The Evolving Supply Chain: An Empirical Investigation of the Impact of Knowledge Dimensions in Manufacturing and Service Supply Chains

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ABSTRACT

> "Where are we now in the evolution of supply chains and what has to occur to advance along the continuum?" (Bowersox et al., 2000)

This thesis aims to go some way to answering this question, by undertaking an empirical investigation of two major evolutionary issues emanating from the literature:

1. The increasing importance of managing knowledge in supply chains,
2. The application of supply chain practices beyond manufacturing- into services.

Existing supply chain literature largely focuses on asset and information elements of exchange between supply chain partners in manufacturing contexts. Yet the exchange and management of knowledge is not so well understood despite its increasing importance as more complex business dynamics shift towards competing supply chains. The above issues are developed through a synthesis of the supply chain literature, and analysed through adopting perspectives from knowledge management and service operations research streams. Three particularly relevant supply chain knowledge dimensions emerge: knowledge transfer, competence and maturity. Investigating the impact upon performance of these dimensions within manufacturing and/ or service supply chain contexts constitutes the research focus of this thesis.

Literature-based definitions of the main constructs are adopted and three sequential essays developed. The first essay explores the transfer of structural and procedural components of knowledge in manufacturing supply chains. The second essay investigates the cultivation of this knowledge into specific skills comprising supply chain competence. Direct comparisons are made between manufacturing and service contexts. The final essay develops the supply chain maturity concept, as defined by level of collaborative knowledge sharing across appropriate practices, and assesses impact in the evolving service-oriented supply chain context of Healthcare.

The empirical investigation is based upon rigorous mail, telephone and Internet survey data collection methodologies and multivariate data analysis techniques such as multiple regression, structural equation modelling and set correlation analysis.

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CHAPTER 1 – INTRODUCTION

> "In my mind, business practices of the future will be defined in a new unit of analysis: the supply chain (not the individual organisation)... Based on my observations of trends in industry, the supply chain will become the effective unit of competition." (Handfield, 2002)

This current and commonly held viewpoint in the operations management literature has not come 'out of the blue'. Operations management has been evolving as a subject of study from its foundations in factory management, production engineering and industrial engineering, to a more inclusive subject encapsulating operations and manufacturing strategy, service operations management, and supply chain management (Voss, 1995; Meredith, 2001). In particular, a steady evolution of literature and practice has been taking place on supply chain issues over the last 15 years or so.

> "During the latter part of the 1980s and all through the 1990s the field of operations management was exposed to a host of research opportunities...Perhaps the greatest impact on the operations management research stream in this time frame was supply chain management." (Krajewski, 2002)

This impact of supply chain management upon the operations management research community has not been surprising, given that its wider impact upon modern society as a whole has been profound. As New (1997) clearly argues:

> "The activities, processes and relationships which fall under the supply chain label are central to industrial modernity. To a very large extent, the details of life for all of us are deeply affected by supply chain phenomena... The shape of cities and the evolution of the countryside are driven by the logistical and locational decision making... The ways in which firms deal with suppliers and customers determine the contours of the economic terrain. The flow of goods through the supply chain is the life-blood of the modern world."

And he summarises:

> "[Supply chain management] is simply the most practically and intellectually significant theme within current managerial and economic research."

The original moves into supply chain research came as a result of realising that what had been studied for single firms should now be examined from the perspective of a chain of firms. Material and information dependencies between firms brought on a great number of interesting issues ranging from the strategic to the operating level. A considerable body of supply chain literature has emerged, with empirical researchers as well as modellers working on the very real problems experienced by business managers (Christopher, 1992; Lamming, 1996; Saunders, 1998; Hines, 2000). Clearly, practitioners have been keen to stay up-to-date with supply chain management issues and have implemented important concepts that have emerged from the many published papers on the topic. These concepts have been put into practice by managers striving to achieve the combined benefits of improved cost, flexibility, delivery and quality (Hayes & Wheelwright, 1984). In fact, such is the extent of current practitioner interest in the development of supply chain management, that the Harvard Business Review recently launched a special three-issue 'spotlight' on the 21st century supply chain:

> "Managing the modern supply chain is a job that involves specialists in manufacturing, purchasing, and distribution... it is also vital to the work of chief financial officers, chief information officers, operations and customer service directors, and, certainly, chief executives. Changes in supply chain management have been truly revolutionary, and the pace of progress shows no signs of moderating." (HBR Spotlight, 2004)

Supply chain theory and practice have evolved hand-in-hand through the 20th century resulting in the emergence of modern lean, agile and leagile paradigms (Lamming, 1996; Harrison et al., 1999; Christopher & Towill, 2001. Nevertheless, at the beginning of the 21st century, many organisations still find that the competitive benefits of developments in supply chain management remain elusive (Davenport, 1998; Bowersox et al., 2000; Fawcett & Magnan, 2002). This indicates a failure to fully get to grips with the complexities of managing modern real-world supply chains. At least it would appear that there are still fundamental gaps in academic and practitioner understanding that need to be investigated (Frohlich & Westbrook, 2001).

One major area for improving understanding relates to the twin concepts of integration and collaboration that lie at the heart of modern supply chain thinking. Many studies relating to flexibility in supply chains, buyer-seller power, inventory replenishment, and the 'bull-whip' effect have made clear that organisations have to break down inter-organisational barriers to smooth uncertainty and enhance the control of supply chains (Lee et al., 1997a). However, it is evident that the value of collaborative integration with upstream suppliers and downstream customers (Stevens, 1989) is limited if it is restricted to 'hard' asset, data and information levels of exchange.

Exemplary companies, such as Dell, have shown that there are tremendous future benefits for those companies that 'go the extra mile' in terms of supply chain integration and collaborative working with supply chain partners (Magretta, 1998). Academics and practitioners alike feel that it is the mechanisms underlying supply chain integration and collaboration that hold the key to better understanding and improvements in supply chain management. Yet an aura of 'je ne sé pas' still surrounds just how such collaborative supply chain integration is achieved in practice (Lee, 2004; Slone, 2004).

Important academic research has identified that acquiring the benefits of true collaborative supply chain integration is likely to require broader arcs of integration that go beyond asset, data and information levels to incorporate the exchange of opinions, expertise and knowledge (Frohlich & Westbrook, 2001). Yet, managing such 'soft' dimensions as opinions and expertise may incur a step-change in terms of theory development and practice implementation. In fact, supply chain academics and practitioners are coming to a similar conclusion to the one the manufacturing stream did some years ago:

> "The hard stuff is easy. The soft stuff is hard. And the soft stuff is more important than the hard stuff." (Hayes & Pisano, 1996)

Academics have argued that it is precisely the softer issues of managing expertise and knowledge within the supply chain that are likely to be the key to the continuing evolution of theory and practice (Bowersox et al., 2000). It seems common sense that to achieve true collaboration between supply chain partners requires developing knowledge sharing. Yet, very little work has been done to explore such crucial and complex knowledge dimensions of supply chain management (Croom et al., 2000) and this represents a significant gap in the literature.

To address this conceptual literature gap, as well as answer calls for new perspectives to be brought into the supply chain field from other disciplines (Stock, 1997), this doctoral study seeks to transfer appropriate theories and concepts from the emerging knowledge management literature. Krajewski (2002) stresses the importance of interdisciplinary research to the field of supply chain management, stating: "I think we still have a long way to go." As with supply chain management, the knowledge management stream of literature is multidisciplinary and offers particularly relevant and useful new insights regarding inter-organisational knowledge creation and transfer (Ingram & Baum, 1997), knowledge adoption and development (Cohen & Levinthal, 1990), and knowledge evolution (March, 1991; Levinthal & March, 1993; Miller & Chen, 1994). Such new perspectives gained through applying the 'knowledge lens' (Amundson, 1998) could prove invaluable in deepening understanding of the mechanisms underlying truly collaborative integration.

In addition to conceptual development, new supply chain contexts are also evolving. Whilst the great majority of the supply chain management literature has advanced with manufacturing organisations in mind (Slack & Bates, 1997), it is clear from practitioner organisations such as the Supply Chain Council that service organisations are also keen to benefit from the implementation of appropriate supply chain concepts and practices. Bringing managerial principles from manufacturing to service operations contexts *per se* is not always recommended, however it can often impart beneficial results (Levitt, 1976; Bowen & Youngdahl, 1998). Giannakis (2001) recognises that this consideration of evolving service supply chains versus 'traditional' manufacturing settings is another significant gap in the literature.

Thus to address this contextual literature gap, this doctoral study seeks to investigate conceptual knowledge dimensions within appropriate manufacturing and/ or evolving service supply chain contexts. In the process, relevant concepts from the manufacturing and service operations literatures are considered. These include perspectives taken from studies on service quality (Roth & Jackson, 1995; Zeithaml et al., 1996), new service development (Froehle et al., 2000), and service strategies (Kellogg & Nie, 1995). Also, studies from the services stream of literature have highlighted two particular service contexts as potentially benefiting from implementing supply chain concepts and worthy of study- the financial services industry and the healthcare service sector.

In summary, to gain a more profound understanding as to how supply chain theory and practice will continue evolving into the 21st century, important conceptual and contextual gaps in the literature need to be addressed. The following section outlines the research focus of this doctoral study and how it aims to contribute to the continued development of the evolving supply chain.

1.1 THE RESEARCH FOCUS

> "Where are we now in the evolution of supply chains and what has to occur to advance along the continuum?" (Bowersox et al., 2000)

This dissertation aims to go some way to answering this question, by undertaking empirical investigations of what emerge from the literature as being important conceptual and contextual issues in the way that supply chains, and their management, are evolving. In particular two gaps are identified in the literature, analysis of which should improve understanding as to what has to occur to advance along the evolutionary continuum. These evolutionary gaps highlight the need for research in the following areas, and represent considerable opportunities for this doctoral study:

1. Consideration of knowledge dimensions in supply chains,
2. Consideration of manufacturing and service supply chain contexts.

Furthermore, any judgement relating to progressing along the evolutionary continuum requires consideration of the impacts upon supply chain performance. Thus this doctoral study addresses the Bowersox et al. (2000) evolutionary question by synthesising supply chain literature and adopting new perspectives, mainly from the knowledge management streams of research, to investigate the following overall research question:

> What is the impact of knowledge dimensions in manufacturing and service supply chain contexts?

Three particularly relevant knowledge dimensions that emerge from the combined supply chain and knowledge management literature are: supply chain knowledge transfer, supply chain competence and supply chain maturity. These correspond to a logical progression from creation and transfer; through knowledge acquisition and improvement; and finally to the evolution of knowledge in the supply chain. Such mechanisms underlying knowledge development are recognised by different literature streams as being crucial to organisational evolution and form the basis of a unifying framework that this study proposes for supply chain knowledge management. The unifying framework is further developed to formulate the overall conceptual research model for this doctoral study.

Consideration of the specific knowledge transfer, competence and maturity conceptual constructs within manufacturing and/ or service supply chain contexts identifies three focused topics for investigation. Each topic addresses a specific primary research question relating to the impact of each of the above knowledge dimensions in fitting supply chain contexts. Subsequent development and analyses of these research questions forms the content of three consecutive essays in Chapters 5, 6 and 7.

In essence, each essay constitutes an empirical investigation of one of the above knowledge dimensions within particular context(s). The three essays follow the developmental sequence of: i) an exploratory study of knowledge transfers in manufacturing supply chains; ii) the direct comparison of an established competence construct in manufacturing and service supply chain contexts; and iii) the development and investigation of a 'supply chain maturity' conceptual framework, as defined by collaborative knowledge sharing across appropriate integration practices, in the evolving healthcare service supply chain context.

Each essay is based upon a separate empirical data collection, respectively implementing and developing 'best practice' mail, telephone and Internet survey methodologies. The data collected includes objective measures of supply chain performance and allows for the appropriate creation of scales based upon existing literature. In order to address the stated research questions appropriate multivariate data analysis techniques, such as multiple regression analysis, factor analysis, structural equation modelling and set correlation analysis are employed.

