationships • Partnership and Alliances on shared logistics • Mostly operating on cost • Proactive business relationship • Functional integration	• FPAL database to prequalify contractors • Share Fair • UK Upstream supply chain management Network (SCMN). • UKOOA • SCCOP
3. AMEC	Supply chain management implementation • CRINE • Cycle time reduction • Innovation for timely completion of projects and cost reduction	• FPAL • Share Fair • OCA – Offshore Contractors Association • UK Upstream supply chain management Network (SCMN) • SCCOP
4. Aker Kvaerner	Supply chain management implementation • People issues; management and provision of highly competent people • People empowerment • Policy: EU policy on working practices • Uncertainty in the supply chain • Sourcing issues • Global sourcing • Speed • Security of supply • Lead time reduction • Global operations • Virtual corporation: 24 hour working model for Project Design Engineering	• Utilises FPAL to access potential suppliers • Share Fair • Membership of OCA • UK Upstream supply chain management Network (SCMN) • Involvement of suppliers in Project Front End Engineering
5. Dynamic	Supply chain management implementation	• Informal contact

Equipment Company	• Provision of Bespoke Engineering Solutions to Operators and Tier 1 contractors • People empowerment • Training and Teaming • Core competence management • Proactive response to requirements of customers •	• Direct selling • Track record/repeat order • Recommendation • Networking • Fair Share

Table 6.6: Result of adoption of agility attributes by case study organisations

Case company/organisation	Business drivers of change	Agility/cluster attributes adopted	Impact of location on agility	Competitive priorities	Business performance
Case organisation 1: Dti	Cyclical nature of business environment	Change behaviour of operators and contractors	Progressing partnership.	Ensure pre-eminence of UK oil and gas region: effective supply chain	Increased activity in UKCS. "Room for all need for all"
Company 2: Venture Productions PLC	Price of oil Cyclical nature of the oil industry	Pace, Speed and Agility is key	Proximity both Geograhically and Contextually	Strong Workforce agility, Teamwork	Agility leads to enhances performance.
Company 3: Chevron	Price of oil Demand for global oil and gas	Location not an issue,	Locational advantages have been exploited through Team Logistics	Cost, Speed, Proactivity, Innovation and novelty, Dependability, Reliability, Customisation	Profitability
Company 4: AMEC	Price of oil, Cost, Quality is given, On time Delivery, Global nature of industry	Transaction and transportation cost, innovation	Helps in terms of communication	Lower cost, Innovation, Proactivity Agility, North Sea Continental Shelf a complex oil region	
Company 5: Aker Kvaerner	Higher energy price, Market force, High cost business environment	Knowledge management, Virtual integration – 24 hour working model	Within its business it believes proximity is important: Supplier Hubs	Responsiveness Quality – First time right, Global Execution Excellence	Customer loyalty Return on Investment (ROI)
Company 6: Dynamic systems limited	Price of oil, Dynamic business environment - Delivery	Empowerment, Core competence, Collaboration	Very high need for proximity	Innovation, Delivery, Customisation, Quality, Reliability, Proactivitye	Customer loyalty, Market share growth, Turnover

6.5 United Kingdom Continental Shelf (UKCS) and North Sea Operatorship

A question in respect of the nature of market of the UKCS and the outlook and challenges faced by the region elicited the following response:

> "We continue to believe that operating capability and scale will drive sustainable value creation in the North Sea end game (2006 - 2030). To safely apply our capital in squeezing the last barrel out we have always believed that operating the majority of the assets we acquire is key; arguably, others in the North Sea have come around to this view too." (Interview materials).

There are currently about 135 participants in UKCS, 35 of which are operators involved in active development and production activities. However, it is estimated that the UK upstream oil and gas industry will consolidate to such a point that eventually there will be 3 to 4 "majors" (that is, major operators) holding the largest oil and gas reserves (otherwise referred to as "trophy assets" within the industry) and big infrastructures as well as 6 to 8 independents who are very focused on the maturing and niche sector of the UK North Sea oil and gas reserve. Although the remaining independent oil and gas operators do not possess the scale and scope of the majors, they possess enough scale to raise enough stable capital to keep developments going on a number of fronts simultaneously.

Figure 6.8 illustrates the operators active in the UKCS and it also indicates the corresponding ranking of the operatorships in their current production assets. For example it can be seen that there are three distinct groupings of operators, with the first two companies being the first group, the second group consisting of the next seven organisations, followed by the final third group. Two companies from the operators participated in the case study; the companies that were involved in the case study belong to the second and third groups of Figure 6.3. While one case study respondent is at the head of the 3rd group on the measure of the producing assets in the UKCS, the other is one of the leading companies in the second group.

Thus, with respect to the operating environment, as the above respondent asserted, capability and scale is among the main business driver in the UK North Sea oil and gas production activity. There is also the issue of sustainable exploration and production. Indeed, due to scale and capacity constraints it was observed that some of the majors appear to be building flexibility into their operations through new infrastructure such as, for example, expansion in pipeline infrastructure in order to provide capacity to

transport crude oil when needed. The need for flexibility through infrastructure availability is contingent on capacity constraints, especially in times of peak operations, when issues of capacity become critical.

According to Chevron, the outlook and challenges faced by the UK oil and gas industry in its bid to exploit the available reserves can be seen to be as follows:

> "I think with the oil and gas industry in Europe it has a very healthy future, I think there is a huge potential for developing fields in the West of Shetland Atlantic Margin region, it could be potentially as big as the North Sea. It is more hostile, deeper water conditions, but we're beginning to see a shift towards the bigger companies beginning to take positions in that area. There is still a healthy amount of reserves in the mature province in the North Sea which will be more and more developed by the small and medium size independents and the Royalty trust companies that are beginning to come in. I personally believe that there is a fairly healthy future. Supply chain management as a support function or service will be very necessary for most of the companies who participate in the sector in this region, so I think things are still very positive actually. Internationally I think we'll see bigger fields developed and focused on by the major oil companies; there will be a lot of emphasis on that. You will see strategic alliances formed, especially across Europe – Eastern Europe with the demand for gas and the huge reserves that are there. It is going to continue to be a very interesting industry and a challenging industry to work in. And wherever there are projects of the magnitude and scale that the oil and gas industry seems to bring and the complexities of supply chain issues and support to those projects, there will continue to be a need for supply chain practitioners, so again a very healthy future for supply chain management or indeed any discipline that is loosely involved in supply chain management, such as Quantity Surveying, or Purchasing or Legal or Contracts, these types of areas and I think also the scope for people from outside the existing oil and gas industry to come in and apply their skills is very much there going forward."

Another aspect revealed by the case study is the issue of real demand presented to the supply chain through the share fair. Share fairs are organised by the Operating and Contracting firms (who are the buyers of goods and services) to present a forward plan

of their forecasted expenditures within the coming 18 months. This forward plan represented by the forecasted expenditure and the detail of the outlay of expenditure offers an opportunity for potential service providers to present their competencies and services they wish to offer targeted in the specific areas that have been highlighted by the customer communities.

For example, in respect of supply chain opportunities within the Aker Kvaerner operations, the following areas were enumerated in the Aberdeen share fair of 2007 to represent potential areas that companies interested in working for AK should look at.

1. Offshore logistics and onshore base support
2. Decommissioning and Refloat studies
3. Platform shutdown and Decommissioning
4. Plugging and Abandonment of Wells
5. Subsea Engineering and Diving Works
6. Specialist Engineering & Environmental Services

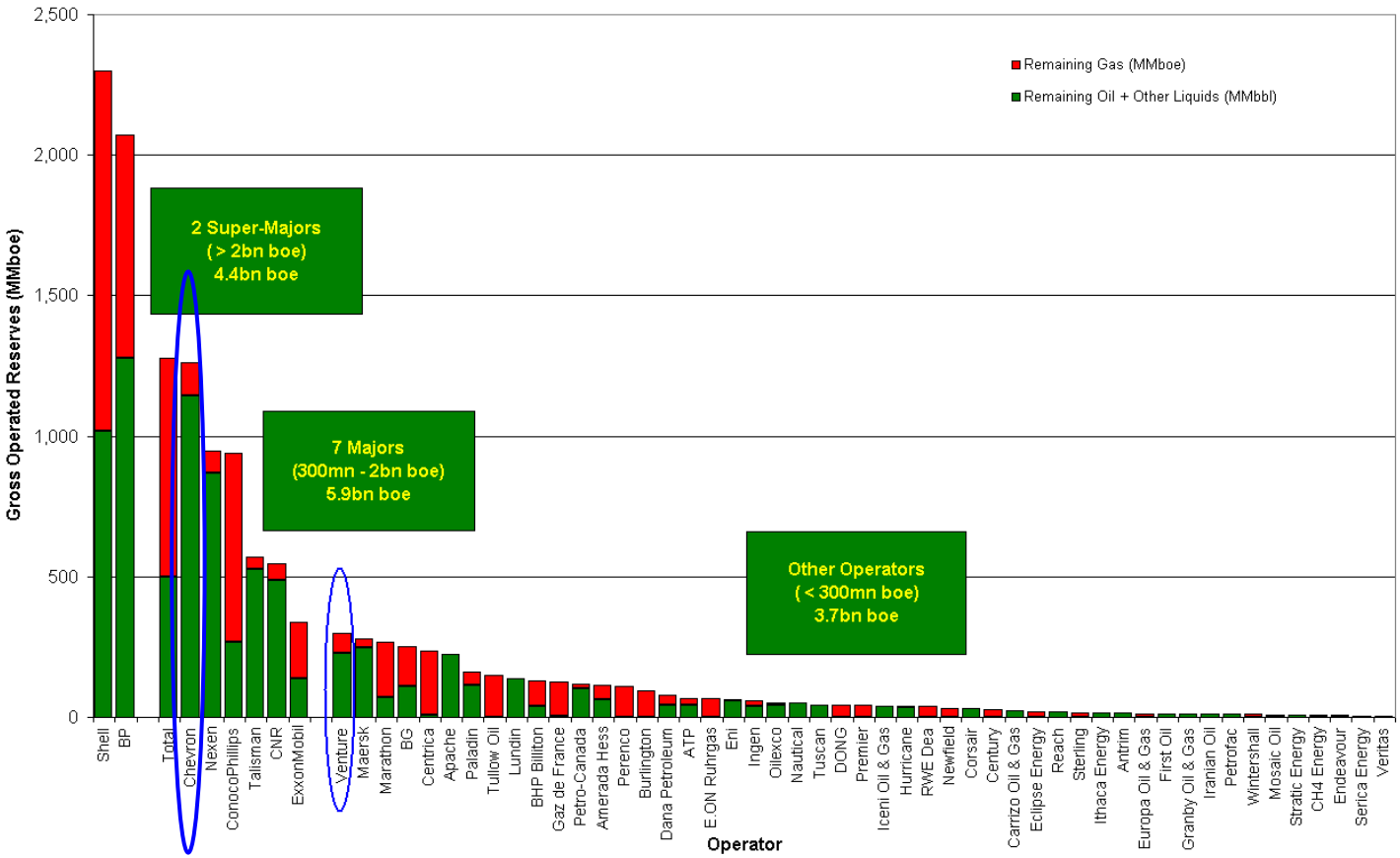

Figure 6.8: UKCS Gross operated reserves by operator as of 2005 (Source: Interview material)

6.6 Discussion

The responses from the case studies indicate contract management and relationships management as the dominant themes within the supply chain. Relationships management arose within the contract management, as well as the choice of appropriate relationship by the buyer in order to secure the services of the seller based on the dynamics of the business environment, which affects the nature of power balance within the supply chain. An earlier study of capabilities in the UK upstream oil and gas industry (Finch, 2002) found that the industry business cycle determines where power balance resides in the supply chain, in that different opportunities arise during business cycle that affect the balance of power in the industry. The oil industry business cycle is approximated by drilling rig rates and price of oil which consequently make decision makers to be reactive in their decisions. However a proactive organisation like case company 2 have adopted a supply chain strategy that will enable it to be competitive especially in a sellers' market.