The following sub-sections outline the more precise research focus for each of the three essays.

1.1.1 Investigating Knowledge Transfer in Manufacturing Supply Chains

The majority of existing supply chain literature and empirical research has focussed on asset, data and information levels of exchange. Whilst these are relatively well understood and widely considered by literature, there is another element of exchange that is not so clearly comprehended- knowledge (Giannakis & Croom, 2004). Yet, as the emphasis of competition shifts from individual companies towards competing supply chains, the management of the more extensive knowledge transfers amongst supply chain partners is becoming increasingly important (Bowersox et al., 2000). More specifically, there is a need to explore the effect upon operational performance of inter-firm knowledge flows. Such knowledge flows can take the form of: i) structural, or declarative, knowledge such as shared information on inventory level, delivery frequency etc.; and ii) procedural aspects of knowing and collaboratively acting in terms of planning, forecasting, coordinating etc. (Kogut & Zander, 1992). The increase in complexity involved in this move from an asset, data and information level of analysis to one of knowledge sharing between supply chain partners leads to new insights with future implications upon supply chain research and practise. In particular, the knowledge management field of research offers new and helpful perspectives as supply chains and their management evolve, and is called-upon to address the research question investigated by the first essay:

> RQ1: "What is the impact of knowledge transfer in manufacturing supply chains?"

This research question is explored by the essay in Chapter 5, which investigates the flows of knowledge between a manufacturer's upstream suppliers and downstream customers. The impact upon performance of these knowledge transfers is assessed. The literature suggests that manufacturers rely on knowledge generated up and down the supply chain. A set of hypotheses is evaluated using data from the International Manufacturing Strategy Survey (IMSS) on 338 European companies to test predicted impacts upon performance. Findings show that while knowledge inflows from both upstream and downstream directions are related to a manufacturer's performance, knowledge derived from customers is especially important. Furthermore, the interaction between upstream and downstream knowledge has the strongest link to performance. This paper extends both the existing knowledge management and supply chain management literature, and its theoretical contributions are discussed. The managerial implications of upstream and downstream sources of knowledge in the supply chain as well as further research are also discussed.

1.1.2 Comparing Supply Chain Purchasing Competence in Manufacturing and Service Contexts

Supply chain concepts that have been developed and observed in manufacturing contexts are being extended and implemented in service supply chain contexts. These relatively new evolving supply chain contexts pose new challenges both to practitioners and to researchers, and present interesting comparative opportunities for doctoral investigation.

One particular opportunity for direct comparative research between manufacturing and service contexts lies in investigating the links between organisational competence and performance (Cox, 1997; Knight, 1998). A definition of supply chain competence emerges from both knowledge management and operations management literature as the improvement of knowledge into specific individual and organisational skills. Manufacturing and service contextual implications show that there are particularly good comparative opportunities on the supply (upstream) side of the supply chain. Therefore, this study contributes to the literature by investigating relationships between the supply chain knowledge dimension "purchasing competence" (Narasimhan et al., 2001) and performance across service and manufacturing contexts. Thus the second essay develops and investigates the following overall research question in Chapter 6:

> RQ2: "Is supply chain purchasing competence equally applicable to manufacturing and service supply chains?"

This essay empirically compares purchasing competence in financial services and manufacturing sectors, and assesses the respective impact upon purchasing performance levels. Data was collected using rigorous telephone survey methodologies on 200 European companies with turnovers in excess of $400 million, evenly distributed between financial services and manufacturing sectors. Established scales for both purchasing competence and purchasing performance are adopted from the literature (Chao, 1993; Narasimhan et al., 2001). The findings have relevance for supply chain professionals and academics.

1.1.3 Investigating Supply Chain Maturity in an Evolving Service Context: Healthcare

Academics have viewed the supply chain, rather than the individual organisation, as becoming the effective unit of future competition. Fundamental to this thinking are the beneficial impacts that arise from collaborative integration concepts underpinning important paradigms such as lean, agile and leagile supply chains (Lamming, 1993; Harrison et al., 1999). Nevertheless, significant disparities exist between organisations and sectors with regard to the assimilation of these ideas and practices, and the goal of collaborative supply chain integration remains elusive for many companies. Yet no detailed frameworks exist to help with the question as to 'where' we are now and what has to happen to advance along the continuum of supply chain evolution (Bowersox et al., 2000). Thus there is the need to formulate conceptually consistent and sufficiently detailed measures of supply chain maturity to enable assessment of current and future development. In keeping with the maturity concept coined by Bowersox et al. (2000), this doctoral study defines supply chain maturity as the level of collaborative knowledge sharing across 'appropriate' supply chain integration practices (Bessant et al., 2003) as identified by the widely used Supply Chain Council SCOR model. The evolving Healthcare supply chain is particularly appropriate to commence the quest for a maturity 'roadmap' with which to help academics and practitioners regarding the collaborative supply chain integration journey (Fawcett & Magnan, 2002). Furthermore, the Healthcare sector is an ideal arena for investigating the effects of supply chain maturity upon operational performance, and thus the following research question:

> RQ3: "What is the impact of supply chain maturity in an evolving service-oriented context?

The concluding third essay empirically explores this question in Chapter 7. To enable assessment of collaborative knowledge sharing across 'appropriate' practices an innovative web-based survey was implemented to collect data for the varying supply chain configurations and operations of 154 1st tier suppliers to the UK healthcare sector. Structural equation modelling techniques are used to validate appropriate supply chain maturity scales and frameworks comprising the SCOR dimensions Plan, Source, Make, Deliver, New Product Development and Returns. Hypotheses relating to the impact of maturity dimensions upon multiple performance measures are supported through set correlation analyses assess. Results indicate that certain dimensions have more significant impact than others and that supply chain maturity can be underdeveloped, appropriately developed or overdeveloped. Managerial implications and areas for further research are discussed.

The work carried-out for each of the above essays is entirely that of the thesis author-Adrian Done. Nevertheless, in preparing these essays and the thesis as a whole, academic advice and opinion has been sought from and given by Professors Mark Frohlich and Chris Voss at London Business School. Their input has been purely in a supervisory capacity. In addition, the second essay sought to replicate and extend the work of Professor Ram Narasimhan (Michigan State University), and as such several conversations were held with him to discuss the value of extending his research and the relative merits and processes of different analysis techniques to ensure research compatibility. Each of the above essays is currently in the process of being further developed for submission to academic journals. In this respect Professors Frohlich, Voss and Narasimhan are providing academic support in terms of editing suggestions and publication advice.

1.2 CONCEPTUAL PERSPECTIVES AND DEFINITIONS ADOPTED

Supply chain management can be studied from several different perspectives. Giannakis and Croom (2004) identify several bodies of literature associated with the investigation of supply chains along with their respective theories and models. They state that:

> "Research in the field of supply chain management has evolved from its core concerns around logistics/ operations processes through the incorporation of theoretical concepts and research in strategic management, industrial organisation, institutional and production economics (transaction costs), inter-organisational relationships, knowledge management and systems theory."

Whilst recognising that the study of supply chains can take several alternative perspectives, this thesis primarily adopts viewpoints, theories and frameworks from the operations management (OM) and logistics literatures. The OM/ logistics perspective is consistent with the author's own research motivations (see Section 1.3) and is deemed to represent the area of greatest potential academic contribution for this thesis. In addition, researchers consider supply chain management as a field of study to have largely developed within the OM and logistics literatures (New, 1997; Croom et al., 2000). Halldorsson et al. (2003) state that much of the conceptual foundation of supply chain management originates in OM and logistics and thus these literatures constitute the conceptual 'point-of-departure' for the literature review in Chapter 2. The overall research questions considered in this thesis are raised by the OM/ logistics literatures and thus this perspective is maintained on a broad level in an attempt to ensure consistency.

Nevertheless, supply chain researchers also note limitations to the OM/ logistics perspective that potentially restrict further theory development in this field (see Section 2.1.9.) In this respect this thesis follows-up on researchers' proposals that further insights could be obtained through combining a core OM/ logistics perspective with concepts from the knowledge management literature (Stock, 1997; Amundson, 1998). Therefore potentially insightful theories relating to knowledge transfer and organisational learning from the field of knowledge management are considered in Section 2.2 and further applied in Chapters 5, 6 and 7.

Other perspectives for investigating supply chain management could have been taken from potential alternative bodies of literature such as purchasing, economics and political science. The fact that this thesis does not draw so heavily upon research in these literatures does not detract from the value of such research. Rather, a pragmatic decision was taken in favour of adopting a broad OM/ logistics perspective over these alternatives for the following reasons:

1. The purchasing and supply literature offers a rich body of knowledge relating to the purchasing function and upstream buyer-supplier relationships (e.g. Ellram & Pearson, 1993; Pearson et al., 1996; Narasimhan et al., 2001). This body of literature includes topics such as JIT, supply networks, purchasing strategies (e.g. multiple sourcing, short-term contracting, competitive bidding) and the strategic importance of the purchasing function. Such topics are very important to supply chain operations. Nevertheless, the focus of the purchasing and supply literature upon the upstream-oriented operations renders such a perspective to be of limited value for this thesis. In addition to upstream issues relating to procurement and sourcing, this thesis also sets-out to consider important downstream elements of delivery and overall supply chain planning. Thus, whilst certain concepts from the purchasing and supply literature are drawn-upon in those parts of the thesis that specifically consider upstream issues (e.g. Chapter 6), the more holistic approach of the OM/ logistics literatures is more in keeping with the general aims of this investigation.

2. Economics literatures divide into micro and macro bodies of research. Of relevance to supply chain researchers are specific research streams associated with industrial organisational economics concerned with structures of governance and ownership, and institutional economics related to the nature of the firm and its boundaries (Giannakis & Croom, 2004). Particularly relevant research within these literature streams include work on organisational and institutional theory, value chains, transaction cost economics (TCE), agency theory, and the firm as a nexus of contracts (Stock, 1997). Research in these areas primarily attempts to answer

questions relating to issues such as: i) why organisations are structured the way they are; ii) why firms behave the way they do; and iii) how organisations adapt and change (Amundson, 1998). These are important areas of consideration for supply chain researchers, but do not accurately correspond to the research focus of this thesis. Certain very specific areas of microeconomics literature relating to the importance of knowledge and learning to organisational evolution are considered relevant to this investigation and are subsumed within the multidisciplinary knowledge management perspective (see Section 2.2.1.)

3. The emphasis of political science oriented supply chain research addresses issues relating to the social and ideological constitution of supply chains, and the ethical and political implications (New, 1997). With increasing levels of globalisation, social and environmental awareness of consumers, and anxiety towards the impact of political conflicts, companies are apparently being forced to review their relationships with supply chain partners (New, 2003; Schrage 2004). Thus political science issues are of relevance to supply chain researchers, and in particular conceptual areas of political science literature relating to issues such as coalition formation, trust, power and governance. Stock (1997) identifies the field of political science as having already made specific conceptual contributions to supply chain logistics research through the theory of "exit, voice and loyalty"- a theory of political dissent or disagreement that identifies the possible behaviours of individuals in politics or organisations within a supply chain system. Whilst each of these topics and concepts are very relevant to supply chain research, they do not correspond to the specific research questions that this thesis seeks to investigate. Thus a decision was taken not to adopt a political science perspective.

Further to the decision to adopt an OM/ logistics perspective, it has been recognised that this thesis makes use of potentially ambiguous terms. The main potential causes for misunderstanding have been identified as the specific terms: integration, evolution, first-tier supplier and coordination. Such terms can have widely differing meanings in different contexts and therefore it is important to recognise semantics and the particular usage adopted within this thesis. Refined definitions and explanations as to how each of these terms is adopted and used in the context of this thesis are given below:

Integration

The Oxford and Collins English Dictionaries provide the following relevant definitions:

> Integrate: 1. To make or be made into a whole; 2. To incorporate or be incorporated.
> Integration: 1. The process of combining or being combined to form a whole;
> 2. To bring or come into participation in an institution or body.

The integration of processes within and between companies and organisations can take-on several forms. The term 'vertical integration' is commonly used in business literature as referring to the degree of in-house responsibility and ownership of upstream and downstream operational processes. For example, the Ford Motor Company was historically considered highly vertically integrated through Ford's ownership and direct control over "everything connected with his cars from the basic raw materials up" (Womack et al., 1990, p. 33). Hayes and Wheelwright (1984, p. 275) relate the issue of vertical integration to "process positioning" within the competitive environment. They consider the importance of fundamental integration decisions such as: 1. "What boundaries should a firm establish over its activities?" and 2. "How should it construct its relationships with other firms- suppliers, distributors, and customers- "outside" its boundaries?" Frohlich and Westbrook (2001) explain the move from the vertical integration ownership of internal operations to the horizontal integration of processes, including integration of processes with external supply chain partners:

> "If the 1980s were about vertically aligning operations with business strategy, the 1990s have been about aligning operations across processes... The most successful organisations seem to be those that have carefully linked their internal processes to external suppliers and customers in unique supply chains. In short, for the new millennium upstream and downstream integration with suppliers and customers has emerged as an important element of strategy."

Harrison and van Hoek (2002, p. 131) define integration in terms of forging relationships and improving communication between departments and organisations, with the aim of aligning value-adding activities, that would otherwise be disconnected, so that supply chain partners can work more closely together to improve overall performance. Similarly, Towill et al. (2002) define integration as supply chain partners "thinking and acting as one", and is achieved "by extending the scope of management outside the company to embrace the suppliers and customers." Fawcett and Magnan (2002) discuss supply chain integration in terms of efforts to align objectives and resources across company boundaries to deliver greater overall value. They identify four types of supply chain integration:

1. Internal, cross-functional process integration
2. Backward integration with external suppliers
3. Forward integration with external customers
4. Complete forward and backward integration to the supplier's supplier and the customer's customer.

In the context of this thesis, Essay 1 in Chapter 5 considers both backward and forward integration with external suppliers. Essay 2 in Chapter 6 investigates internal, cross-functional process integration. Essay 3 in Chapter 7 studies complete forward and backward integration with external suppliers and customers. Throughout the context of this thesis the emphasis is upon integration to align processes, forge relationships, improve communications and leverage knowledge across appropriate parts of the supply chain. This usage of the term is consistent with the existing supply chain literature definitions outlined above.

Evolution

The Oxford and Collins English Dictionaries provide various definitions:

> Evolution: 1. (Biological) A gradual change in the characteristics of a population of animals or plants over successive generations. 2. A gradual development to a more complex form. 3. (Chemistry) The giving-off of gas, vapour, heat etc. 4. A pattern formed by a series of movements or something similar. 5. (Algebra) An algebraic operation in which the root of a number is extracted.6. (Military) An exercise carried out in accordance with a set plan.

Clearly, therefore the term 'evolution' can be taken to mean different things in different contexts. Apparently, only the first two of the above definitions are adopted by broader business research streams. For the first biological definition of the term, both Darwinian and Lamarckian theories of biological evolution and natural selection are considered by certain streams of evolutionary economics (e.g. Alchian, 1950; March, 1994). Nelson and Winter (1982, p. 41) state that:

> "The general idea that market competition is analogous to biological competition and that business firms must pass a survival test imposed by the market has been a part of economic thought for a long time."

To the author's knowledge, however, such 'survival-of-the-fittest' evolutionary theories have not been applied or tested within supply chain contexts. As such, this thesis does not attempt to adopt definitions relating to biological evolution of populations or species over successive generations. Instead, this thesis adopts the second of the above evolutionary definitions relating to gradual development towards a more complex form. This definition is most appropriate to the contexts considered within this thesis and is consistent with usage of the term within the supply chain literature. Supply chain literature broadly uses the term 'to evolve' as being synonymous with 'to develop', 'to progress' and 'to mature'. For example, Lee and Billington (1996) investigated "the evolution of supply chain management models and practice at Hewlett-Packard". They observed benefits throughout the organisation of developing supply chain maturity, stating that:

> "The [HP] supply chain methodology is now mature."

Another example of usage of the evolutionary term within the supply chain management literature is given by Christopher and Towill (2001). They define and characterise four "supply chain evolution phases" relating to the progressive development from product driven lean supply in the early 1980s, to the incorporation of elements of agile market driven supply chain paradigms in the late 1980s and early 1990s, towards the development of customised "leagile" supply chains in the late 1990s.

Bowersox et al. (2000) use the evolutionary term to describe the development of supply chains towards more sophisticated management practices:

> "The transitions underlying some of the mega-trends represent the challenges of the emerging decade for logisticians and supply chain executives and identify the direction for change. A critical question is: Where are we now in the evolution of supply chains and what has to occur to advance along the continuum? In the opinion of the authors, the current maturity of the mega trends is uneven."

The Bowersox et al. (2000) mega-trend analysis gives an indication of where and how supply chain management should evolve in order to attain performance improvements. See Section 2.1.7 for further discussion of Bowersox et al. (2000) relating to the evaluation and development of supply chain maturity in specific areas.

Within the supply chain context of this thesis the term 'evolution' corresponds to progress towards more sophisticated forms of supply chain management, the development of supply chain maturity and, ideally, the consequential improvement in supply chain performance. Such usage of the term is consistent with the above supply chain literature.

First-tier (or tier 1) supplier

According to Brown et al. (2005, p.229), the term 'first-tier supplier' was first coined by observers of Japanese industrial structure to describe the suppliers that delivered components, materials and products directly to the household name manufacturers (OEMs) of cars, consumer durables and capital equipment that were part of Japan's post-war revival. Brown et al. (2005, p.230) warn that, whilst in the Japanese *keiretsu* supply organisations the tiers are clearly marked, elsewhere the definition may not be so clear:

> "The image of tiers is so strong that there is a tendency to call suppliers 'first tier' or 'second tier' without a logical basis. A tier, after all, is a very specific feature of a structure: it has a hierarchical position and lateral links to others in the same tier... The danger of referring to organisations in the supply chain, base or network as 'first tier' (or second tier, and so on) is that the expectations thus created bear no resemblance to the activity that will be addressed by the organisation in question."

There are two main issues with the tier concept. Firstly, use of the term tends to assume that communications only occur between the tier levels, when in fact it is quite possible that more complex forms of communication can occur. For example, suppliers may communicate with other suppliers in the same tier, and similarly, second- or third tier suppliers may communicate directly with the OEM customer. Secondly, it is quite possible to arbitrarily change the tiered position of a supplier. For example, the allocation of one first-tier supplier as a systems integrator may arbitrarily reposition other previously first-tier suppliers as second-tier suppliers.

Nevertheless, whilst it is important to consider more complex forms of communication within and between tiers and the arbitrary nature of tier positioning, Harrison and van Hoek (2002, p. 8) provide the following simplified definition relating to tier 1 suppliers:

> "The supply chain is *tiered* in that supply side and demand side can be organised into groups of organisations with which we deal. Thus if we place an assembler such as the Ford plant at Valencia as the 'operation', tier 1 comprises suppliers of major parts and subassemblies who deliver directly to Ford, while tier 2 suppliers deliver to the tier 1s etc."

This notion of a supply chain structure whereby first-tier suppliers are designated as those communicating with and delivering directly to a specified focal company within the supply chain, and second- tier suppliers delivering directly to first-tier suppliers (and so on), is commonly adopted by the supply chain and broader operations management literature. For example, Slack et al. (1998, p. 152) define a first-tier supplier as being part of the immediate supply network in direct contact with an operation:

> "On the supply side is a group of operations that directly supply the operation; these are often called 'first-tier' suppliers. They are supplied by 'second-tier' suppliers."

Similar definitions are given by other supply chain and operations management texts (e.g. Hill, 2000, p. 400). Furthermore, usage within the literature of tiered supply chain terminology assumes a closer relationship, with more dominant levels of communication, between the focal company and first-tier supplier than between focal company and second-tier supplier (Fawcett and Magnan, 2002). Strength of relationship is implied to decrease with increasing tier levels.

Within this thesis the term 'first-tier supplier' is used mostly in relation to the third essay (Chapter 7) and is applied in the same manner as the above Harrison and van Hoek (2002, p. 8) example. That is, for a given product supply chain the immediate upstream supplier with whom the 'operation' has direct contact (i.e. the supplier with whom the customer has most communication) is designated the first-tier supplier. Instead of Ford, however, the term is applied in Chapter 7 specifically to those suppliers that deliver goods or products directly to major UK Healthcare service providers (i.e. NHS, Bupa, BMI-General). These are the product suppliers with whom the healthcare service providers have direct relationships and with whom they have initiated major efforts to develop closer relationships with the aim of improving supply chain performance (Argyle, 2002). In this thesis, supply chain tiering terminology is used to differentiate between companies that supply direct to the healthcare providers and those companies that are the supplier's supplier (second-tier), the supplier's supplier's supplier (third-tier), and so on. The overall research model of this thesis comprises linear supply chains (See Figure 3.3 on page 126) not more complex *keiretsu* style supply networks or associations. Thus, whilst they potentially represent a worthwhile area of investigation, a consideration of more complex forms of tier communication or tier positioning is beyond the scope of this thesis.

Coordination

Excluding specific mathematical, geometrical, military, biological and chemical definitions, the Oxford and Collins English Dictionaries provide the following relevant definitions:

> Coordinate: 1. To integrate diverse elements in a harmonious operation. 2. To bring the different elements of (a complex activity or organisation) into a harmonious or efficient relationship. 3. To work together harmoniously. 4. To take or be in the form of a harmonious order. 5. To negotiate with (others) in order to work together effectively. 6. Of or involving coordination.
> Coordination: 1. The act or process of coordinating.

Clearly such definitions have high relevance within the context of supply chains. In the chapter on "Coordinating the supply chain" Womack et al. (1990, p. 138) outlines the challenges of bringing complex supplier and automotive assembler organisations together in harmonious and efficient relationships:

> "The key to a competitive parts-supply system is the way the assembler (for example, Ford or Renault or Toyota) works with its suppliers."

Harrison and van Hoek (2002, p. 131) outline practices for coordination of value adding activities between supply chain partners in order to help with improving performance in areas such as lead-time. Harrison and van Hoek (2002, p. 225) go on to link supply chain coordination with the related terms of cooperation and collaboration in supply chain partnerships. They characterise cooperation, coordination and collaboration as the supply chain relationship types in Table 1.1, stating that increasing levels of commitment and trust as relationships move towards collaboration are linked to success.

Table 1.1 Supply Chain Cooperation, Coordination and Collaboration

Partnership Type	Activities	Time Horizon	Scope of Activities
Cooperation	Fewer suppliers Longer-term contracts	Short-term	Single functional area
Coordination	Information linkages WIP linkages EDI exchange	Long-term	Multiple functional areas
Collaboration	Supply chain integration Joint planning Technology sharing	Long-term with no fixed date	Firms see each other as extensions of their own firm

Source: Harrison and van Hoek (2002, p. 226)

The broader supply chain literature also relates the term 'coordination' to upstream and downstream information exchange. For example Lee et al. (1997a) state that:

> "One important mechanism for coordination in a supply chain is the information flows among members of the supply chain."

Similarly, Frohlich and Westbrook (2001) discuss the "coordination of information technologies and the flow of data" with external supply chain partners:

> "As companies have aggressively pursued cost cutting over the years, they have begun to reach the point of diminishing returns within their organisation's own boundaries and now believe that better coordination across corporate boundaries- with suppliers and distributors- presents the greatest opportunities. Happily, the growing acceptance of this view has coincided with the emergence of electronic networks that facilitate closer coordination."

Frohlich and Westbrook (2001) clarify that "better coordination in the supply chain reduces uncertainty throughout the manufacturing networks", and that "tighter coordination helps eliminate any non-value-adding activities from internal and external production processes." Fawcett and Magnan (2002) identify the link between coordination and collaboration:

> "Early adopters of supply chain practice have discovered that real collaboration goes beyond information exchange and are working diligently to establish other integrative mechanisms to enhance coordination with truly important first-tier suppliers and customers."