Additionally, the case study also revealed that within the supply chains studied there is a high level of partnering and alliancing existing between organisations in the course of undertaking their businesses and activities. Indeed, partnering and alliancing is sanctioned and monitored by the industry body – DTI. Interviewed managers indicated that partnering and alliancing, with the aim of accessing the available core/complementary competencies within the Aberdeen based oil and gas cluster, was adopted as part of value chain integration. Within the industry, exploration and production activities may be arranged between operating and services companies through invited tender/sealed bid auction method or through alliances. The independent oil companies, who account for a third of operators, as shown in Figure 6.8, adopt alliances with the operating companies as the interview revealed, while the majors adopt the invited tender/sealed bid in the first instance and then over time move to alliances. Perhaps, as was observed by Finch (2002), they did not embark upon forming alliances so as to manipulate the contract for maximum commercial benefit.

However, it is worth noting that the main driver for the collaborative working within by oil and gas operating firms is the need for reducing the cost of oil and gas exploration, development and production. Hansen and Nohria (2004) contend that the drivers of organisational collaboration are cost, heuristics (that is the need for better decision

making), revenue enhancement, innovation and capacity for collective action. However, they observe that where organisations collaborate solely for cost reduction, the potential to exploit the other more salient advantages may not be pursued. This was highlighted by one of the interviewed managers of a contracting company, who stated that:

> "Cost Reduction in the New Era (CRINE) is industry driven because of low oil price. But now they are saying that they have probably cut cost back too far so looking back they are now paying for it in terms of poor maintenance and poor productivity." (Interview)

Thus, although the industry recognises the counter effect of being fixed on efficiency yet cost constitutes a dominant business driver.

This section reveals the nature of organisational arrangement adopted within the industry and the attendant impact of business drivers.

6.6.1 Impact of clusters on the agility of oil and gas supply chains

It has been suggested that enhanced competitiveness can be attained by looking beyond the individual firms to clusters of firms. Firms are related to each other as customers, suppliers and competitors and in some cases even as co-operators to build common talent, technology and infrastructure (Waits, 2000). Waits (2000) also indicate that strategies, policies and actions to strengthen the interrelationship and specialized support base will benefit the entire cluster and therefore are much more likely to affect the overall competitiveness of state and regional economies than are efforts to aid single firms. Additionally, clusters have been identified in meeting the challenges of customer input, responsiveness, accessibility, coordination and scale. Moreover as a collection of similar or related businesses, clusters provide a critical mass of customers making them a good incentive for various supplier organisations to integrate and coordinate their services, or even bring them closer to the cluster, rather than requiring businesses to seek them out (Waits, 2000).

Generally the case study companies observe that being in clusters enhanced their competitiveness. Case company 2 stated that the proximity in clusters is a source of competitive advantage due to the fact that "technology start to trade...processes get better and better".

Enablers of cluster agile supply chains based on the case study were found to include the following:

- Improved internal competencies will be critical factor in meeting new customer demands, for example case companies Venture Production PLC and Dynamic Equipment Company.

- Being technically aware and understanding the operations of the customer as is evident from a respondent to the question about core skills and competencies needed by potential suppliers:

  "Our activities involve large projects, and engineered Products are specialised and bought by the project teams. Commodity/consumer items are bought by our central procurement teams. So you need to know the project buyers"

- Ability to exploit industry bodies and networks, such as FPAL, Achilles, LOGIC, and Share Fairs – essentially being visible and creating visibility of demand to enable potential suppliers to respond.

- Moving up the value chain by offering a broad range of service. Figure 6.2 shows the characterisation of the core value stream in the supply chain.

- Responsiveness and Flexibility offer competitive advantage – especially for new independents oil and gas operators.

Main inhibitors to adoption of agile supply chain attributes identified by responding case study organisations were:

- Relationships between the players within the industry indicate lack of direct access to the customers/buyers by the lower tier members of the supply chain.

- There are issues affecting the nature of doing business in the industry in respect of design and production of parts and practices; codification of practices and standardisation of parts and activities will lead to reduction in cost of doing business in the industry.

- The super majors – major operating oil companies see the lack of global reach, especially the SMEs as a constraints and limitation on their part. This in an environment in which the customers increasingly require global reach by their suppliers. This is with the view that since most of the customers and the tier 1

integrated service providers are multinational corporations they also will want a situation where they can move with their supply chain whenever they need to be in a new business environment.

- Lack of understanding the industry by the service providers; especially the SMEs do not have an understanding of the oil and gas industry which affects their ability to sell their product and services to potential buyers.

- Differentiation: Lack of differentiated service by the SMEs.

The oil and gas industry has witnessed changes that led it to embrace outsourcing of activities by the oil and gas operating majors so as to enable them cut costs and concentrate on their core activities or competence. With the outsourcing of non-core functions by the operators, the contractors have formed associations in a bid to provide a one-stop shop that will undertake the tasks of the operating majors – in such a way as to provide an economy of scope by having all services provided by one body, so as to reduce the transaction costs of dealing with many suppliers. This has necessitated that operators go into special relationships with the contractor groups through partnering or alliances so as to achieve a JIT supply (Cookson and Ogden, 1998).

6.7 Summary

This section presents the results of the case study in which companies among the three tiers of the oil and gas industry supply chain were interviewed to determine the extent of diffusion of agile supply chain attributes within their supply chains. Additionally, the case study also tried to establish the impact of being in industrial clusters – in this case the oil and gas cluster – on speed, flexibility and responsiveness and overall agility of their supply chains.

In carrying out this case study, the choice of site for the study is deliberate because the oil and gas industry, as an extractive industry has to be situated where the resource is and all the organisations that are involved with the industry will be located there.

The case study was preceded by a survey by questionnaire. The result of the survey by questionnaire demonstrated that there is minimum impact of industrial clusters on the competitive dimensions and business performance of organisations. However the same organisations indicated that adoption of agile supply chain attributes impacted on their competitiveness and business performance. Furthermore the survey indicated that there

is insignificant effect of clusters on the agility of an organisation, although there were significant relations between the benefits of being in a cluster – such as skilled labour pool, specialist firms and local information networks (Cumbers and MacKinnon, 2004). In light of the findings of the survey, the case study was carried out to give further insight into the result of the survey through a context-based in-depth study of the same phenomena.

The road to achieving industrial clusters is multidimensional. For example industrial clusters can derive their existence to the presence of the natural resources in the location such that companies from the industry that is involved with the extraction, development and processing of the resources will congregate to undertake the activities within the industry. As well as the presence of natural resources in a particular location, industrial clusters could also arise as a result of the strong entrepreneurial exploits of opportunities at a particular place or business environment, the characteristics of a location such as abundance of infrastructure or labour availability, or the presence of an existing cluster that stimulates more activities in similar or complementary activities. A strong and competitive industrial cluster will have all that is needed within it in terms of the requirements of the organisations and firms that are located in it. Looking at the Aberdeen oil and gas cluster, it can be stated that if it is a strong competitive cluster then there will be availability of all that is needed. However, even if everything is present if quality is poor it is necessary for reasons of competitiveness, to source the missing capability from outside the cluster.

In light of the need for a strong and competitive cluster, it is apparent that Aberdeen as an oil and gas region will face challenge from emerging regions that can boast of the presence of higher hydrocarbon yields or the presence of high quality manpower. These are the two critical challenges to Aberdeen cluster as the moment. The high cost of finding oil in Aberdeen and the lack of labour are issues that were highlighted by all the respondents to the case study. Moreover, some of the integrated contractors stated that as an organisation they have adopted a policy of global sourcing and by implication there is a reduction in the amount of locally sourced inputs. However all the respondents agreed that the Aberdeen cluster is taking measures, through initiatives such as supply chain effectiveness to retain its pre-eminence as an important oil region globally. Furthermore, the Aberdeen oil and gas cluster derives immense benefits from the industrial cluster concept and agglomeration of firms serving the industry.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter presents the conclusions drawn from the research; it starts by restating the research aims and objectives, research methodology and major tasks undertaken. In addition, by way of conclusion, research hypotheses and the grounds for their validation and acceptance are reiterated. The chapter also outlines the contributions of the study to theory and practice as well as enumerates the limitations of the research; finally suggestions for further study are made.

7.2 An Overview of the research

The primary objective of the research was to study the diffusion of agility attributes within established industrial clusters as well as attempt to demonstrate the impact of being in industrial clusters on agility of a supply chain. Furthermore the study sought to justify agility as a means of attaining competitive advantage and enhanced business performance. Four dimensions of agile supply chain attributes were discussed in the thesis. The four dimensions were customer enrichment through offering solutions rather than simply products, Cooperation between complementary equals, as well as, even with competitors in order to enhance competitiveness, Mastering change and uncertainty through process integration and Leveraging the impact of people and information through employee empowerment and sharing real demand information.

In order to test for the impact of being located in industrial clusters on agility of supply chains, a survey by questionnaire and six industrial case studies were undertaken. The survey and case studies collected data from companies on their supply chain practices, location and cluster dimensions, and attainment of competitive and business performance objectives. Based on the empirical evidence collected, statistical analysis was carried out to test the hypothesis that location and cluster factors have impact on both the competitive objectives and business performance, as well as impacts on the agility of a supply chain. Furthermore the data was tested to show that the dimensions of agile supply chain have impact on competitive objectives and business performance.

Prior to the empirical and field work for data collection, an extensive literature review on agile manufacturing and production systems and management was carried out to trace the evolution from the single plant focus to supply chain management, thus

demonstrating the need to take into account an extended supply chain view rather than focus on a single plant or organisation. However, the production model recently evolved into the agile supply chain (Christopher, 2000). The agile supply chain emerges as an organisational orientation to mitigate increase in market instability and product complexity. Furthermore explained was the concept of industrial clusters within the operations management arena as a production system so as to look at its link with established area of supply chain management (Bartezzaghi, 1999; Carbonara et al., 2001).

As part of the evolving production management revealed, lean production which supplanted mass production was underpinned by managing through achieving a level schedule which becomes intractable in conditions of change and uncertainty in demand character of the contemporary business environment. Thus, agile manufacturing was born as the new competitive manufacturing paradigm (Vokurka and Fliedner, 1998). Whereas Lean production strives to attain level schedule, Agile manufacturing benefits from the unpredictable customer demand by investing in structures for real time mobilisation of global resource capabilities and tapping temporal opportunities. Indeed, previous production management methods such as mass production and lean production are not competitive tools any longer given the fast pace of change in the emerging business environment. Accordingly, being able to enrich a business environment that is fickle, volatile and unpredictable requires capabilities that are beyond a single organisation. Hence, companies should master change by seeking competitive advantage through collaborating with the supply chain. Thus, the need for agile supply chains was justified by the literature review as a means of attaining competitive objectives such as Cost, Quality, Speedy delivery, Dependability, Flexibility, Innovation, Proactivity and Customisation.