In the supply chain context of this thesis the term 'coordination' is used in a manner consistent with the above literature examples. More specifically, usage of the term in this thesis is consistent with Harrison and van Hoek (2002, p. 225) in that coordination is considered as an important form of supply chain relationship as supply chain partners develop mutual commitment and trust and move from cooperative to fully collaborative partnerships. This thesis therefore regards the coordination of data and information between supply chain partners as being a prerequisite for enabling the collaborative leveraging of expertise and knowledge across appropriate parts of the supply chain.

1.3 PERSONAL BACKGROUND TO THIS DOCTORAL STUDY

> "There are at least three major philosophical questions that should be addressed at the outset of the research. These are: Why research? What to research? And how to research?" (Remenyi et al., 1998, p. 23)

Answers to these questions depend, at least partly, on the researcher's previous education and experiences and the resulting personal conceptual and cognitive frameworks. As most research methodology texts recommend, any piece of research should begin with a reflection upon personal reasons, conceptual standpoints and potential biases behind a researchers interest in a particular topic. Whilst the third of these questions relating to how to research is addressed in detail in Chapters 3 and 4, a personal reflection of the first two questions serves to identify the 'catalyst' behind my doctoral research in this particular area. As Singleton and Straits (1999, p. 66) state:

> "To carry out a research project, with its inevitable complications, obstacles, and demands for time and money, requires considerable interest and commitment on the part of the investigator. What sustains this interest more than anything else are highly personal motivations for doing research on a particular topic. Thus an investigator may choose a topic not only because it is considered theoretically important, novel, or researchable, but also because it piques the researcher's interest."

My own educational background and career trajectory as a Chartered Engineer have led me to view rigorous academic research in operations management- and particularly supply chain management as a fundamentally stimulating and important occupation. I have been exposed, as a practitioner, to the implementation and development of many operations management philosophies and techniques from the mid-1980's. I started as a 'fast-track' trainee mechanical engineer with Ford Motor Company, at a time when the company was fighting to stay competitive and to stave-off the growing superiority of

Japanese manufacturers. My sponsored 'sandwich' degree course at Loughborough University interspersed with 6-monthly Ford work placements across the UK and in all areas of operations afforded maximum academic and practical exposure to 'new' engineering techniques such as CAD/ CAM, Finite Element Analysis, Failure Modes and Effects Analysis, automated Statistical Process Control, Taguchi Methods and Robotic Production.

In the early 1990's my automotive experience moved upstream as a Project Engineer, Internal Consultant and then Production Manager with GKN- a major global supplier of transmission and other engineered components to most automotive OEMs including Ford, Toyota, Nissan, Rover, GM, Peugeot, Citroen, Renault, and VW. Exposed to the enormous pressures put upon suppliers by automotive OEMs and in positions of responsibility at a time of intense and sustained competition instilled in me a grass-roots understanding of many of the emerging management philosophies such as Total Quality Management, Just-In-Time, Total Productive Maintenance, Cellular and Flexible Manufacturing, Quality Function Deployment, Kanban, Continuous Improvement and the broader Toyota Production System.

During my automotive experience I developed a high regard for academic research aimed at helping managers deal with real issues. Seminal works such as "The Machine that Changed the World" (Womack et al., 1990) fired my enthusiasm for getting to the heart of problems and the arena of operations management research. In fact, I started with Ford in 1985, the same year that the International Motor Vehicle Program kicked-off at MIT. As a young engineer I was working on the Ford Mondeo 'world-car' project (the CDW 27 Tempo/ Topaz/ Sierra replacement) whilst this important book was being researched and written, and as methods of lean production were being recognised in the west. For anyone involved in the sector it was hard not to be enthused with statements like:

> "Lean production is a manufacturing system that results in a better, more cost-efficient product, higher productivity, and greater customer loyalty. [Its hallmarks] are teamwork, communication, and the efficient use of resources. And the results are remarkable: cars with one-third defects, built in half the factory space, using half the man-hours." (Womack et al., 1990, p. 4)

And, as someone gaining both upstream and downstream automotive experience in this dynamic period, I was particularly excited by the supply chain coordination aspects of lean production:

> "The modern car is almost unimaginably complicated. A typical model is made up of more than 10,000 parts, each of which must be designed and made by someone. Organizing this enormous task is probably the greatest challenge in manufacturing a motor vehicle. Yet it is the one least understood and appreciated by the outside world." (Womack et al., 1990, p. 138)

This struck a chord and stimulated me to dig deeper into the concepts and mechanisms of supply chain management theory and practice and has led to this doctoral research. As an ex-practitioner a specific emphasis of my research is to investigate important 'real-world' issues with a view to helping practitioners with the "What should I do?" question (Krajewski, 2002: See below) when they are faced with the tremendous challenges of supply chain coordination.

1.4 OVERALL GUIDING RESEARCH PRINCIPLES

In seeking to make a useful contribution to the operations management (OM) field, this doctoral study adopts general guidelines recently proposed by eminent researchers in the area. This section summarises the main principles and guidelines expressed by respected OM academics in dealing with concerns as to the direction that the field is taking.

In his "Hopes for the Future of Operations Management", Meredith (2001) makes the point that research in the field should be of interest to both academicians and to practicing managers- and yet still "demand the rigour and depth of knowledge that have historically characterised our field." Also Meredith (2002) points out that one of his editorial goals was to encourage OM researchers to develop relevant, managerial theory that was focused on real situations. This focus on real situations is explicit in the definition of the OM field as addressing "the operating problems of managers who are responsible for the direction and control of the processes that transform inputs into products and services" (Krajewski, 2002).

Regarding the future of the OM field, Krajewski (2002) states:

> "The decade of the 1990s fostered a resurgence of the importance of operations management in the eyes of the practitioner. The popular press was full of

> instances where Cinderella dot-com companies were failing because they did not match the importance of operations with that of marketing...As a field of researchers, we are indeed more relevant by virtue of the problems we address. Our thrust into empirical research has helped in this regard. Further, we have done a better job of putting the word "management" back into operations management...As we develop our field, let us not lose sight of our roots. We need to provide answers when a manager asks, "What should I do?""

Regarding the question of whether to use management science/ operations research (MS/ OR) or empirical research avenues, Krajewski (2002) states that both are needed by the OM field. Both have their pros and cons. "Whilst "MS/ OR modelling is useful for providing the means for making rational decisions... its findings are often limited to very stringent conditions that make general applications difficult. Too often the focus is narrow, and the "big picture", so important to operations management, is not considered." On the other hand, whilst being limited to the current field data, this study adopts an empirical research approach as being "appropriate for understanding what is currently happening in our field."

Hill (2002) proposes five principles for rising to the challenges of future research in the operations management community. In urging OM researchers to avoid "selling snake-oil" yet not "miss the penicillin", Hill makes the point that they should examine assumptions and be critical of the assumed 'facts', without being too cautious or rejecting ideas because they are outside our narrow research methods and paradigms. The principles he puts forward are:

- Use strong research methodologies
- Nurture new ideas
- Continue to rejuvenate the area with expansive thinking about problem domains
- Be innovators and leaders, not just reporters
- Address relevant and important problems ("make sure the ladder is against the right wall").

1.4.1 Methodological Rigour, Scientific Method and Managerial Relevance

Handfield (2002) adds to the above principles by stipulating guidelines particularly with respect to the issues of methodological rigour, scientific method, and managerial relevance. He states:

> "OM has been slow to shrug off its roots in operations research (Handfield & Melnyk, 1998). It should be noted that empirical research in OM spans a broad diversity of methods... the nature of the problem should drive the research method chosen... a solid set of precedents exists for empirical methods which must be utilised to drive methodological rigour into OM empirical research. If there is any weakness to the recent set of OM empirical research, it is that they suffer from poor research and sampling designs (Malhotra & Grover, 1998) or poor underlying theory development."

Regarding managerial relevance, Handfield (2002) believes "in conducting research that contributes to our field as a scientific discipline and to apply this knowledge to the practice of management as a profession." To this end, he suggests that OM researchers force themselves to develop an intimate understanding of the problems facing OM practitioners.

This doctoral study aims to comply as far as possible with these overall guiding principles of rigour, method and relevance.

1.5 SUMMARY

This chapter introduces supply chain research and the particular motivations and focus of this doctoral study. Supply chain literature has had a considerable impact upon the wider operations management research stream, as well as upon practising managers- to the point that supply chains are seen as the main units of future competition. Theory and practice have evolved resulting in the emergence of modern lean, agile and leagile paradigms. Yet, fundamental deficiencies in understanding still pervade and constitute potential barriers to further evolution of theory and practice, particularly relating to the important concepts of collaboration and integration that underpin supply chain thinking.

To gain a more profound understanding, the conceptual scope of supply chain research needs to go beyond asset, data and information levels of exchange. Truly collaborative supply chains necessitate broader 'arcs of integration' encompassing the exchange and development of knowledge. Greater comprehension of how to manage knowledge dimensions within supply chains is likely to be a key to continuing evolution of theory and practice. Yet little work has been done to explore these more complex dimensions and this represents a significant conceptual gap in the supply chain literature. Furthermore, supply chain concepts traditionally developed in manufacturing are increasingly being applied in evolving service supply chain contexts. However, few studies have investigated such service-oriented supply chains and this represents a significant contextual gap in the literature.

This study aims to explore these gaps by applying conceptual perspectives from the emerging knowledge management literature and contextual insights from the service operations literature. In particular, this study investigates three knowledge-based dimensions that emerge from the combined literatures: knowledge transfer, supply chain competence and supply chain maturity in manufacturing and evolving service contexts. The impacts of these knowledge dimensions upon supply chain performance are investigated empirically and discussed in three consecutive essays:

Essay 1: Investigating Knowledge Transfer in the Manufacturing Supply Chain

Essay 2: Comparing Supply Chain Purchasing Competence in Manufacturing and Service Contexts

Essay 3: Investigating Supply Chain Maturity in an Evolving Service Context: Healthcare

A variety of appropriate data collection and multivariate analysis techniques are used in the empirical investigations that constitute these essays. As a whole, this doctoral study attempts to comply with recognised principles regarding methodological rigour, scientific method and managerial relevance in operations management research.

The following chapter looks at the major concepts and themes within the relevant bodies of literature. Potential gaps in the supply chain literature are reviewed with the aim of identifying particular areas where this study could make a valuable contribution. Chapter 3 goes on to develop the overall conceptual framework and builds-up specific propositions and refined research questions to be addressed. Chapter 4 outlines the study's survey and analysis methodologies. Chapters 5, 6 and 7 then develop the three consecutive essays. Finally, Chapter 8 draws overall conclusions, and implications for academics and managers are considered.

CHAPTER 2 – LITERATURE REVIEW

Whilst the main focus in this literature review chapter is upon the Supply Chain Management stream, three other academic streams are also considered to varying degrees: Knowledge Management, Manufacturing Operations and Service Operations. These additional streams are included with a view to obtaining enriching new insights and concepts with which to address specific outstanding supply chain issues. The streams of supply chain management, manufacturing operations and service operations are considered in this review as largely 'belonging' to the broader Operations Management area of literature. The knowledge management/ organisational learning stream, however, is composed of perspectives from numerous fields beyond the generally considered realm of operations management.

With a view to informing the direction of research in this study, and to identifying potential gaps in the literature where possible contributions could be made, this chapter starts from a broad literature review and then hones in upon specific issues of interest. Since the research focus of this study is based in the supply chain literature, this constitutes the main thrust of the review in Section 2.1. The other literature streams are reviewed afterwards, in the light of identified deficiencies in the supply chain literature, and in terms of distinct perspectives and novel conceptual and contextual dimensions that they could add. Section 2.2 conducts a conceptual overview of the knowledge management and organisational learning literatures, identifying particular theories that could help address conceptual gaps in supply chain management research. Section 2.3 reviews the limited literature that has considered the overlap between supply chain management and knowledge/ learning literatures. Section 2.4 summarises contextual differences between manufacturing and services and implications with regard to the scope of this doctoral research. Finally, in attempting to ensure this is an original piece of work making new contributions to the literature, Section 2.5 considers recent, unpublished, doctoral theses that address similar issues.

2.1 SUPPLY CHAIN MANAGEMENT

> "Traditionally, supply chains created value through low price and broad product assortment. Today, however, supply chain managers are learning to accommodate

> customers who demand greater control of the buying process, have the financial ability to make choices, and are willing to utilise a variety of ways to purchase goods and services to satisfy their lifestyle requirements... How should a firm and its supportive supply chain be structured to create end-customer value as it moves into the 21st century?" (Bowersox et al., 2000)

In view of the above comment, this supply chain management literature review explores traditional, current and potential future developments in the evolution of supply chain theory and practice. The 'flow' of the review takes the following course. Firstly, the scope of supply chain research is examined in Section 2.1.1. Section 2.1.2 follows with an overview of bodies of literature associated with the field of supply chain management. Existing research is then put into context in Section 2.1.3 by an historical consideration of the challenges of coordinating supply chains that led to the emergence of lean supply in the 1980's. Section 2.1.4 considers the last 20 years of continued evolution of supply chain management from lean, agile to leagile paradigms. Two key conceptual issues emerge as underpinning these new evolving philosophies: supply chain integration and collaboration, and these issues are reviewed in Section 2.1.5. Subsequently, Section 2.1.6 analyses current 'good' practice, as promoted by reputable consulting companies and practitioner organisations, and shows concurrence with evolving literature in stressing the need to go beyond pure asset, data and information sharing between supply chain partners.

Discussion from previous sections provides the basis upon which Section 2.1.7 then focuses upon the 'thought' paper of Bowersox et al. (2000)- which reflects upon 'mega trends' for the future evolution of supply chain theory and practice. The importance of managing knowledge dimensions emanates as a fundamental supply chain evolutionary 'mega-trend' and Section 2.1.8 explores the three key conceptual supply chain knowledge dimensions that emerge: knowledge transfer, competence, and maturity.

Finally, Section 2.1.9 examines recent comprehensive literature reviews identifying important gaps in the supply chain literature that warrant further research. Specific conceptual gaps correspond to the knowledge dimensions highlighted by the earlier mega-trend discussion. This, combined with recent calls for new cross-functional conceptual perspectives, suggests that exploring the organisational learning/ knowledge management literatures could bring useful insights to the supply chain literature and this is reviewed in Sections 2.2 and 2.3. Also a significant contextual gap is identified in that most supply chain research has been conducted within manufacturing contexts, with scant regard to service supply chains. This suggests benefits to the field of supply chain management could accrue from a comparative literature review of manufacturing and service operations, and this is carried out in Section 2.4.

2.1.1 The Scope of Supply Chain Management Research

> "Supply chain management is far too important to be considered either a temporary fad or a parochial arena for a guild of specialist researchers. Instead, it is simply the most practically and intellectually significant theme within current managerial and economic research. It is not in any sense a new area; what is new is having a label under which diverse research can be connected." (New, 1997)

In their seminal work on the automotive sector Womack et al. (1990, p.138) encapsulate the importance of supply chain management and give a clear view as to the huge challenges it presents to managers:

> "The modern car is almost unimaginably complicated. A typical model is made up of more than 10,000 parts, each of which must be designed and made by someone. Organising this enormous task [of coordinating the supply chain] is probably the greatest challenge in manufacturing a motor vehicle. Yet it is the one least understood and appreciated by the outside world."

Clearly, such complexity and lack of understanding presents considerable challenges to the academic research community. In his review of the scope of supply chain management research, New (1997) recognises that research in supply chain management is suited to explanatory approaches which adopt multidisciplinary methodological pluralism, but is concerned with "the problem of defining the conceptual boundaries of supply chain management as a field of study." Croom et al. (2000) agree that "supply chain management has received attention since the early 1980's, yet conceptually the management of supply chains is not particularly well understood."

Supply chain management and other similar terms, such as network sourcing, supply pipeline management, value chain management, and value stream management have become subjects of increasing interest in recent years, to academics, consultants, and business management (Christopher, 1992; Hines, 1995; Saunders, 1995; Lamming, 1996; Saunders, 1998). This has developed to such an extent that it is recognised in some parts of the literature that the supply chain should be seen as the central unit of competitive analysis (Cox, 1997). The development of the idea of the supply chain owes much to the emergence from the 1950s onwards of systems theory, and the associated notion of holism (i.e. that the whole is greater that the sum of the parts) (Cavinato, 1992). This can be summarised by the observation that the behaviour of a complex system cannot be understood completely by the segregated analysis of its constituent parts (New, 1997). Related to the philosophy of considering the whole supply chain rather than individual companies within it is one of the key themes that companies should not seek to achieve cost reductions or profit improvement at the expense of their supply chain partners, but rather seek to make the supply chain as a whole more competitive. In short, the contention that it is supply chains, and not single firms, that compete is emerging as a central tenet in the field of supply chain management (Christopher, 1992; Macbeth et al., 1992).

Whilst there are several common supply chain management themes emerging, many authors have highlighted the necessity of clear definitional constructs and conceptual frameworks in the field (New, 1995; Cooper, Lambert, & Pagh, 1997; Babbar & Prasad, 1998; Saunders, 1998). Yet Saunders (1995) warns that pursuit of a single universal definition may be fruitless given the fragmented nature of the field of supply chain management- that draws upon various antecedents such as industrial economics, system dynamics, marketing, purchasing and inter-organisational behaviour. Nevertheless, the scientific development of a coherent supply chain management discipline does require that advancements be made in the development of common theoretical models to inform our understanding of supply chain phenomena. Such a model is the Forrester (1961) industrial dynamics model which translates to supply chain contexts in the form of the "Forrester Effect". Its value lies in the ability to aid understanding of the actions of material flows across a chain, and has provided a basis for further advancement of understanding supply chain dynamics by subsequent academics in the field (for example, Sterman, 1989; Van Ackere, Larsen, & Morecroft, 1993; Towill, 1996; Lee et al., 1997a). Cooper et al. (1997) support this view of the field evolving through building upon key works, pointing to the fact that whilst supply chain management as a concept is a recent development, much of the literature is based on the adoption and extension of older, established theoretical concepts.

New (1995) and Saunders (1995) contend that within the supply chain management literature there is a confusing profusion of overlapping terminology and meanings. In the literature, many labels can be found referring to supply chain and to practices for supply chain management, including: integrated purchasing strategy (Burt, 1984), supplier integration (Dyer, Cho, & Chu, 1998), buyer-supplier partnership (Lamming, 1993) supply base management, strategic supplier alliances (Lewis, Naim, & Towill, 1997), supply chain synchronisation (Tan, Kannan, & Handfield, 1998), network supply chain (Nassimbeni, 1998), value-added chain (Lee & Billington, 1992), lean chain approach (New & Ramsay, 1995), supply pipeline management (Farmer, 1996), supply network (Nishiguchi, 1994), and value stream (Jones, Hesterly, & Borgatti, 1997). Harland, Lamming et al. (1999) prefer the term 'supply strategy':

> "The reasons for moving from supply chain management to supply strategy are to broaden the concept, extending it beyond the materials and information flows orientation of much of the work to a more strategic domain, and to overcome the confusion caused by the label being used to represent purchasing relationships, internal supply issues and logistics issues all at once."

Croom et al. (2000) set out to provide a taxonomy with which to map and evaluate supply chain research. In an attempt to delineate or define the subject domain, they come up with a "topology" of the field of supply chain management as shown in Table 2.1. They highlight a sample of definitions associated with the concept of supply chain management. As they state, "this is not intended to provide a comprehensive review of supply chain definitions, rather the purpose is to highlight some of the contrasting approaches to supply chain management existing in the literature."

Analysis of the sample of supply chain management definitions in Table 2.1 confirms that they share at least one thing in common "... they focus on the external environment of an organisation, with the boundaries of the latter defined conventionally in terms of an entity identified legally as a company or some other form of business unit" Saunders (1997). Yet, even in this 'external' respect the literature has not gained complete consistency since certain management fields do study internal supply chains (Harland, 1996); notably the business re-engineering (Lee & Dale, 1998) and operations management literature (Slack et al., 1998).

Table 2.1 A Sample of Definitions of Supply Chain Management

Authors	Definition
Tan et al. (1998)	Supply chain management encompasses materials/ supply management from the supply of basic raw materials to final product (and possible recycling and re-use). Supply chain management focuses on how firms utilise their suppliers' processes, technology and capability to enhance competitive advantage. It is a management philosophy that extends traditional intra-enterprise activities by bringing trading partners together with the common goal of optimising efficiency.
Berry et al. (1994)	Supply chain management aims at building trust, exchanging information on market needs, developing new products, and reducing the supplier base to a particular OEM so as to release management resources for developing meaningful, long-term relationship.
Jones and Riley (1985)	An integrative approach to dealing with the planning and control of the materials flow from suppliers to end-users.
Saunders (1995)	External chain is the total chain of exchange from original source of raw material, through the various firms involved in extracting and processing raw materials, manufacturing, assembling, distributing and retailing to the ultimate end customers.
Ellram (1991)	A network of firms interacting to deliver product or service to the end customer, linking flows from raw material supply to final delivery.
Christopher (1992)	Network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer.
Lee and Billington (1992)	Networks of manufacturing and distribution sites that procure raw materials, transform them into intermediate and finished products, and distribute the finished products to customers.
Kopczak (1997)	The set of entities, including suppliers, logistics services providers, manufacturers, distributors and resellers, through which materials, products and information flow.
Lee and Ng (1997)	A network of entities that starts with the suppliers' supplier and ends with the customers' customer, involving the production and delivery of goods and services.

Such a confusing array of terms and definitions present in the supply chain management literature could be seen as inconvenient for the purposes of this doctoral thesis. In addition, in several ways this doctoral research is in tune with alternative supply chain terminology, such as the 'supply strategy' developed by Harland, Lamming et al. (1999). Thus this study could adopt the more broadly defined term of 'supply strategy' instead of 'supply chain management'. Certainly the definition of supply strategy fits closely to the conceptual stance adopted throughout this doctoral thesis:

> "Supply strategy relates to the integration of supply activities within firms, in dyadic relationships, in chains of firms and in inter-organisational networks... Common to all these levels is the flow of supply and the activities and decisions associated with that flow. The concept of supply may therefore be summarised as 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."

Nevertheless, in noting that terminology and definitions are often based upon metaphors (chains, pipelines, networks etc.) or "ideal types" rather than objective entities, Saunders (1997) concludes that "... attempts to pursue universal definitions may lead to unnecessary frustration and conflict". Thus the decision was taken to stay with the term 'supply chain management' as the more widely used and accepted in the operations management literature, and to remain within the conceptual scope of the term as used by the broader operations management academic community.

Furthermore, Croom et al. (2000) state that "the lack of a universal definition of supply chain management is in part due to the way the concept of supply chain has been developed...The concept of supply chain has been considered from different points of view in different bodies of literature." Hence they believe the absence of consistent terminology or universal definitions to be almost inevitable, given the multidisciplinary origin and evolution of the field. Croom et al. (2000) argue that what is considerably more concerning is the lack of robust conceptual frameworks for the development of theory in the field. They go further to say that:

> "As a consequence the schemes of interpretation of supply chain management are mostly partial or anecdotal with a relatively poor supply of empirically validated models explaining the scope and form of supply chain management, its costs and its benefits."

Such a serious concern provides considerable motivation for this piece of doctoral research to aim to contribute to the literature by empirically validating literature-derived supply chain models and investigating impacts upon performance.

The next section conducts a review of the bodies of literature associated with supply chain management.