Equally, the literature review argues that location within clusters and industrial districts can offer opportunity for enhancing the agility of an organisation. Furthermore, cluster firms have a higher performance relative to spatially dispersed firms due to several inter-firm linkages, which include access to inputs such as highly skilled labour, information spillover, complementary goods and services, as well as high propensity for cooperation and competition, all of which goes to enhance the productivity of the cluster based organisation. Similarly, as a result of co-location of supply chain members, it was argued that cluster members can derive cost advantages such as low

transportation and transaction costs. This is due to the reduced spatial distance and close geographic proximity of members. Proximity enables frequent and sustained face-to-face contact between transacting organisations. Indeed, clusters and industrial districts have been postulated as a production model (among the industrial organisation methods) by their proponents. Thus, within this research a synthesis of the two paradigms was attempted by proposing that being in clusters will enhance the collaborative potential of organisations, which results in enhancing the agility dimensions such as cooperating to enhance competition.

The literature review also points to issues and limitations arising from the concepts of agility and cluster. Thus, in respect of agility, it was contended that rather than saying that it is a clean break from the past production systems, it indeed encompasses aspects of past systems such as lean production, blended with techniques for surviving market instability induced. Equally, in respect of the industrial cluster conceptualisation rather than being grounded in rigorous empirical study to demonstrate its efficacy, it is presented as a policy prescription targeted at solving all problems of productivity and regional development by policy makers. Moreover, most of the empirical studies on clusters are case studies that attempt to measure functional dimension of clusters such as agglomeration forces. Thus, the main critique of the current cluster postulation is the lack of empirical study that attempts to operationalise it in terms of business performance that includes financial and customer based measures. This study has measured the impact of clusters on financial and customer based business performance.

Finally, the literature review studied the nature of competitive objectives and business performance. It was argued that companies should extend emphasis from cost and quality to higher order objectives such as product customisation, flexibility, proactvitiy, speedy delivery, dependability and innovation. The evidence was tendered that flexibility was the most difficult competitive objective to attain and that it demands precise targeting by the agility dimensions. The nature of business performance objectives was also reviewed. Three broad dimensions were identified as financial and market based. The conclusion was reached that adoption of the agility dimension would enhance simultaneous attainment of competitive objectives, which in turn would boost business performance outcomes.

A conceptual framework was developed consisting of four concepts namely, dimensions of agile supply chains, industrial clusters, competitive objectives and business

performance objectives. The synopsis of the conceptual model is that being in an industrial cluster enhances the agility of a supply chain and that higher adoption of agility enablers is a requisite for enhanced competitive attainment of competitive objectives and in turn higher business performance. Based on this, six research hypotheses were proposed to test the validity of relationships specified in the conceptual framework.

A survey by questionnaire was conducted with a questionnaire administered to 880 companies selected randomly from a wide range of industries. Ninety five companies provided useful data, the analysis and results of which were used as a basis for making inferences and reaching conclusions. The survey results validated some aspects of the six research hypotheses and therefore certain aspects of central argument espoused in the conceptual framework. The survey results confirmed that a significant relationship existed between being in clusters and the agility of a supply chain, and that adoption of agile supply chain attributes enhances competitive advantage. Equally, a significant relationship was also identified between agility (which the study defined as simultaneous attainment of competitive objectives) and attainment of business performance objectives. In contrast, for the non cluster based firms there was insignificant relationships between the cluster dimensions and agility. However, both the cluster and the non-cluster based organisations show significant relationships between the agility attributes adoption and competitive objectives and business performance.

In order to test the validity of emerging results in different settings, six in-depth case studies were conducted. The variables used in the survey were extended into more minute details in order to explain the survey findings and address aspects of the research findings which were not positively influenced by the agility enablers. For the case study triangulated data collection was adopted in which qualitative data was collected through interviews as well as secondary sources. Qualitative data illustrates and reveals processes but it does not test or prove relationships as well as quantitative data. Thus the case story may serve as illustrative background to the study or provide a qualitative contextualisation of the study and in-depth exploration of the findings from the questionnaire survey. Accordingly the case study findings validated the survey results and identified specific cases within the case study organisations in which the location

was leveraged for enhanced business performance, cost reduction, and attainment of speed, flexibility and responsiveness.

7.3 Validation of research hypotheses

The purpose of this research is to examine the agile supply chain management dimensions adopted by the UK upstream oil and gas industry cluster as well as the impact of clusters on the agility of the supply chain. Three research questions were enacted to guide the research effort. To answer the three research questions, six research hypotheses were crafted and tested using the data from the survey and case studies. The hypotheses and bases for validating them are as follows.

Hypothesis 1: There is a strong relationship between agile supply chain attributes and business performance.

The prevailing business environment has been described as characterised by change and uncertainty. Effective management of the supply chain to overcome the change drivers is now seen as key, as the prevailing change drivers have been seen to threaten business performance. Accordingly, an agile supply chain is seen as an indispensable means of limiting the threats arising from change and uncertainty as well as profiting from them. Thus, a way to test whether an agile supply chain indeed profits from the change is to measure its correlation with business performance and that gave rise to hypothesis 1.

Hypothesis 1 was tested and supported using tests for correlation amongst the agility attributes and business performance. The scores by companies on the scales employed to capture data on each of the two concepts were aggregated into summary scores and tested for correlations between the study constructs. The correlation coefficients indicated the strength of relationship amongst the two concepts. The results showed that the relationship between agility attributes and business performance was strong. Equally the case studies supported the survey findings. The case companies studied agreed that the cyclical nature of the business environment in the industry imposes uncertainty on the organisations, as well as various levels of risk. According to Vokurka and Fliedner (1998) organisations undertake numerous initiatives such as partnerships, supply chain performance improvement, teamwork and cross-functional management teams and business process reengineering to be agile and enrich the customer. Most of the case study companies reported combinations of the initiatives highlighted by

Vorkurka and Fliedner (1998) in their bid to be competitive and reported enhanced business performance. Indeed, the case study revealed that there is an industry-driven initiative targeted at improving supply chain effectiveness. The dominant issues under consideration, by the initiative, are the need to change traditional adversarial form of working to collaborative one, workforce utilisation through enhanced competence such as training and empowerment.

Hypothesis 2: Companies that pay simultaneous attention to a wide range of manufacturing competitive objectives leads to enhanced agility.

Based on the justification of hypothesis 1, Hypothesis 2 also measures the competitiveness of the organisation in light of the impact of agile change initiatives. The data provided the evidence that relatively equal attention to a wide range of competitive objectives enhances business performance more than focusing predominantly on a narrow range of competitive objectives (Meredith and Francis, 2000). As with hypothesis 1, this proposition was also tested by bivariate correlation between aggregate agility and aggregate competitive objectives. Equally the different competitive objectives were correlated with the four dimensions of agile supply chains. It was shown that Innovation and Speed posted the highest correlation with Master change and uncertainty and Leveraging the impact of people and information respectively. Table 5.17 shows the details of this result. Furthermore, Proactivity and Speed correlate with all the four dimensions of agility while Delivery, Quality and Innovation correlate with three dimensions, similarly, Cost and Flexibility correlating with Customer enrichment.

Hypothesis 3 Being in a cluster will be related to competitive dimensions.

Hypothesis 4: Being in a cluster will be related to business performance.

Hypotheses 3 and 4 constitute part of the research questions posed in this study. The two hypotheses purport to demonstrate the possibility of attaining competitive advantage and business performance when an organisation adopts some agility attributes and is situated in an industrial cluster. Moreover, theoretical discussion from a firm strategy perspective suggests that being in an industrial cluster benefits firms from strategic resources, organisational routines and collective knowledge (Molina-Morales,

2001; Hervas-Oliver and Albros-Garrigos, 2007), and that these shared resources and capabilities may yield returns in terms of enhanced competitiveness and business performance. Thus the proposition that being in clusters enhances the competitiveness and business performance of an agile supply chain was tested. The two hypotheses are tests of the impact of clusters as a construct on the competitiveness of the studied organisations and business performance in terms of both financial and non-financial performance. Furthermore, the results of the same two hypotheses were validated by the findings from the case studies. For example in case company 2, proximity through co-location and intellectual proximity through relationships that conferred sustained competitive advantage of being a customer of choice even in a sellers' market when scale diminishes in value. Equally case company 6 contended that proximity accorded it the ability of being responsive to customer needs while case company 5 also stated that for specialist services being clustered around is very important. Overall, the statistical analysis reveals that being in clusters impacts on the agility of the organisation in terms of attainment of competitive objectives. Indeed all the nine competitive objectives correlated significantly with agility dimensions. Thus, the importance of geographic proximity on competitiveness is that local suppliers they differentiate by fast Delivery, which also enhances their Dependability. This demonstrates that being in close proximity enables some organisations to attain time-based competitive objectives. Furthermore, evidence of impact of being in clusters on both financial and non financial performance objectives were also suggested by some of the respondents. For example, case company 2 pointed to the profitability of his organisation, by immediately going online to check, the company's share price on the London Stock exchange. The level of the share price was argued to have been determined by the competitive strategy adopted by the company.

Hypothesis 5: Attainment of competitive objectives is related to business performance.

The hypothesis provided the evidence that relatively equal attention to a wide range of competitive objectives enhances business performance more than focusing predominantly on a narrow range of competitive objectives. Earlier studies on manufacturing strategy have linked competitive objectives such as cost, quality, delivery and flexibility to business performance. Hypothesis 5 was tested through

correlation analysis as well as regression analysis. The correlation analysis shows that there is a positive significant relationship between business performance and competitive priorities. Equally the regression coefficient between competitive objectives and business performance shows that there is a significant positive effect of competitive objectives on business performance. However this explains very little (7%) of enhancement of the business performance. So, taken together, the correlation and regression analyses test indicated that hypothesis 5 can be accepted and in effect attainment of competitive objectives can lead to enhanced business performance.

Hypothesis 6: Being in industrial clusters affects the agility of a supply chain.

The central argument of this hypothesis is that for an organisation that is in close proximity to upstream and downstream members, its supply chain can enhance the agility of the whole supply chain. In contrast non-cluster-based firms are distant from a cluster or they do not see themselves as part of a cluster at all. After classifying the data, correlation analysis was then carried out to test the relationships between the clusters and agility factors for the two groups of data i.e. the proximate and dispersed. The correlation analysis shown in Table 5.8 shows that the cluster based firms posted a significant strong positive correlation between the agility dimension and cluster factors, while the data from the dispersed respondents indicated a non significant correlation between the two variables. Accordingly, this shows that being in cluster can affect the agility of a supply chain. Moreover, another data set was computed cluster agility attributes were tested for correlation with competitive objectives and business performance. Significant positives correlations were indicated between the cluster agile supply chain attributes and attainment of competitive objectives. Similarly there was significant positive correlation between cluster agile supply chain attributes and business performance.

In light of the empirical evidence from the survey by questionnaire and case study in chapters 5 and 6 respectively, the six research hypotheses proposed in chapter 4 were validated. Table 7.1 summarises the tests of the hypotheses that were carried out within the survey by questionnaire and in-depth case study of some of the firms that were surveyed. However, Table 7.1 should be read in conjunction with the conceptual framework of the research presented in Figure 4.1. As can be seen, Table 7.1 shows all the hypotheses and the specific results of the data analysis that support the hypothesis.