2.1.2 Bodies of Literature Associated with Supply Chain Management

> "The performance of an organisation is... widely agreed in contemporary management and organisational literature to be influenced to a greater or lesser degree by the actions of the organisations that make up the network or supply chain in which it operates." (Giannakis & Croom, 2004)

And yet; "The origins of the concept of supply chain management are unclear" (Croom et al., 2000). According to Giannakis and Croom (2004) the term "supply chain management" was first used in its popular sense through a consideration of strategic issues within the Logistics literature by Oliver and Weber (1982). The term was then replicated in a series of articles by Houlihan (1988) in the logistics and strategic management literatures to describe the management of materials flows across organisational boundaries. The development of the supply chain management concept was initially along the lines of physical distribution and transport, using the techniques of industrial dynamics, derived from the work of Forrester (1961). Another antecedent can be found in the Total Cost approach to distribution and logistics (Heckert & Miner, 1940; Lewis, 1956). Both of these approaches showed that focusing on a single element in the chain cannot assure the effectiveness of the whole system. Since then, several researchers have investigated the concept of supply chain management (Ellram, 1991; Harland, 1996), establishing its theoretical and operational bases as we know them today.

Supply chain management is an increasingly important topic, however a significant challenge for supply chain scholars is the diverse, yet growing bodies of literature on the topic not only in the specialised supply chain journals but also in general popular management journals (Giannakis & Croom, 2004). Supply chain management has been examined from different perspectives, encompassing a multidimensional field of research. As a result, a rich body of knowledge regarding supply chain management phenomena has been built and continues to grow. However, the literature concerning supply chains "is patchy and unconnected" (Harland, 1996) and as Giannakis and Croom (2004) reflect "this adds to the ataxia around the explanation of the term".

Researchers in the field of supply chain management (Saunders, 1995; Cooper et al., 1997) have stressed the fact that supply chain management has evolved largely through an increasing trend toward the "externalisation" of performance measurement in the field of operations management (Harland, 1996). This was accelerated mainly by rapid changes in information technology and the new competitive global environment created by economic, demographic and political developments. Research in the field of supply chain management thus evolved from its core concerns around logistics/ operations processes through the incorporation of theoretical concepts and research in strategic management, industrial organisation, institutional and production economics (transaction costs), inter-organisational relationships and systems theory. This indicates that the fields of research associated with supply chain management research cut across the physical, functional and legal boundaries of companies (Giannakis & Croom, 2004).

The above discussion indicates that supply chain management, as a term, has been applied beyond logistics activities and planning and control of materials and information flows. Some authors have used the term to describe strategic, inter-organisation issues (Cox, 1997), others to discuss an alternative organisational form to vertical integration (Thorelli, 1986). Yet others have used it to identify and describe the relationship a company develops with its suppliers (Sako, 1992; Lamming, 1993; Hines, 1995).

In their extensive review of the supply chain literature, Croom et al. (2000) identified eleven "core" subject areas that have contributed to the building-up of the supply chain management stream. These are:

1. Purchasing and supply literature,
2. Logistics and transportation literature,
3. Marketing literature,
4. Organisational behaviour, industrial organisation, transaction cost economics and contract view literature,
5. Contingency theory,
6. Institutional sociology,
7. System engineering literature,
8. Network literature,
9. Best practises literature,
10. Strategic management literature,
11. Economic development literature.

In presenting these core subject areas, they note that there is partial overlapping among them, and that the same subject can be considered from different perspectives in more than one subject area.

In an attempt to clarify the agenda for future research Giannakis and Croom (2004) refined the previous content overview of the existing literature of Croom et al. (2000). They conducted a survey of European and North American expert academicians' perceptions of the topics that constitute supply chain management- classifying responses according to the element of exchange between supply chain partners and the level of analysis considered. Table 2.2 shows the supply chain literature content identified. This table is repeated and discussed further in the analysis of conceptual gaps in the supply chain literature in Section 2.1.9.1.

Table 2.2 Supply Chain Literature Content Matrix

Level of Analysis		Element of exchange considered: Assets	Information	Knowledge	Relationships
Dyadic	**Suppl. Manuf.**	Transaction cost (specificity of assets)	Information technology support	Collaborative design	Outsourcing/ subcontracting
		Transportation routes rationalisation	Tools for analysis of information flow	Guest engineer	Trust/ power/ commitment
		Exchange of technology	Interplant planning and logistical integration (EDI)	HR development	Supplier development
		Redesign HR organisational incentives			Transaction cost approach
	Manuf. Distr.	Distribution channel redesign	Information technology support	Product teams	Logistic partnership (with logistic service providers)
		Facilities location (warehouses, etc.)	Interplant planning and logistical integration (EDI)		Trust/ power/ commitment
		Transportation routes rationalisation	Communication processes		Outsourcing/ subcontracting
Chain	**Suppl.- Manuf.- Distr.**	Quick response, ECR, etc.	Industrial dynamic approach	Supply chain councils	Scenarios good for supply chain management
		Industrial dynamic approach	Information Technology support		Opportunism/ trust/ power/ commitment
		Reverse supply chain management	Structured systems analysis and design method		Positioning in the supply chain
		Total cost of ownership	Modelling the information flow		Influence of product technology on supply chain relationships
		Value system analysis	Communication processes		
Network	**Upstream**	Supply network sourcing	Information technology support	Suppliers meetings	Partnership sourcing
		Transportation routes rationalisation	Supply Network communication processes		Lean supply
		Supply network structure	Interplant planning and logistical integration (EDI)		Network sourcing
		Redesign HR organisational incentives			Supply base integration
	Downstream	Transportation routes rationalisation	Information technology support		Trust/ power/ commitment
		Distribution channel redesign	Supply network communication processes		Logistic partnership (with logistic service providers)
		Facilities location (warehouses, etc.)	Interplant planning and logistical integration (EDI)		Opportunism/ trust/ power/ commitment
		Design for supply chain management			Outsourcing/ subcontracting
	Whole	Business network redesign approach	Information technology support		Value stream analysis
		Value system analysis	Business network redesign approach		Supply network partnership
		Design for supply chain management	Supply network communication processes		Trust/ power/ commitment/ opportunism
		Industrial dynamic approach			

Giannakis and Croom (2004) then conducted an "axial coding" classification to assist in the identification of underpinning and antecedent literatures related to the content of the supply chain literature. Sixteen bodies of literature were identified with associated theories and models. These are outlined in Table 2.3.

Table 2.3 Principle Component Bodies of Supply Chain Literature

BODIES OF LITERATURE	SUBJECT OF RESEARCH	ASSOCIATED THEORIES AND MODELS
HRM	Personnel management	Guest Engineer
Industrial Organisational Economics	Structure of the supply chain Governance/ Ownership	Organisational Theory, Value Chain, TCE, Institutional Theory
Information Technology	E-commerce, Internet, EDI	Information Theory
Institutional Economics	Nature of the firm, Boundaries of the firm, Ownership	TCE, Property rights theory, Agency Theory, Firm as a Nexus of Contracts
Inter-Organisational Relationships	Relationship dynamics, Trust, Resource dependence, Agency theory	Interaction Model, Systems Theory, Agency Theory, Transformation Model, Resource-Based Theory
Knowledge Management	**Knowledge transfer, Organisational learning**	**Learning Theories**
Law	Contracts design	Contract Law Model
Management Accounting	Management of financial assets flows	
Marketing	Relationship marketing, Customer satisfaction	Relationship Marketing, Reverse Marketing
Network Analysis	Embededness, Integration of companies	Governance, Embededness
Operations Research	Inventory management, Decision making	Game Theory, Linear Dynamic Programming
Operations Management	**Integration of flows of Materials and Information** Logistics, Transformation, Production planning, Forecasting, Capacity management, Inventory management, Distribution channels, Procurement, Planning control, Postponement, Reverse logistics	Transformation Model, Systems Theory
Organisational Behaviour	Power, Trust, Capabilities management	
Sociology	Social networks, Relationship dynamics	Chaos Theory, Fuzzy Logic
Strategic Management	Decision making, Outsourcing, Position in the supply chain, Value chain, Integration of companies, Structure of the supply chain, Partnerships/ Alliances, Benchmarking, Postponement, Supplier management	Resource Based View, Agency Theory, Transformation Model, Systems Theory, Portfolio Management, Contingency Theory
Systems Engineering	Industrial dynamics, Resonance	Forrester & Burbridge Effect, Chaos Theory

In relation to the above content overview, several of the cross-functional issues are considered in the literature review for this doctoral thesis and raised in subsequent analysis and discussion chapters. In particular, the review focuses upon issues within the operations management arena- more specifically the aspect of integration of materials and information flows is considered. In addition, the knowledge management body of literature is reviewed with regard to particular aspects of "organisational learning" and "knowledge transfer". The reasons for focusing upon these particular aspects becomes clearer when considering the considerable historical challenges faced in coordinating supply chains over the last century. These challenges are reviewed in the following section.

2.1.3 The Historical Challenge of Coordinating the Supply Chain

The previous sections give some idea of the complex issues of defining conceptual boundaries and of the proliferation of literature streams that could be reviewed as part of a doctoral study in the field of supply chain management. At this point I return to the personal background, motivations and objectives behind this research. As noted in Section 1.2 this study set-out to investigate important 'real-world' issues with a view to helping practitioners with the "What should I do?" question when faced with the tremendous challenges of supply chain coordination. Thus a brief overview of the historical challenges facing the supply chain professional is conducted here with the aim of identifying the most pertinent areas for further supply chain literature review.

In the literature, perhaps the clearest account of the historical challenges of coordinating supply chains is given by Womack et al. (1990) in their seminal work "The Machine that Changed the World: The Story of Lean Production". They devote considerable attention to the challenges of managing and coordinating supply chains. They coined the term 'lean supply' as a form of 'idealised' supply chain management in the context of the automotive sector. In particular Womack et al. (1990) highlighted the crucial importance of the relationship between the automotive supplier and assembler, and how this relationship works in practice.

Womack et al. (1990, p. 138) illustrate very clearly the hugely complex, yet fundamental, problems involved in obtaining reliable, flexible and economical supplies by considering the evolution of automotive industry supply issues during the twentieth century:

"Henry Ford thought he had solved the problem by the time of World War 1: Do it all yourself in your own company. However his solution raised as many questions as it answered: How do you organize and coordinate hundreds of thousands of employees in hundreds of factories and engineering offices? What do you do with your machines and factories, all dedicated to making specific parts for our own parts, when demand shifts or the economy goes sour?"

Alfred Sloan thought he had found one answer to these problems:

"Do it all in your own company, but set up decentralized parts-making divisions as independent profit centers... [to] impose the cost and efficiency discipline of the market while preserving the coordination advantages of a unified company... Sloan had a solution to the problem of the cyclical car market as well: When the market slumps, lay off workers in the supply system just as you lay off workers in the assembly plant."

But by the 1950's Ford had largely returned to the world of "arm's length, market-based, short term interactions with independent supplier businesses", whereby "the lowest bidder generally won a one-year contract. When the market slumped, these suppliers were laid off by means of cancelled contracts, just like workers."

At the time of researching "The Machine that Changed the World", the mass-production automotive companies of the 1980's were using these approaches around the world- and failing! Various 'cost-comes-first' style bidding games were played between automotive assembler giants (e.g. Ford, GM) and suppliers. For obvious reasons, suppliers (even in-house ones) jealously guarded information about their operations to avoid being 'squeezed' down on prices in follow-on contracts. Such practices usually backfired on the assembler customers when it came to the inevitable post-launch processes of 'debugging' car models, when intense interaction between assembler and supplier was needed. Often this required renegotiation of contracts and respecification of quality requirements, at the assemblers' expense. Such steps inevitably led to supplier-assembler conflict, frequently leading to fully tooled-up suppliers, already supplying below cost in order to win the contract, being dumped for 'mid-process' lower bidders. Additionally, "as if these hurdles weren't enough, there's the added problem of fluctuating volume" with rapid shifts in the volume and mix of products that consumers demand. In such hostile a climate, mass-producers usually took the view that any oversupply of parts as a result of demand fluctuation was the suppliers' problem and were prone to sudden cancellation of orders. As a result, suppliers would "build overstock contingencies into their bids, and, in the end, the consumer pays for the erratic flow of business."

As the automotive sector was beginning to wake-up to the benefits of lean production ("in the twilight of [automotive] mass production") many companies reduced the fraction of parts obtained from in-house suppliers, inspired by the belief that lower wages in outside supplier companies were the competitive secret of the Japanese supply systems. Yet, as Womack et al. (1990, p.140) stressed, these companies were missing the point:

> "The key to a competitive parts-supply system is the way the assembler works with its suppliers."

One of the keys to successful supply chain coordination for Japanese car manufacturers, specifically Toyota, was "managing the relationship" in a far more cooperative way so as to provide incentive for suppliers to "merge their learning curves" (i.e. sharing findings about how to make parts better, cheaper, faster and with less effort) with the customer and other suppliers.

Lamming (1993) built-upon the work of Womack et al. (1990) , characterising such cooperative supply relationships as "beyond partnership". In "Squaring Lean Supply with Supply Chain Management", Lamming (1996) goes on to outline the importance of such cooperative supply chain coordination beyond the automotive sector, but emphasises that differences exist:

> "Inter-firm supply relationships exhibit very different natures when sectors of commerce and industry, and indeed different products within one sector, are contrasted with one another."

Whilst Lamming (1996) indicates that many organizations in different sectors (e.g. high street retail and computer manufacture) have moved to adopt cooperative lean supply type relations, he makes it clear that this not necessarily the norm:

> "The degree to which product technology flows between customer and supplier depends on the relationship between the two organizations, which is itself usually deemed to be affected by the different levels and types of power which each may exercise. One might expect that, in situations in which the customer is dependent on the supplier because of the nature of the product the inter-firm relationship would exhibit attitudes and behaviour indicative of common interests and collaboration. In fact, such relationships appear to exist only rarely, suggesting that the crude commercial power (i.e. buyer's market or seller's market) has more influence than the potential benefits... which might accrue from efficient flows of technology."

Thus Lamming (1996) poses "lean supply as a challenge for supply chain management" and as a way that supply chains could, and possibly should, be managed. As such he infers that the attainment of lean supply may be seen as a potential goal of good supply chain management (though the supply chain management precepts of 'vantage point' and 'customer superiority' are contrary to lean supply):

> "The challenge of lean supply for proponents of supply chain management is to redesign the way in which responsibility for value management is shared, in order to exploit expertise wherever it lies in the chain and to recognise the impacts in one part of the chain, of decisions made in another."

Theoretically, "in lean supply, the entire flow from raw materials to consumer is considered as an integrated whole. Interfaces between stages (i.e. between companies-suppliers and customers) are thus seen as artificial- created not as natural transformation stages in the development (or addition) of value, but as a result of economic arrangement of assets (boundaries of firms) governed by other factors..." Whilst Lamming (1996) is careful to point out that lean supply may, in theory, appear an absolute, in practice it may be acceptable to be leaner than competitors while never achieving total 'leanness'. At the level of the total supply chain it may therefore be impractical to achieve such philosophical perfection. This acceptance of different 'levels of leanness' being appropriate also infers scope for further evolution of the lean philosophy according to development in differing business contexts, and is addressed in the next section.

2.1.4 The Continuing Evolution of Supply Chains: Lean to 'Leagile'

The previous discussion, outlines how supply chains evolved through the 1900's to the adoption of the lean supply concept in the 1980's (Womack et al., 1990; Lamming, 1996). Whilst this development represented a huge step for the development of supply chain management, the evolution of theory and practice has continued such that it is now supply chains that compete, not individual companies, and the success or failure of supply chains is ultimately determined in the marketplace by the end-consumer (Christopher, 1992). Getting the right product, at the right price, at the right time to the consumer is not only the linchpin to competitive success but also the key to survival. Supply chain initiatives strive to match supply to demand, thereby reducing uncertainty within the supply chain as much as possible. Sometimes, however, uncertainty is impossible to remove from the supply chain due to the type of product involved (e.g. fashion garments). Thus, certain supply chains are faced with the situation whereby they have to accept some uncertainty but still need to develop a strategy that enables them to still match supply and demand (Christopher & Towill, 2001). Thus new supply chain paradigms have evolved:

> "The latter part of the twentieth century saw the lean production paradigm positively impact many market sectors from automotive through to construction. In particular there is much evidence to suggest that level scheduling combined with the elimination of muda [waste] has successfully delivered a wide range of products to those markets where cost is the primary order winning criteria. However, there are many other markets where the order winner is availability. This has led to the emergence of the agile paradigm typified by "quick response" and similar initiatives. Nevertheless, "lean" and "agile" are not mutually exclusive paradigms and may be married to advantage in a number of different ways." (Christopher & Towill, 2001)

As Lamming (1996) had brought the lean paradigm into the realms of supply chain management, Harrison et al. (1999) broadened the agile manufacturing debate into the supply chain management literature. Naylor et al. (1999) provide useful summarised definitions to contrast the lean and agile paradigms:

> "Leanness means developing a value stream to eliminate all waste [muda], including time, and to ensure a level schedule."

> "Agility means using market knowledge and a virtual [integrated] corporation to exploit profitable opportunities in a volatile market place."

Mason-Jones et al. (2000) elaborate upon these definitions, in the light of Hill's (1993) manufacturing strategy 'order winners and qualifiers', and create the matrix shown in Figure 2.1. This illustrates the crucial differences in focus between lean and agile supply chains. They expand the order winners and qualifiers to encompass 'market winners and qualifiers', where the notion is that to be truly competitive requires not just the appropriate manufacturing strategy, but rather an appropriate holistic supply chain strategy.

Figure 2.1 Lean and Agile Supply Chains- Market Winners and Qualifiers

	Market Qualifiers	Market Winners
Agile Supply Chain	**1. Quality 2. Cost 3. Lead Time**	**Service Level**
Lean Supply Chain	**1. Quality 2. Lead Time 3. Service Level**	**Cost**

Mason-Jones et al. (2000) stress that each of the criteria are important for both lean and agile paradigms, lean supply chains are most powerful when the winning criterion is *cost;* agile supply chains are likely to be *most* powerful when *service and customer value* enhancement are prime requirements.

Naylor et al. (1999) highlight the prerequisite characteristics of the lean and agile paradigms, identifying similarities and differences between them, as shown in Table 2.4.

Table 2.4 The Importance of Characteristics of Leanness and Agility

Keyword	Lean	Agile
Use of downstream knowledge	○ ○ ○	○ ○ ○
Integrated supply chain	○ ○ ○	○ ○ ○
Lead time compression	○ ○ ○	○ ○ ○
Eliminate *muda*	○ ○ ○	○ ○
Rapid reconfiguration	○ ○	○ ○ ○
Robustness	○	○ ○ ○
Smooth demand/ level scheduling	○ ○ ○	○

Note: ○ ○ ○ = Essential. ○ ○ = Desirable. ○ = Arbitrary.

Van Hoek, Harrison et al. (2001) state that "the relevance of agility depends very much on the operating environment of the supply chain in which a company operates." Fisher (1997) suggests two specific operating environments as shown in Figure 2.2. Functional products with predictable demand benefit most from "physically efficient" supply chain operating structures; innovative products demand "market responsive" supply chain processes that are focused on speed and flexibility rather than cost. (The Fisher Framework and its implications for supply chain integration and collaboration are discussed in more detail in Section 2.1.5)

Figure 2.2 The Fisher Framework

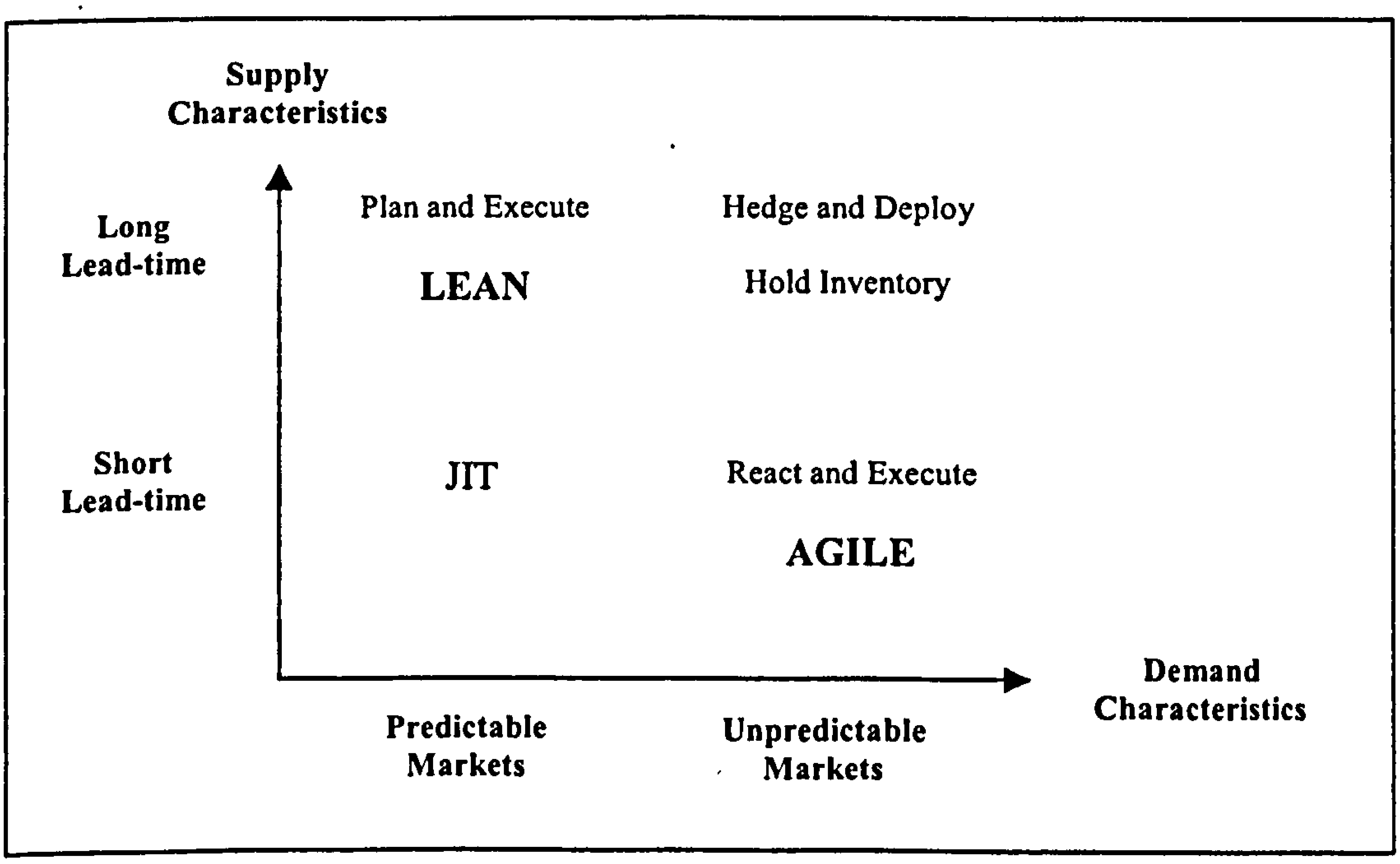
		Products	
		Functional	Innovative
Supply Chains	Efficient	Match	Mismatch
	Responsive	Mismatch	Match

Van Hoek, Harrison et al. (2001) relate both lean and agile to the two operating environments proposed by Fisher (1997) reasoning that "efficiency" has been defined in the lean terms of productivity and quality, and "responsiveness" corresponds to the agile philosophy. Lamming et al. (2000) also support and build-upon the work of Fisher (1997) to derive and study a similar product-based classification for lean/ agile supply networks "consisting of sets of intercorrelated supply chains". Their cross-sector research similarly found clear distinctions between "innovative-unique" and "functional" product based supply networks, concluding that:

> "The most evident difference between supply networks of innovative-unique products and those of functional products was the nature of information and knowledge sharing..." Lamming et al. (2000).

Based on the notion that there are operating environments that favour lean and others that favour agile, and that there is no single best solution, van Hoek and Harrison (2001) propose the respective applicability of each paradigm under differing demand and supply conditions. This is shown in Figure 2.3.