Equally, it can be seen that all the hypotheses proposed have been supported from the data. Furthermore, support for hypothesis 5 there was found from the case study phase. All case study companies except company 4 observed that being in a cluster enhances their business performance. On the other hand, due to the empirical evidence presented, the relationship between being in industrial clusters and competitiveness cannot be wholly refuted as well, it can only be stated that further research needs to be carried out.

Table 7.1: Summary of the results for the research hypotheses tested

Research questions	Expected relationship	Relationship found	Outcome of test
H1a	Adoption and diffusion of dimensions of agility into oil and gas cluster	Yes (Table 5.10)	Supported
H1b	Being in industrial clusters affects agility dimensions	Yes (Tables 5.11, 5.12 and Figure 5.13 chapter 5)	Supported
H2	Agility diffusion leads to enhanced competitiveness	Yes (Tables 5.7, 5.8, 5.9, 5.18, chapter 5)	Supported
H3	Being in clusters is related to attainment of competitive objectives	Yes (Figure 5.14, Tables 5.40, 5.41)	Supported
H4	Agility dimensions is related to business performance	Yes (Table 5.13)	Supported
H5	Being in clusters leads to enhanced business performance	Yes (Tables 5.35, 5.36, 5.41)	Supported
H6	Attainment of competitive objectives is related to business performance	Yes (Tables 5.7, 5.8, 5.39, 5.40, 5.41)	Supported

7.4 Contributions

Agile supply chain is seen as the mode of gaining competitive advantage in an uncertain and dynamic business environment. For example in assessing the evolution of agile supply chains, Ismail and Sharifi (2006) contend that supply chains need to be designed incorporating flexible mechanisms to respond appropriately to changing dynamics of the business environment. Unfortunately the current exposition on agility of a supply chain is at best limited in terms of empirical verification especially in a cluster based organisations; thus it is imperative to study factors that contribute to agility. This study explore and highlight the facets of agility so as to act as a guide in designing supply

chains that will possess the necessary agile capabilities to cope with changing business environment. Specifically the results of the study make important contributions to knowledge in the following:

In respect of the first research question which concerns the impact of being in clusters on the agility of a supply chain. This study found that geographic proximity as in clusters affects the agility of supply chains. The study found strong significant correlation between competitive objectives of speed and cluster location. Speed impacts two agility dimensions i.e. "master change and uncertainty" and "enriching the customer". Additionally the networking that arises due to proximity also enhances ease of tacit knowledge exchange which enhances innovativeness. Equally the case study reveals that the close and intense buyer-supplier linkages derived from proximity leads to steady technological upgrading in the supply-base, close coordination for just-in-time deliveries and flexibility in the face of market volatility (especially in times of falling oil price) that allows for redeployment of workers and suppliers on short notice. Thus, the study has demonstrated that the industrial cluster concept benefits supply chain attainment of competitive objectives as well as enhanced business performance. It has shown the positive impact of operating within an integrated supply chain in a geographically concentrated cluster. Furthermore, this study has established a linkage between the industrial cluster theory and supply chain management theory by showing the evidence for cluster impact on agility dimensions as well as supply chain management practices.

In respect of research question 2, the impact of geographic proximity on competitive objectives was also revealed from the results of this study. This illustrates the advantages for firms who are in close proximity to their suppliers and customers, leading to reduction in cost, lead time and increase in quality and innovation. Furthermore, the impact of clusters on competitive objectives is also illustrated by case company 2 having reduced lead time in purchasing decisions, while company 6 had reduced transaction cost, enhanced quality and innovation respectively. Additionally the study corroborates Goldman et al's (1995) assertion of the impact of dimensions of agility for enhancement of competitive advantage, by finding that "customer enrichment" and "mastering change and uncertainty" could be deployed by organisations especially in markets characterised by rapid changes and uncertainty

which goes to increase the inherent risk of the business environment. Furthermore proximity enhances organisations ability to master change and uncertainty, since closely located suppliers to customers compete effectively through quick delivery and enhance proactive response of organisations in a dynamic business environment.

This study has shed light on the oil and gas industry. This is important because the industry is in transition and insights from application of supply chain management in other industries may be inadequate for implementation in this industry. The study has provided an oil and gas cluster map showing the main players and the type of networking existing among them, as well as the relationship between the tiers of the supply chain and the product value stream. Moreover results from the case study reveal fragmentation of the supply chain such that successful organisations adopt organisational arrangement that is based on "relational production networks" (Sturgeon 2003; 210) that adapt to volatile markets as well as the agility to meet the requirements for short lead times, fast delivery, small batch sizes, and quick market entry and exit.

The important contribution is as follows:

The practical significance of this study is the demonstrated value of clusters as an enabler of agile supply chains that leads to attainment of competitive advantage in terms of reduced cost and responsiveness of the supply chain, as well as increased business performance. However, there is a need for this study to be extended to different clusters and industrial settings such as automotive industry clusters and food and drink clusters to gain more insight. The attempted investigation of the value of clusters in the agility of oil and gas supply chain is unique. The research has shown that through easy access to specialised labour, specialized knowledge and associated inputs, being in a cluster correlates with competitive objectives as well as business performance.

Whereas agility impacts on competitive dimensions and business performance, clusters only impacts competitive objectives but do not affect business performance. However agility has a higher level of impact on competitive objectives than clusters. Although Goldman et al (1995) argue that the four dimensions of agility all impact competitiveness; results from this study reveal that organisations significantly place less emphasis on enriching the customer which is the essence of being agile. Perhaps this could be explained by the fact that organisations are taking incremental step to

implementing agility dimensions by first concentrating on upgrading their internal capabilities and competencies (which include agility dimensions of "cooperating to compete", "master change and uncertainty" and "leveraging the impact of people and information") before acquiring and deploying "enriching the customer" which is an outward focussed agility dimension.

Nevertheless whilst findings from this study indicate that most organisations have implemented significantly the other three dimensions of agility such as intra and inter organisational cooperation through team working, alliance and partnerships; master change and uncertainty; as well as effective utilisation of people and information, it is also evident from the field study, that the best performing organisations (exemplars) are those few (as shown by the case study) that in addition to adopting the three internal capability focussed agility dimensions also adopted outward looking agility dimension of customer enrichment. Thus, while this study found impact of aggregate agility dimensions on business performance and competitive objectives, there is the need to explore through further studies the effect of internal and external agility dimensions on business performance and competitive objectives.

Additionally this finding corroborates an earlier empirical study by van Hoek et al (2001) in which they found that there is modest diffusion of agile supply chain within the UK and European organisations whilst the results from this study demonstrate marked adoption and diffusion of agility dimensions within the UK upstream oil and gas supply chain. Furthermore evidence from the case study revealed that the more agile organisations utilised information systems as well as relationship management as to augment decision making. More agile organisations indicate that ability to reduce lead time of decision making improves the agility of their supply chains. This in turn impacts the attainment of competitive objectives of the agile organisations.

Finally the result of this study can be summarised as showing that industrial cluster firms can drive enhanced speed and flexibility through exploiting advantages such as access to high quality information, labour and co-operative exchanges that enhances operational performance and competitiveness.

7.4.1 Managerial implications

The business environment of the oil and gas industry is characterised by the pressures arising from sources that include oil price which is subject to swings, the need to deliver top performance of assets such as oil wells and the acquisition of critical inputs such as drill rigs, vessel and subsea products and solutions, as well as labour and manpower needs. These needs are aimed at attaining overall supply chain effectiveness. At the same time the UKCS has to compete with other oil and gas regions for access to these inputs. However, the UKCS is both a high cost region as well as having a mature oil and gas asset. Hence, reduction of the costs of operating the existing oilfields will substantially extend the operating life of the oilfields. Accordingly, return on investments in the UK continental shelf will be attractive and new fields will continue to be developed. Moreover, where a group of companies or individuals need to work for a common goal or objective within constraints of time and cost, they are more likely to succeed if they work in a collaborative rather than adversarial manner (Barlow, 2000). Furthermore, a cardinal principle of collaborative relationship is the need for all parties to work for the objective of improved overall performance (Hamel et al., 1989; Hansen and Nohria, 2004). In this case improved performance requires that client and contractors work on activities that increase value rather than costs. In order to have a shared objective for collaborative working, the gain must be clear to all the players within the collaborative working environment. In other words, it must be apparent for all the players participating in the collaboration that there is a gain for them.

The UK upstream oil and gas industry is a matured oil region with the most difficult oil production conditions in the global oil industry. Collaborative working will reduce costs and enhance the ability of extracting more oil from the denuded oilfields. Thus, the findings from this research will inform managers in light of the above business environment by pointing to specific factors to concentrate on in order to attain specific competitive objective as well as business performance. The following are some of the specific insights drawn to aid in managerial decisions:

- The results of the study have demonstrated that exploiting networking opportunities such as informal contacts as sources of information can enhance market share, for example. Indeed one of the respondents from the oil companies stated that contract opportunities are not advertised; hence alternative sources of

information about the industry need to be visible to the customers. Thus, active participation in the industry Share Fairs is important. Moreover, the result of the study found that Share Fairs and informal contact enhance attainment of competitive objectives of Innovation and Dependability respectively.

- Within the industry, there is a perception that cooperation with competitors has a negative impact on market share and customer loyalty. This is due to the fact that generally, collaborating members feel the risk of loss of proprietary knowledge through collaborating on innovative product solution for a customer. However, results from the correlation analysis show that collaborating with complementary equals and customer involvement enhance operational performance such as Innovation, Flexibility, Proactivity and Delivery.

- Within the oil and gas industry this study has shown that the requirements of the independent operators are different from those of the major operators. However, the industry generally considers Quality and Delivery as order qualifiers, with Responsiveness and Flexibility as order winners. Hence, this study has found that the agility dimensions impact on the attainment of competitive objectives of the whole industry, as well as differences in the requirements of the buyers. For example it was found that mastering change and uncertainty has the highest impact on the type of competitive pressures of the industry. Furthermore the specific dimension of Mastering change and uncertainty and the factor of Encouraging risk lead to enhanced performance relative to competitors.

- Moreover, unlike past empirical studies on clusters (Hervas-Oliver and Albros-Garrigos, 2007) this study established correlations between cluster resources and capabilities (such as sources of labour, information and inputs) and competitive objectives as well as business performance.

The following section will highlight some of the limitations of the study.

7.5 Limitations of the research

A research project, in as much as it attempts to answer some questions, equally poses new ones, as well as the research having some inherent limitations. The limitations could arise from the methodological paradigm that guided the research and by

implication the type of data collected, the research instrument, and the choice of research site. In other words there can never be a perfect methodology for conducting a research and there is never a perfect research that is devoid of limitations. Accordingly, this section presents a critique of the methodology and results of the study. It is an assessment of the extent to which the research aims were achieved and an acknowledgement of limitations inherent in the research methodology and the emergent empirical results.

Although the research methodology was justified and whilst several tests of validity and reliability were carried out, the study had some shortcomings in design, methodology and results. The general limitations of surveys by questionnaire including the prevalence of close-ended questions, validity of relative scales relative to absolute scales as well as parametric analysis of ordinal data were recognised in section 5.1.

Measurement error refers to how well the conceptual framework in Figure 4.1 addressed all relevant issues and the extent to which research instruments emanating from the framework captured appropriate data. Although the conceptual framework was justified, its inherent limitation is that it emerged from the researcher's interpretation and synthesis of the extant literature on diverse areas that were considered relevant to the topic. Thus, to minimise the incidence of measurement error, concepts were measured by multi-item variables, field-based pre-testing of variables was performed whilst content validity, construct validity and data reliability tests were also conducted.

In this study sample definition was carried out, however despite extensive the sampling frame was clearly defined, incidence of sampling error also potentially arises, as errors associated with respondents' customer base being diverse and not limited to the oil and gas. Nevertheless the need for random sampling being met, since the companies studied were selected randomly from a public database. Moreover the response rate of about 11 percent was rather low. However, tests showed that non-response bias was insignificant. Additionally, in order to increase validity of the research findings and reduce the danger of basing conclusions on aggregate data alone, triangulation of the research results was carried out. Accordingly six case studies – two operators, two contractors, an SME and the DTI – were carried out; however resource constraints in terms of time and funding limited the depth of research generally in both stages of the research methodology.

The nature of the responses to the study and the result arising therefrom also poses a possible limitation to the studies. The data is derived from perceptual views of respondents within the industry studied. However, the following caveats should be noted in respect of perceptual data.

1. They are subject to the subjective judgement of respondent which as consequence bears on the choice and selection of a response.

2. Equally the response was elicited from a single respondent within the organisation.

The low response rate arising from the survey by questionnaire hampered the level of statistical analysis that can be carried out. Equally, due to the response rate there is a merging of classes that, due to low frequency, could not be classified as distinct groups. Finally, the study was carried out on the oil and gas industry and so cannot be generalised to other industrial sectors. Thus, the response rate and the sector focused nature of the study means that the results and conclusions should interpreted with caution.

7.6 Recommendations

The results of this study have various implications for further studies on agility as well as clusters and industrial districts. For example, although power was not studied in this research it was revealed in the course of the case study that power dynamics is at play depending on the nature of the market – that is whether buyer or supplier – and this affects the customer supplier relations. Therefore, there is a need to study the influence of soft issues such power balance on the agility of a supply chain further within all the tiers of the oil and gas industry. There is also a need to study the nature of agile supply chain in other industrial clusters such as automotive and biotechnology in order to determine the different effects associated with agility and networking under different conditions. Indeed proponents of agility (Goldman et al, 1995) contend that agility is context specific. Thus, it is likely that studying different industrial settings would reveal different aspects of agility to be relevant. Furthermore, as business drivers faced by organisations differ, this may affect the level of adoption of agility by organisations in different settings. Thus, a possible research question is to determine a typology of

agility dimensions that relates to industrial clusters. The result arising from this study will benchmark the clusters to agility requirements so as to determine the level of agility required by individual companies within a cluster. This will help organisations focus on specific aspects that will enhance their competitiveness, in contrast to the more generic results of existing studies on agility. Another possible line of enquiry in respect of the cluster theory analysis is the impact of different cluster life cycle on the agility of a supply chain.

7.7 Summary

This study aimed to study the adoption of agility dimensions in oil and gas clusters as well as the impact of being clusters on the agility of a supply chain. The study was carried out on the UK upstream oil and gas industry cluster located at Aberdeen. Three research questions were posed and six hypotheses were formulated in order to accomplish the research aim and objectives.

In light of the findings from the study, the aim and objectives of this research have been met by addressing the research questions and hypotheses. Empirical study using survey by questionnaire as well as case study was carried out to validate the hypotheses. The result of the survey by questionnaire attested to the impact of clusters on agility of a supply chain as well as the impact of clusters on the attainment of competitive objectives. Case studies validated the findings from the survey by questionnaire by affirming the impact of clusters on agility, attainment of competitive objectives as well as business performance.

In respect of the adoption of the agility dimensions within the studied organisations, the survey reveals that various aspects of the agility attributes were implemented within the oil and gas cluster. However the specific aspects of the attributes implemented involved cooperating to compete as well as leveraging the impact of people and information. The critical people issues were found to be empowering the workforce through devolution of decision making to frontline staff and training. Similarly the survey results show that information was extensively used to capture demand information. Thus organisations perceived that being able to capture demand information enabled enhanced financial and market business performance.

In respect of the case study organisations typically the findings were divided into two.

1. The aspirations of the operators who are the customers, and

2. The tasks performed by the contractors and the suppliers who constitute the service providers.

The customer group are divided into the majors and the independents. The majors are mostly concerned with cost and therefore consider efficiency as the dominant criterion for winning their orders, while the independents who are of smaller size and by implication scale are mostly concerned with lower Lead times, Flexibility and Responsiveness by the service providers. Hence, they value agility in winning their orders. Thus, within the customer group the need for both lean and agile modes of operations exists.

Similarly, looking at the service provider and supplying organisations' operations strategy to see if there is a match with those of the customers, that is the operators, the following can be observed.

- The three firms that constitute the contracting and contracting organisations all consider themselves as providing solutions to problems faced by the customers. However, it must be said that the organisations differ from each other in terms of the level of this type of service that they provide.

- The companies all have different classifications of themselves and the type of service they provide. For example, one considers itself a supply chain company, while another classifies itself as an integrated service provider, while another states that it provides design and innovative solutions and consultancy. Thus indicating varying perceptions of what they are and confirming the diverse nature of the oil and gas industry.

For practitioners the implications of the research were enumerated. Accordingly managers should realize the importance of close geographic proximity, due to the fact that, it can enhance company's competitive position through collaboration and knowledge transfer. Furthermore for academics the contribution of the research to theory building on the subject of agility and cluster theory were highlighted. Most

important the link between clusters and agility as well as the link between clusters and competitive objectives and business performance is worthy of note.

Finally, more empirical research on the links highlighted is needed to explain the influence of geographic proximity in other industrial settings. Indeed research in other areas is also appropriate in order to advance or refute the findings from this exploratory study. Further limitations of the research were noted in terms of generalising the result, single industry focus of the study, as well as sample size. Sample size limitation prevented further categorisation of the data for detailed analysis of the sub-samples. Recommendations, such as extending the study to other clusters (for example automotive, biotechnology, food and drink, and advanced metals manufacture) as well as comparative study of adoption of agility in other clusters to create a typology of cluster agility attributes, need to be carried out.

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APPENDICES

APPENDIX 1: QUESTIONNAIRE

Dear Sir,

RESEARCH QUESTIONNAIRE ON SPEED AND FLEXIBILITY (AGILITY) IN SUPPLY CHAINS

Mohammed Dauda, a PhD student attached to the Centre for Systems Studies in Hull University Business School, is undertaking a research project to investigate the adoption and implementation of speed and flexibility (agility) in the supply chains of companies located in clusters.

We would very much welcome your participation in this innovative and commercially relevant research. The project forms a vital link between operations performance, clusters and supply chain management. By participating in the study, your organization will be able to assess its operations and competitiveness against tested criteria.

We would very much appreciate your contribution to this important research by completing the enclosed questionnaire. You will take only a short time (fifteen minutes) to complete this questionnaire as most of the questions require on a tick (✓). It will be most helpful if you could be as accurate as possible and return your responses **within two weeks**.

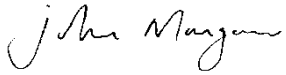
In the event that you find yourself unable to respond to some or all of the questions, we would welcome your passing the questionnaire to someone within your organisation whom you judge qualified to make the necessary response.

Information for the study and the results will be used for academic purposes only; you and your organization's names will not be divulged as strict confidentiality is assured. If you are interested a summary of the findings of the research will be made available to you.

If you have any queries please to contact Mohammed Dauda on phone using 07796783750 or by email at *M.Dauda@hull.ac.uk.*

Thanking you so much for your time and support.

Yours sincerely,



Professor John Mangan
Director
Logistics Institute
The University of Hull
Hull HU6 7RX

SPEED & FLEXIBILITY IN SUPPLY CHAIN STUDY QUESTIONNAIRE

A. General Company Information

1. Name of company……

2. Address of company……

   Post Code……Tel.No……E.Mail……

3. When was your company established (approximately)……

4. Location of your company, please tick (✓) all that applies to you.

   (a) Aberdeen only…..(b) Expanded into other locations (please specify) ……(c) Moved into Aberdeen

5. Please indicate the work flow process currently in use in your company by ticking (✓) the appropriate below

   (a) Project (b) Jobbing (c) Batch (d) Mass production

   (e) Continuous

6. Name of the respondent (optional) ……

7. Designation (position) of the respondent ……

8. What is the average **annual procurement/contracted expenditure (or sales turnover)** of your company? Please tick (✓)

(a) Less than £1million (b) £1million - 5million (c) 6million - 10million (d) £11m - £30mi

(e) £31 - £50 (f) £51m - £100m (g) 101million - £250 (h) £250m - £500

(i) £501 - 750 (j) £751m - £1,000m (k) £1000m - £2500 (l) Over £2500m

9. What is the total number of employees in your company? Please tick (✓)

(a) 1- 9 (b) 10-49 (c) 50-100 (d) 101-200 (e) 201-300 (f) 301-500

(g) 501 - 1000 (h) 1001-2000 (i) 2001 - 5000 (j) Above 5000

10. Which of the following (a-f) best describes the pattern of competition in your industry? Please tick (✓).

a. The industry is composed of several companies of relatively equal size.
b. Two large companies dominate the industry
c. Some few large companies dominate the industry
d. The industry is made up of one major company, and several other companies of relatively small size.
e. Any other pattern (please specify) ……

11. What is your company's major line of products? Please tick (✓) **all that apply**

Lines of products and activities	Tick(✓)
Exploration and Production	
Consultancy including Geophysical services	
Marine, Transport and Allied services	
Engineering services (Reservoir, Drilling & Well engineering, Facilities engineering and Subsea services)	
Offshore construction, Maintenance of platforms and vessels	
Computer, office and communication equipment, components, accessories, etc	
Supply and/or Rental of equipment, Specialty Chemicals, Drill bits etc	
Transport, storage and Communications	
Bases, Logistics, Catering, Administration etc	
Construction and operation of processing and landing facilities	
Automobile and automotive assembly, parts, components, accessories, etc	
Electrical and electronics equipment, components and allied products	
Food, drink, chemical, and pharmaceutical products	
Industrial, hospital and agricultural equipment, machines and components	
Aircraft and ship-building assembly, components, accessories, etc	
Any other business activities (please specify)……..	

B. Direction of change in the performance of your company

For a major project you are executing or have undertaken, please answer the following questions:

12. Please tick (✓) the direction of change in the following measures of performance in your company in the last three years.

Business performance measures	Sharp increase	Modest increase	Static	Modest decrease	Sharp decrease
Procurement/contracted expenditure [CAPEX and OPEX] or Turnover	1	2	3	4	5
Net profit	1	2	3	4	5
Market share	1	2	3	4	5
Customer loyalty based on repeat orders	1	2	3	4	5
Performance relative to competitors	1	2	3	4	5

C. Creating customer value

13. Please tick **(✓)** on the appropriate box according to the practices adopted by your company.

Factors	Agree strongly	Agree	Neutral	Disagree	Disagree strongly
Delivering reconfigurable products	5	4	3	2	1
We are focussed on customer satisfaction	5	4	3	2	1
We measure customer satisfaction	5	4	3	2	1
Use on time delivery to determine customer satisfaction	5	4	3	2	1
We tend to be focused on stock availability	5	4	3	2	1
Flexible and adaptable to customers needs	5	4	3	2	1
We strive for customization of products	5	4	3	2	1
We are focused on providing standard products	5	4	3	2	1
Offer solutions rather than products to customers	5	4	3	2	1
Products ready for use without added effort by customers	5	4	3	2	1
Customer-driven products	5	4	3	2	1
Fast delivery of new products	5	4	3	2	1
Looking for ways/opportunities to increase customer value	5	4	3	2	1
Retain and grow customer relationships	5	4	3	2	1

D. Cooperation to Enhance Competitiveness

14. Please tick **(✓)** on the appropriate box your degree of agreement with the following statements.

Operations practices	**Agree strongly (1)**	**Agree (2)**	**Neutral (3)**	**Disagree (4)**	**Disagree Strongly (5)**
We are organised along *functions and departments*	1	2	3	4	5
We are organised along *business processes*	1	2	3	4	5
Our reward system is based on *team performance*	1	2	3	4	5
Our reward systems is based on *individual performance*	1	2	3	4	5
Information is *readily available enterprise-wide*	1	2	3	4	5
Information *hard to find and not generally shared*	1	2	3	4	5
Projects are run with representatives from several functions	1	2	3	4	5
The decision to partner is a *first choice*	1	2	3	4	5
We adopt partnering as a *last resort*	1	2	3	4	5
Our company benefits from forming alliances with other companies	1	2	3	4	5
It would be easy for our company to enter into a temporary alliance	1	2	3	4	5
Alliances motivated by difficult operating conditions	1	2	3	4	5
We actively *share intellectual property* with partners	1	2	3	4	5
We *protect intellectual property* as an internal asset	1	2	3	4	5
We regard the inbound supply chain as *'network associates'*	1	2	3	4	5
Inbound supply chain *are 'fixed' set of formal, long-term partners*	1	2	3	4	5
We cooperate with our suppliers	1	2	3	4	5
Suppliers are involved in product development	1	2	3	4	5
We use cross functional customer teams	1	2	3	4	5

E. Role and importance of alliances

15. Please tick **(✓)** the box that describe your company's use of alliances and partnerships within the supply chain.

Partnerships and Alliances	**Very high (5)**	**High (4)**	**Moderate (3)**	**Low (2)**	**Very low (1)**
Interaction with competitors	5	4	3	2	1
Customer involvement	5	4	3	2	1
Supplier integration	5	4	3	2	1
Exchange of core competencies	5	4	3	2	1
Alliances motivated by difficult operating conditions	5	4	3	2	1
Collaboration with complementary equals	5	4	3	2	1
Computer-based data exchange with other companies	5	4	3	2	1
Knowledge sharing on design, engineering and manufacture	5	4	3	2	1

F*. *<u>Mastering change and uncertainty</u>

16. Please tick (✓) the box that describes the degree of agreement with the following statements in your organization.

Competencies, Practices and Attributes	**Agree Strongly (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Disagree Strongly (1)**
Concurrent conduct of operations facilitate rapid decision making	5	4	3	2	1
Encourage environment of risk taking	5	4	3	2	1
Discourage risk taking e.g. punishing mistakes or failure	5	4	3	2	1
People asked to think and take initiatives	5	4	3	2	1
Infrastructure in place to encourage innovation	5	4	3	2	1
Proactive response within supplier network to changing markets	5	4	3	2	1
Develop new supplier processes to follow market trends	5	4	3	2	1
Organisational boundaries non existent		4	3	2	1
Our company respond rapidly to changes in product by customer	5	4	3	2	1
Operations measured in terms of productivity and quality	5	4	3	2	1
Integrated broad based set of measures of capabilities are used	5	4	3	2	1
Any other (please specify)…….	5	4	3	2	1

G. <u>Leveraging the impact of People and Information</u>

17. Please indicate by a tick (✓) the **emphasis** that your company places on the following practices.

Practices regarding people and information	**Very low (1)**	**Low (2)**	**Moderate (3)**	**High (4)**	**Very high (5)**
Employee autonomy over routine operations	1	2	3	4	5
Team spirit among workers and departments	1	2	3	4	5
Team-based performance	1	2	3	4	5
Individual performance	1	2	3	4	5
Reward based on acquired competencies not seniority	1	2	3	4	5
Employees' involvement in decision making	1	2	3	4	5
Skills development and training	1	2	3	4	5
Managing core skills and competencies	1	2	3	4	5
Capture demand information immediately	1	2	3	4	5
Prefer to keep information on file	1	2	3	4	5
Information accessible supply chain-wide	1	2	3	4	5
Intelligent interpretation of customer needs	1	2	3	4	5

H. Cluster location attributes

18. Please how important are the following **proximate firms and institutions** as suppliers of specialized labour to your organization?

Sources of Labour for your organization	Very high (1)	High (2)	Moderate (3)	Low (4)	Very low (5)
Universities	1	2	3	4	5
Competitors	1	2	3	4	5
Other firms	1	2	3	4	5
Suppliers	1	2	3	4	5
Customers	1	2	3	4	5
Head hunting of other organizations staff	1	2	3	4	5

19. Please to what extent do the following factors influence the location decisions of your organization?

Criteria	Very high (5)	High (4)	Moderate (3)	Low (2)	Very low (1)
Transportation costs to supplier/customer	5	4	3	2	1
Labor availability	5	4	3	2	1
Infrastructure (including Logistics Access)	5	4	3	2	1
Proximity to raw materials	5	4	3	2	1
Proximity to suppliers	5	4	3	2	1
Proximity to markets/customers	5	4	3	2	1
Proximity to parent company facilities	5	4	3	2	1
Proximity to competitors	5	4	3	2	1
Quality of life	5	4	3	2	1
Legal and regulatory framework	5	4	3	2	1
Economic factors	5	4	3	2	1
Government and political stability	5	4	3	2	1
Social and cultural factors	5	4	3	2	1
Characteristics of the location	5	4	3	2	1

20 Please select the percentage share of inputs purchased from suppliers in geographic proximity to you.

Input type	0	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Basic											
Specialist											

21. Please rate the importance of following as sources of knowledge for innovative activities for your organization.

Sources of Information	Very important (1)	Important (2)	Moderately Important (3)	Little Importance (4)	Unimportant (5)
Specialist trade press	1	2	3	4	5
Conference/Fairs	1	2	3	4	5
Business press	1	2	3	4	5
Internet	1	2	3	4	5
Informal contact	1	2	3	4	5
Other (specify)	1	2	3	4	5

I. Strategic distinctive competence

22. Please rate each of the following operational functions/departments in your company.

Operation functions/departments	Strength (1)	Average (2)	Weakness (3)
Purchasing/Procurement	1	2	3
Engineering and Design	1	2	3
Marketing/Selling	1	2	3
Market Research	1	2	3
Product Research and Development	1	2	3
Financial Management	1	2	3
Production	1	2	3
Distribution	1	2	3
Legal	1	2	3
Personnel	1	2	3
General Management	1	2	3

23. Please indicate by a tick (✓) the extent to which the following core competencies for effective and responsive operations are relevant to your company's performance.

Emerging Core Competencies	Very high (5)	High (4)	Modest (3)	Low (2)	Very low (1)
Employees' knowledge and skills	5	4	3	2	1
Concurrent or simultaneous conduct of operations	5	4	3	2	1
Effective adaptation of facilities and systems	5	4	3	2	1
Networking for exchange of knowledge.	5	4	3	2	1
Any other capability (please specify)…….	5	4	3	2	1

J. Competitive objectives in operations

24. Please indicate by ticking **(✓)** your company's attainment of competitive objectives.

Competitive objectives	Very high (5)	High (4)	Modest (3)	Low (2)	Very low (1)
Product customisation (Engineer -to-order))	5	4	3	2	1
Flexibility (ability to deliver any quantity)	5	4	3	2	1
Low cost	5	4	3	2	1
Innovation	5	4	3	2	1
Speed	5	4	3	2	1
Quality	5	4	3	2	1
Dependability (order fulfillment)	5	4	3	2	1
Proactivity	5	4	3	2	1
Delivery (on time and on schedule) reliability	5	4	3	2	1

K. Impact of adopted current practices on responsiveness

25. Please identify the degree of importance of the following factors on the responsiveness of your organization

Factors	Very low (1)	Low (2)	Moderate (3)	High (4)	Very high (5)
Creating customer value	1	2	3	4	5
Cooperating to enhance competitiveness	1	2	3	4	5
Mastering change and uncertainty	1	2	3	4	5
Leveraging the impact of people and information	1	2	3	4	5
Location	1	2	3	4	5
Strategy	1	2	3	4	5

26. Would your company like to participate in the second stage of this research, which is an industrial case studies involving four companies? a) Yes. b) No.

Please comment freely on any aspect of supply chain management in your industry in the space below

……
……
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Please return the questionnaire by email to M.Dauda@hull.ac.uk or mail to:

Mohammed Dauda
Doctoral Research Student
Centre for Systems Studies
Business School
The University of Hull
Hull HU6 7RX

APPENDIX 2: CASE STUDY QUESTIONS

Cluster based agile supply chains

Aim: The case study aims to determine the effect of being in industrial clusters on the agility of a supply chain.

Agility – Agile supply chains – is defined as the capability of an organisation to satisfy customer demand in a dynamic and complex business environment characterised by change and uncertainty. Agility has also been defined as speed, flexibility and responsiveness.

Clusters: is the collection of firms in close geographic proximity which tends to enhanced collaboration, cooperation and sometimes competition.

Questions related to the basic information of companies:

Basic information of the companies

- number of persons, turnover, the year of foundation, line of business, main products and main customers

Knowhow

- Core competence of the company, tacit know-how?
- What competencies does the company outsource to other companies in the network?
- What untapped competencies does the company have to provide other companies?
- What other competencies does the company need in the future?

The level of cooperation

- With which companies in the cluster are you cooperating and what kind of cooperation is it?
- What is the level of cooperation today and what is the need for cooperation in the future?
- What kind of problems do you have in cooperation?

Information systems

- What kind of ICT systems does the company have?
- How does the exchange of inter-organizational information exchange happen?
- What problems do you have in information management?
- What requirements are needed to integrate ICT systems?

Indepth questions related to the main theme of the case study

Question 1

1a. Does your company choose a narrow product-market domain? (because of limited resources, and the organisation has been carefully designed to serve this domain.)

1b. Does your firm need to make major adjustments in your technology, structure, or methods of operation in the next three years?

1c. Does your firm devote primary attention to improve the efficiency of existing operations?

1d. Does your firm operate in two types of production-market domains, one relatively stable, the other changing?

Question 2

How do you evaluate your company's overall business performance?

Question 3

What is the major consideration, for example, product cost, quality, delivery speed, innovation, flexibility or proactivity that influences the business performance of your company?

Question 4

What is your perceived ranking against competitors in respect of the following factors relating to your manufacturing/production process? Please note that 2 and 3 mean 2nd and 3rd out of 9 respectively.

- in terms of achieving *Speed* priority? 1 2 3 4 5 6 7 8 9
- in terms of achieving *quality* priority? 1 2 3 4 5 6 7 8 9
- in terms of achieving *cost* priority? 1 2 3 4 5 6 7 8 9
- in terms of achieving *innovation* priority? 1 2 3 4 5 6 7 8 9
- in terms of achieving *proactivity* priority? 1 2 3 4 5 6 7 8 9
- in terms of achieving *dependability* priority? 1 2 3 4 5 6 7 8 9
- in terms of achieving *Innovation* priority? 1 2 3 4 5 6 7 8 9
- in terms of achieving *Flexibility* priority? 1 2 3 4 5 6 7 8 9
- in terms of achieving *Product Customisation* priority? 1 2 3 4 5 6 7 8 9

Question 5

To what degree do you consider the ability to quickly respond to customer requirement impact on your company's specific priorities, for example, Speed, quality, cost and proactivity?

Question 6

Some companies enter into partnership in order to provide better customer service:

- What exactly does the best partner mean in your company?
- Do you experience any conflicts in selecting business partners?

Question 7

What major initiatives have been introduced over the last five years to make your company more quickly and effectively respond to changing customer requirements?

Question 8

What major innovations have been introduced over the last five years in order to cope with changing customer preferences and the complexity of modern products?

Question 9

Manufacturing strategies are changing from traditional Mass production to Agile Mass Customisation.

- To what extent and for what purpose is your company part of the change?
- What cost or penalties can you attribute to the change?

Question 10

In an effort to enhance responsiveness to customer requirements, several companies are empowering their employees through training, teaming and delegation.

(a). What exactly does employee empowerment mean in your plant?

(b). Do you experience any conflicts in training and teaming needs and practices?

Question 11

What changes have been introduced over the last five years in your company's relationships with the following stakeholders? What lessons were learnt?

a. Relationship with customers

b. Relationship with suppliers

c Relationship with competitors

Question 12

Manufacturers are widening the brands and models of available products in an effort to extend market share. However, speculation is rife that such efforts add more to cost than to revenue and that new products should be transparent in added value.

a. In the light of these concerns, how does your company differentiate its various models and brands from one another, and from the products of other plants?

b. To what extent would you describe your order winning capabilities as cost driven, quality driven, flexibility driven, technology driven or speed driven?

c. What short-term and longer-term innovation is necessary in order to enhance your ability to win more customers and orders in the next five years?

Question 13

What new technologies are crucial in winning more customers in the next few years?

Question 14

Does being in a close geographic proximity to your

- Customers
- Suppliers
- Competitors
- Partners

Affects your business in terms of competitive objects and performance? Please explain.

APPENDIX 3: RESULT OF T-TEST OF AGILITY DIMENSIONS AND CLUSTER LOCATION ATTRIBUTES

Appendix 3.1: Enriching the customer through creating customer value						
Effect	Proximate		Distance		t-value	P-Value
	M	SD	M	SD		
Reconfigurable products	3.36	1.03	3.53	0.99	-0.777	0.444
Customer satisfaction focus	4.33	0.61	4.58	0.64	**-1.919**	**0.058**
Measure customer satisfaction	3.8	0.91	4.23	0.80	**-2.361**	**0.020**
Stock availability focus	2.75	1.19	4.10	0.96	**-5.939**	**0.000**
Ontime delivery	3.1	1.05	3.6	1.15	**-2.15**	**0.034**
Flexible to customer needs	4.07	0.63	4.20	0.76	-0.865	0.390
Customization of products	3.18	0.91	3.40	0.96	-1.134	0.260
Providing standard products	3.15	1.18	3.03	1.00	0.524	0.602
Offer solutions rather than products	3.95	1.08	3.75	1.11	0.972	0.334
Products ready for use	3.64	0.87	3.88	0.82	-1.352	0.180
Customer driven products	3.58	0.94	3.00	0.72	**-2.465**	**0.016**
Fast delivery of products	3.24	0.94	3.75	0.90	**-2.675**	**0.009**
Increase customer value	4.20	0.68	4.30	0.69	-0.706	0.482
Customer relationships	4.49	0.64	4.58	0.59	-0.655	0.514
Value added products	4.45	0.63	4.00	0.82	**3.056**	**0.003**

Appendix 3.2: Cooperating to enhance competitiveness						
Effect	Proximate		Distance		t-value	P-Value
	M	SD	M	SD		
Organised long functions and departments	3.55	1.20	3.45	1.18	0.386	0.700
Organised along business processes	3.56	1.03	3.55	1.04	0.063	0.95
Reward based on team performance	3.75	1.08	3.83	0.98	-0.369	0.713
Reward based on individual performance	3.29	1.05	2.93	1.14	1.618	0.109
Information available	3.84	0 .79	3.80	0.94	0.205	0.838
Information difficult to find	2.31	0.88	2.10	0.87	1.149	0.254
Matrix project team	3.80	0.890	3.95	0.78	-0.852	0.396
Partnering is first choice	3.18	0.960	3.35	0.98	-0.835	0.406
Partnering is last choice	2.65	0.865	2.33	0.94	**1.763**	**0.081**
Alliances benefit our company	3.71	0.896	3.70	1.091	0.045	0.965
Easy to go into temporary alliances	3.78	0.832	3.23	1.050	**2.883**	**0.005**
Share intellectual property	2.95	0.891	2.93	0.76	0.117	0.907
Protect intellectual property	3.15	0.931	2.80	0.992	**1.736**	**0.086**
Network associates	3.64	0.969	3.63	1.005	0.056	0.956
Long-term partners	3.42	0.832	3.55	0.932	-0.725	0.471
Cooperation with suppliers	3.24	0.860	3.03	1.097	1.013	0.315
Product development	3.87	0.747	4.30	0.564	**-3.041**	**0.003**
Cross-functional customer teams	3.49	0.960	3.83	1.035	**-1.621**	**0.108**
Alliances due to difficult operating conditions	3.29	0.956	3.23	1.291	0.273	0.786

Appendix 3.3: Role and importance of Alliances						
Effect	Proximate		Distance		t-value	P-Value
	M	SD	M	SD		
Interaction with customers	2.93	1.230	2.38	0.925	**2.389**	**0.019**
Customer involvement	3.67	0.963	3.88	0.992	-0.998	0.321
Supplier integration	3.44	0.938	3.63	0.868	-1.011	0.315
Core competencies	2.96	0.981	3.00	0.751	-0.205	0.838
Alliances	3.04	0.922	2.92	0.764	0.624	0.534
Collaboration	3.13	0.982	3.00	0.877	0.652	0.516
Data exchange	2.95	1.129	2.85	1.122	0.408	0.684
Knowledge sharing	2.95	1.026	2.53	1.154	**1.871**	**0.065**

Appendix 3.4:Mastering change and uncertainty						
Effects	Proximate (55)		Distance (40)		t-value	P-Value
	M	SD	M	SD		
Rapid decision making	3.62	0.850	3.80	0.911	-0.999	0.321
Encourage risk taking	2.93	1.016	3.45	0.986	**-2.507**	**0.014**
Discourage risk taking	2.62	0.972	2.20	0.823	**2.206**	**0.030**
Take initiatives	4.04	0.667	4.08	0.859	-0.247	0.805
Encourage innovation	3.89	0.762	3.53	1.012	**2.011**	**0.047**
Proactive response	3.80	0.826	3.73	0.847	0.432	0.666
New supplier processes	3.85	0.705	3.73	0.816	0.827	0.410
Organisational boundaries non-existent	2.89	0.832	2.98	1.025	-0.441	0.660
Rapid response to customer changes	3.65	0.886	3.83	0.903	-0.918	0.361
Productivity and quality are measures of operations	3.91	0.752	3.93	0.859	-0.096	0.924
Integrated broad based measures of capability used	3.73	0.827	3.80	0.911	-0.405	0.686

Appendix 3.5:Leveraging the impact of people and information						
Effect	Proximate		Distance		t-value	P-Value
	M	SD	M	SD		
Autonomy	3.55	0.603	3.43	0.844	0.812	0.419
Team spirit	3.98	0.593	3.90	0.672	0.628	0.532
Team-based performance	3.91	0.646	3.83	0.813	0.561	0.576
Individual performance	3.60	0.807	3.83	0.813	-1.337	0.184
Reward based on competencies	3.47	0.790	3.65	0.834	-1.055	0.294
Involvement in decision making	3.69	0.742	3.48	0.816	1.342	0.183
Training	3.85	0.678	3.80	0.939	0.329	0.743
Managing core competencies	3.82	0.669	3.55	0.876	**1.692**	**0.094**
Capture demand	3.60	0.852	3.43	0.931	0.951	0.344
Keep information on file	2.55	0.919	2.98	1.000	**-2.167**	**0.033**
Information accessible	3.33	0.963	3.20	0.966	0.635	0.527
Customer needs	4.02	0.623	3.80	0.853	1.441	0.153

Appendix 3.6: Impact of adopted practices on responsiveness						
Effect	Proximate		Distance		t-value	P-Value
	M	SD	M	SD		
Enriching the customer	4.07	0.766	4.20	0.687	-0.834	0.406
Cooperating to compete	3.67	0.818	3.78	0.768	-0.617	0.538
Mastering change and uncertainty	3.93	0.634	3.68	0.797	1.717	0.089
Leverage the impact of people and information	4.15	0.780	3.55	0.677	3.880	**0.000**
Location and cluster factors	3.22	0.956	2.88	1.090	1.628	**0.107**
Chosen strategy	4.00	0.882	3.75	0.954	1.318	0.191

Appendix 3.7: Emerging core competencies						
Effect	Proximate		Distance		t-value	P-Value
	M	SD	M	SD		
Knowledge an d skills of employees	4.49	0.635	4.65	0.622	-1.216	0.227
Concurrent execution of operations	3.80	0.779	3.90	0.810	-0.607	0.545
Adaptable systems and technologies	3.75	0.844	3.83	0.747	-0.476	0.635
Networking	3.75	0.886	3.48	0.751	1.564	0.121

Test of Cluster location attributes

Appendix 3.8: Source of Labour in a cluster						
Effect	Proximate		Distance		t-value	P-Value
	M	SD	M	SD		
Universities	3.13	1.171	2.18	1.083	**4.036**	**0.000**
Competitors	3.05	1.079	2.25	1.056	**3.621**	**0.000**
Other firms	3.16	0.856	2.98	0.947	1.014	0.313
Suppliers	3.04	1.053	2.73	1.086	1.404	0.164
Customers	2.44	1.135	2.13	0.966	1.404	0.164
Headhunting	2.53	0.997	2.38	1.234	0.665	0.508

Appendix 3.9: Sources of Inputs and Information						
Effect	Proximate		Distance		t-value	P-Value
	M	SD	M	SD		
Basic Inputs	7.05	3.223	4.83	3.145	3.363	**0.001**
Specialist input	6.00	3.037	3.60	2.916	**3.867**	**0.000**
Trade press	3.67	1.019	3.75	0.981	-0.371	0.712
Conference/Fairs	3.62	1.045	3.28	0.960	**1.634**	**0.101**
Business press	3.24	0.860	3.20	0.883	0.201	0.841
Internet	3.80	0.951	3.80	0.911	0.000	1.000
Informal contact	4.11	0.975	3.80	0.939	1.549	0.125

Appendix 3.10: Transportation and transaction cost						
Effect	Proximate		Distance		t-value	P-Value
	M	SD	M	SD		
Transportation costs	2.49	1.17	2.98	1.21	**-1.97**	**0.052**
Raw materials	2.56	1.24	2.53	1.22	0.151	0.881
Suppliers	2.64	0.99	2.50	1.06	0.643	0.522
Markets/customers	3.87	1.16	3.08	1.27	**3.19**	**0.002**
Competitors	2.20	1.04	1.88	0.88	1.60	0.114
Regulatory framework	2.9	1.19	2.3	1.27	**2.34**	**0.022**
Economic factors	3.09	1.28	3.40	1.08	-1.24	0.22
Political stability	2.93	1.26	2.50	1.30	1.61	0.11
Social and cultural factors	2.80	1.12	2.68	1.22	0.52	0.61
Characteristics of the location	3.35	0.97	2.95	1.22	**1.76**	**0.08**
labour availability	2.96	1.036	3.30	0.939	-1.625	0.108
Infrastructure	3.24	1.053	3.28	1.012	-0.179	0.858
Parent company facilities	1.85	0.848	1.43	0.549	**2.991**	**0.004**
Quality of life	2.91	1.175	3.03	1.143	-0.480	0.632

T-test of competitive objectives and distinctive competencies

Appendix 3.11: Competitive objectives						
Effect	Proximate		Distance		t-value	P-Value
	M	SD	M	SD		
Customisation	3.49	1.169	3.83	0.903	-1.571	0.135
Flexibility	3.91	0.928	4.30	0.800	-0.636	0.526
Cost	3.20	1.026	3.58	0.931	**-1.829**	**0.067**
Innovation	3.87	0.883	3.55	1.061	1.615	0.110
Speed	3.93	0.790	3.90	0.841	0.776	0.872
Quality	4.38	0.593	4.45	0.677	-0.521	0.604
Dependability	4.13	0.771	4.43	0.712	**-1.918**	**0.055**
Proactivity	4.04	0.693	3.95	0.815	0.557	0.579
Delivery	4.20	0.704	4.40	0.709	-1.363	0.176

Appendix 3.12: Impact of distinctive competencies on the operations of the organisations						
Effect	Proximate		Distance		t-value	P-Value
	M	SD	M	SD		
Purchasing/Procurement	2.44	0.714	2.45	0.597	- 0.098	0.922
Engineering and Design	2.56	0.688	2.43	0.675	0.978	0.331
Marketing/Selling	2.07	0.742	2.25	0.776	-1.128	0.262
Market Research	1.82	0.748	1.75	0.707	0.449	0.665
Research and Development	1.96	0.793	1.88	0.822	0.530	0.598
Financial Management	2.15	0.678	2.53	0.554	**-2.903**	**0.005**
Production	1.95	0.756	2.53	0.599	**-4.018**	**0.000**
Distribution	1.82	0.722	2.23	0.698	**-2.749**	**0.007**
Legal	1.80	0.704	1.78	0.660	0.175	0.861
Personnel	2.16	0.764	2.15	0.700	0.089	0.929
General Management	2.18	0.641	2.48	0.716	**-2.096**	**0.039**

APPENDIX 4: TABLES OF CORRELATION COEFFICIENTS BETWEEN AGILITY DIMENSIONS AND CLUSTER LOCATION ATTRIBUTES.

Appendix 4.1: Correlation of enriching the customer and cluster location attributes

	Conference/Fairs	Business press
Customer satisfaction focus	**-0.222* (0.030)**	
Measure customer satisfaction	**-0.271** (0.008)**	
Stock availability focus	**-0.230* (0.025)**	
Offer solutions rather than products		**0.260* (0.011)**
Products ready for use		**-0.252* (0.014)**
Customer relationships	**-0.283** (0.006)**	
Value added products	**-0.207* (0.044)**	
*Significance at 5% level indicated by *, at 1% level indicated by **		

Appendix 4.2: Correlations of sources of Inputs to Enriching the customer

	Basic Inputs	Specialist inputs
Ontime delivery	**-0.239* (0.019)**	**-0.343** (0.001)**
Stock availability focus	**-0.359** (0.000)**	-0.347** (0.001)
Offer solutions rather than products	**0.243* (0.018)**	**0.219* (0.033)**
*Significance at 5% level indicated by *, at 1% level indicated by **		

Appendix 4.3: Correlation of transportation and transaction costs with enriching the customer

	Competitors	Quality of life	Economic factors	Political stability	Social and cultural factors
Customer satisfaction		**0.244* (0.017)**			
Measure customer satisfaction			**0.223* (0.029)**		
Ontime delivery		**-0.211* (0.040)**			
Stock availability	**-0.394** (0.000)**				
Flexible to customer needs		**0.301** (0.003)**			**0.241* (0.019)**
Customization of products			**-0.236* (0.022)**		
Providing standard products			**0.289** (0.005)**	**0.204* (0.047)**	
*Significance at 10% level indicated by *, at 5% level indicated by **, at 1% level indicated by ****					

Appendix 4.4: Correlation of transportation and transaction costs with cooperating to compete

	Regulatory framework	Economic factors	Political stability	Social and cultural factors	Characteristics of location	Markets/ customers
Organised along functions	**0.312** (0.002)**	**0.324** (0.001)**	**0.308** (0.002)**	**0.249* (0.015)**		
Organised along business processes					**0.232* (0.023)**	
Reward based on individual performance	**0.301** (0.003)**	**0.275** (0.007)**	**0.454** (0.000)**	**0.262* (0.010)**		
Information difficult to find	**0.255* (0.013)**		**0.323** (0.001)**			
Partnering is last choice			**0.240* (0.019)**		**0.206* (0.045)**	**0.257* (0.012)**
*Significance at 5% level indicated by *, at 1% level indicated by ** *						

Appendix 4.5: Correlation of transportation and transaction costs with cooperating to compete

Cooperation to compete	Transportation and Transaction Costs						
	Transport costs	Labour availability	Infrastructure	Raw materials	Suppliers	Parent company facilities	Competitors
Organised along business processes	**0.251* (0.014)**			**0.388** (0.000)**		**0.207* (0.044)**	
Reward based on individual performance						**0.346** (0.001)**	
Information available		**-0.227* (0.027)**					
Information difficult to find	**0.276** (0.007)**		**0.243* (0.017)**				
Matrix project team			**0.296** (0.004)**				
Partnering is a last choice		**0.266** (0.009)**			**0.203* (0.049)**	**0.214* (0.037)**	**0.271* (0.008)**
Share intellectual property							**0.211* (0.040)**
Protect intellectual property							**0.212* (0.040)**
Network associates		**-0.263* (0.010)**					
Long-term partners	**-0.215* (0.036)**						
Product development						**-0.323** (0.001)**	
Cross customer teams				**0.279** (0.006)**			
Alliances due to difficulty			**0.221* (0.031)**			**0.368** (0.000)**	**0.219* (0.033)**
*Significance at 5% level indicated by *, at 1% level indicated by ** *							

Appendix 4.6: Correlation of transportation and transaction costs with partnering and alliances

Transportation and Transaction costs	Partnering and Alliances					
	Interaction with competitors	Customer involvement	Core competences	Operating Environment	Collaboration	Data exchange
Transportation costs			**0.203* (0.048)**	**0.224* (0.029)**		
Infrastructure			**0.355** (0.000)**			
Raw materials	**0.242* (0.018)**		**0.216* (0.036)**	**0.218* (0.034)**	**0.224* (0.029)**	
Suppliers	**0.301** (0.003)**					
Markets/customers					**-0.268** (0.009)**	**-0.280** (0.006)**
Parent company facilities	**0.349** (0.001)**		**0.257* (0.012)**			
Competitors	**0.320** (0.002)**			**0.328** (0.001)**	**0.202* (0.050)**	
Quality of life		**0.274** (0.007)**				
Regulatory framework	**0.209* (0.042)**					
*Significance at 5% level indicated by *, at 1% level indicated by ** *						

Appendix 4.7: Correlations between sources of inputs and cooperating to compete

	Basic Inputs	Specialist inputs
Our company benefits from forming alliances with other companies		**0.234* (0.023)**
It would be easy for our company to enter into a temporary alliance	**0.308** (0.002)**	0.384** (0.000)
We actively *share intellectual property* with partners	**0.260 (0.011)**	**0.278** (0.006)**
We *protect intellectual property* as an internal asset		**0.275** (0.007)**
Suppliers are involved in product development	**-0.223* (0.030)**	**-0.231* (0.024)**
*Significance at 5% level indicated by *, at 1% level by ** *		

Appendix 4.8: Sources of information and cooperating to compete

	Conference /Fairs	Business press	Internet	Informal contact
We are organised along business processes	**0.212* (0.039)**	**0.231* (0.025)**		
Our reward systems is based on individual performance		**0.225* (0.028)**	**-0.234* (0.023)**	
Information is readily available enterprise-wide		**0.257* (0.012)**		
Information hard to find and not generally shared				**-0.245* (0.017)**
Projects are run with representatives from several functions		**0.318** (0.002)**		
We actively share intellectual property with partners			**-0.277** (0.007)**	
We protect intellectual property as an internal asset		**0.267** (0.009)**		
Suppliers are involved in product development	**-0.301** (0.003)**			
*Significance at 5% level indicated by *, at 1% level by **				

Appendix 4.9: Correlations of Sources of Labour for organisations and Enriching the customer.

	Universities	Competitors	Other firms	Suppliers	Customers
Stock availability focus		**-0.252* (0.014)**			
Customization of products			**0.228* (0.026)**		
Offer solutions rather than products				**0.233* (0.023)**	
Products ready for use	**-0.233* (0.023)**				**-0.295** (0.004)**
Increase customer value				**0.236* (0.021)**	
Value added products		**.327** (.001)**		**0.204* (0.047)**	
*Significance at 5% level indicated by *, at 1% level indicated by **					

Appendix 4.10: Correlation of transportation and transaction costs with mastering change and uncertainty

	Rapid decision making	Encourage risk taking	Discourage risk taking	Take initiatives	Encourage innovation	Proactive response	New supplier process	Rapid response to customer changes	Broad based measures of capabilities used
Infrastructure									**0.202* (0.050)**
Raw materials						**0.209* (0.042)**	**0.224* (0.029)**		**0.278** (0.006)**
Parent company facilities	**-0.262* (0.010)**	**-0.222* (0.031)**							
Quality of life				**0.273** (0.008)**	**0.206* (0.045)**			**0.257* (0.012)**	
Regulatory framework	**-0.202* (0.050)**							**-0.227* (0.027)**	
Economic factors			**-0.240* (0.019)**	**0.258* (0.012)**					
Political stability							**-0.272** (0.008)**	**-0.209* (0.042)**	
Characteristics of location			**0.204* (0.047)**						
*Significance at 5% level indicated by *, at 1% level by **									

Appendix 4.11: Correlation of transportation and transaction costs with Leveraging the impact of people and information.

	Team spirit	Individual performance	Reward based on competencies	Involvement in decision making	Training	Keep information on file	Information accessible	Customer needs
Labour availability						**0.313** (0.002)**		
Infrastructure			**0.228* (0.026)**					
Raw materials	**0.301* (0.003)**						**0.241* (0.018)**	
Suppliers				**0.256* (0.012)**				
Parent company facilities		**0.249* (0.015)**						
Quality of life				**0.229* (0.025)**		**0.273** (0.007)**		
Economic factors		**0.352** (0.000)**		**0.209* (0.042)**		**0.243* (0.018)**	**-0.255* (0.013)**	
Political stability						**0.233* (0.023)**		
Social and cultural factors				**0.206* (0.045)**		**0.278** (0.006)**		
Attributes of location					**0.219* (0.033)**		**0.247* (0.016)**	**0.268** (0.008)**
*Significance at 5% level indicated by *, at 1% level by **								