Figure 2.3 Lean and Agile Under Demand and Supply Conditions



Van Hoek and Harrison (2001) take the discussion further:

> "The reasoning behind different operating environments for the two approaches has progressed to the introduction of "leagility". The thinking here is that if agility requires development of lean capabilities to start with, the two approaches

> may co-exist within a single supply chain. The notion of leagility is that before the customer order decoupling point (the point in the supply chain from which operations are order driven) operations can be lean, whereas downstream they need to be agile. This "hybrid" approach recognises the good in both approaches: no supply chain will fit into one single box of [Figure 2.3]."

Naylor et al. (1999) illustrate the "leagility" concept with case studies, such as Hewlett Packard, emphasising that lean and agile paradigms are equally valid and complementary within the correct supply chain strategy. Naylor et al. (1999) also point out the importance, in combining lean and agile components, of correctly locating the 'decoupling point' – separating "the part of the supply chain that responds directly to the customer from the part of the supply chain that uses forward planning and a strategic stock to buffer against the variability in the demand of the supply chain. Downstream from the decoupling point all products are pulled by the end-user, that is, they are market driven. Upstream from the decoupling point the supply chain is initially forecast driven. However, with the advent of Kanban driven supply this has become more than simply a push system." Naylor et al. (1999) conclude that:

> "Manufacturers should not be looking at operations in isolation from the rest of the supply chain. Whether to develop an agile or a lean manufacturing structure will be dependent upon where in the supply chain the members are located. This total supply chain perspective is essential and companies should be striving for "leagility"- that is carefully combining both lean and agile paradigms."

> "The use of either paradigm has to be combined with a total supply chain strategy particularly considering [downstream] knowledge and positioning of the decoupling point as agile manufacturing is best suited to satisfying a fluctuating demand and lean manufacturing requires a level schedule."

Christopher and Towill (2001) incorporate the previous issues, and outline the evolution of supply chain management from the 1980's in terms of lean and agile characteristics, leading to a customised hybrid "leagile" supply chain. They present this evolution from product driven to customer driven philosophies as shown in Table 2.5.

As the previous discussion indicates, many important and worthy research issues arise from the evolution of lean, agile and leagile supply chains and several researchers have focused upon developing these management philosophies further (e.g. Huang et al., 2002). Nevertheless, the previous discussion also indicates that at the core of the lean, agile, leagile supply chain evolution outlined by Christopher and Towill (2001) are the two inter-related concepts of integration and collaboration. These concepts underpin much of the lean and agile research. For example, in addition to emphasising the need to consider the total supply chain, Naylor et al. (1999) identify supply chain integration and use of downstream knowledge to be of equal, "essential" importance to both lean and agile paradigms. Thus, inherent in both paradigms is the fundamental need for high levels of supply chain integration "to remove all boundaries to ease the flow of material, cash, resources and information".

Table 2.5 The Phases of Recent Supply Chain Evolution

Supply Chain Evolution Phase	I	II	III	IV
Supply Chain Time Marker	Early 1980's	Late 1980's	Early 1990's	Late 1990's
Supply Chain Philosophy	Product Driven	Market Oriented	Market Driven	Customer Driven
Supply Chain Type	Lean functional silos	Lean supply chain	Leagile supply chain	Customised leagile supply chain
Market Winner	Quality	Cost	Availability	Lead time
Market Qualifiers	1. Cost 2. Availability 3. Lead time	1. Availability 2. Lead Time 3. Quality	1. Lead Time 2. Quality 3. Cost	1. Quality 2. Cost 3. Availability
Performance Metrics	1. Stock turns 2. Production cost	1. Throughput time 2. Physical cost	1. Market share 2. Total cost	1. Customer satisfaction 2. Value added

According to Huang et al. (2002) the development of lean, and subsequently agile, supply chains occurred directly as a result of issues such as: i) inadequate integrated flow of information upstream leading to suppliers not being fully informed- and the "bullwhip" effect, ii) weaknesses arising as a result of insufficient collaboration and manufacturing companies not forming good relationships. Literature dealing with such issues is reviewed in the next section.

The concept of the supply chain as an "integrated whole" is central to the lean philosophy (Womack et al., 1990; Lamming, 1996) . Lamming (1996) characterises such integration as "customers and suppliers being "in the same boat", or perhaps, by the concept of "mutual destiny" recognised by neighbours in the supply chain." This understanding of "mutual destiny" leads to the "beyond partnership" type relationships between customers and suppliers, and realises the value of high levels of cooperation and collaboration. Such integration and collaboration issues are also implicit within the important lean concepts of cost and value 'transparency'- "the two-way exchange of information and knowledge between customer and supplier" (Lamming, 1993; Lamming et al., 2001).

Certainly, as companies strive towards incorporating aspects of agile and achieving leagile supply chains, there is an even greater need to work together with supply chain partners to determine such complex issues as positioning the decoupling point (Harrison et al., 1999). Such issues would require unprecedented levels of cooperation and collaboration between supply chain partners (Christopher & Towill, 2001). As van Hoek, Harrison et al. (2001) state:

> "Over the past decade literature has managed to communicate a number of lessons from business experience very accurately. One is that companies have to align with suppliers, suppliers' suppliers, customers and customers' customers to streamline operations... Another lesson is that within the supply chain, companies should work together to achieve a level of agility beyond the reach of the individual company. Companies as wide as raw materials suppliers, manufacturers and retailers may need to be involved in the process of achieving an agile supply chain."

Thus this literature review now takes a step back from the specific evolving philosophies of lean and agile- and turns towards exploring the fundamental concepts of integrated supply chain relationships and collaborative ways of working that explicitly underpin these important paradigms. The next section concentrates upon the supply chain literature specifically addressing the core issues of integration and collaboration.

2.1.5 The Continuing Evolution of Supply Chains: Integration to Collaboration

> "Benetton was the first fashion apparel manufacturer of any scale that was able to change its product range during the fashion season to satisfy consumer demand, particularly for the colour of the garment that emerged as fashionable for the season. Benetton achieved this through... an integration of what have been traditionally viewed as logistics, operations management, purchasing and supply management, industrial marketing and service management, conducted as a coordinated, integrated inter-organisation network of which it owned very little." (Harland et al., 1999)

One thing that most of the supply chain related literature streams agree upon is that with challenging economic climates and ever-heightened competitive pressures, companies are being driven to constantly change their business operating strategies. Furthermore, for some time organisations throughout the world have been taking bold steps to break down both intra and inter-organisational barriers to smooth uncertainty and enhance control of supply chains (Stevens, 1989). Thus the previously outlined definitions of supply chain management could translate to cross-functional integration activities beyond the borders of individual organisations to encompass channel participants (Stank et al., 2001).

As with lean supply outlined above, supply chain integration is not a new concept (Stank et al., 2001). To match developments in the business world, approximately 15 years ago academics broadened their focus of research from the narrower analysis of logistics to a more comprehensive view of the entire value chain system from suppliers to customers. This growing supply chain literature stream has given growing consensus concerning the strategic importance of integrating data and information between suppliers, manufacturers and customers (Reck & Long, 1988; Leender & Blenckhorn, 1988; Bowersox et al., 1989; Syson, 1989; Freeman & Cavinato, 1990; McGinnis & Kohn, 1990; Morris & Calantone, 1991; Cammish & Keough, 1991; Eloranta & Hameri, 1991; Burt & Doyle, 1992; McGinnis & Kohn, 1993; Clinton & Closs, 1997). As Bowersox et al. (2000) clarify:

> "The goal of integrated supply chain logistics is to enhance end-customer value."

With such a crucial business goal, the issue of supply chain integration has emerged as the major concept in this literature stream- to such an extent that proponents such as Ragatz et al. (1997) claim that "effective integration of suppliers into product value/ supply chains will be a key factor for some manufacturers in achieving the improvements necessary to remain competitive." For practitioners, the importance of integration is reflected in the Supply Chain Council's popular Supply Chain Operations Reference (SCOR) model that assumes all businesses should include sourcing, making, and delivering processes to strategically link suppliers and customers to manufacturers. (The SCOR model is explored further in Section 2.1.6.)

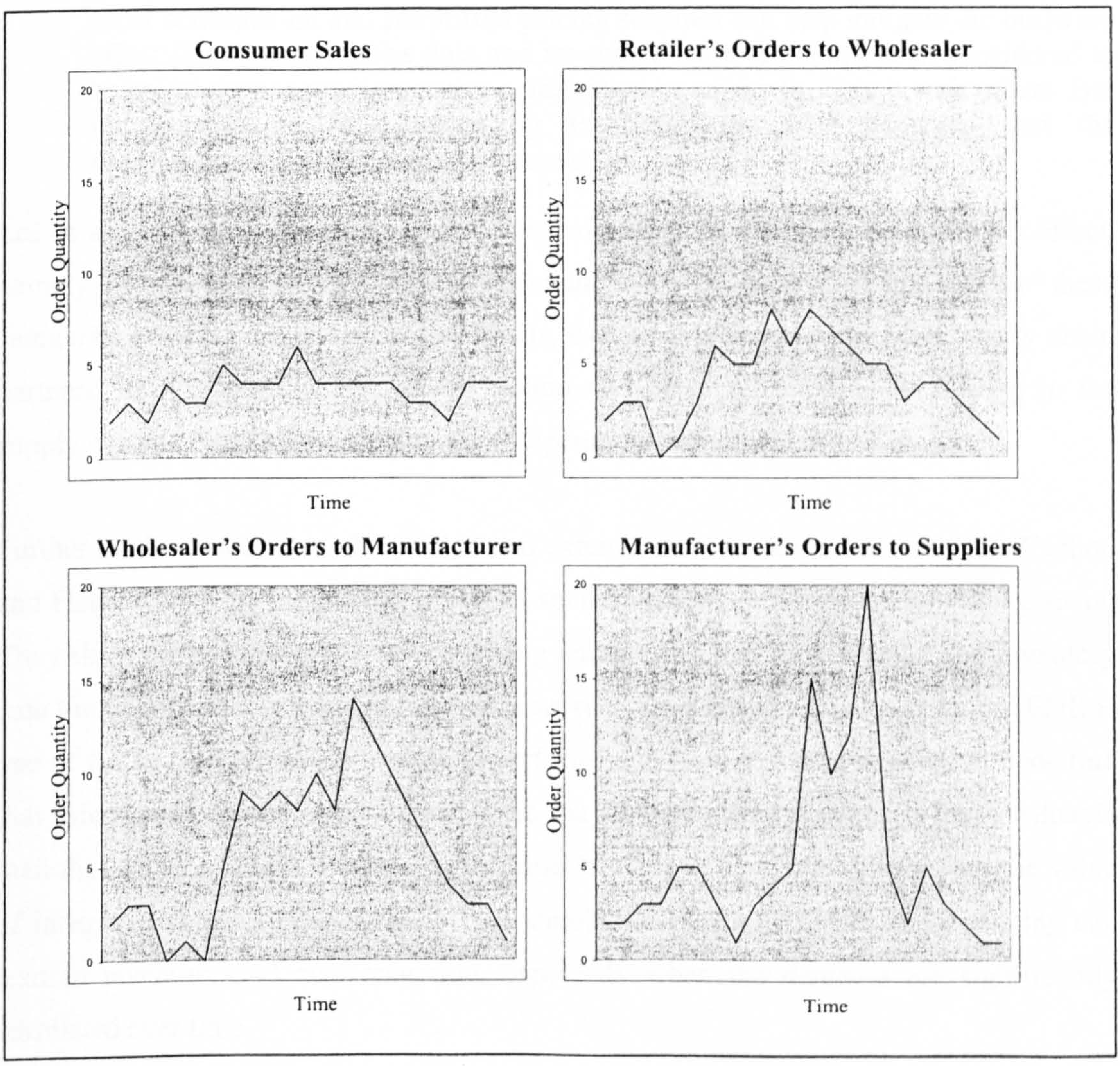
The case for improving supply chain integration through asset, data and information coordination has consistently found support in the increasing wealth of mathematical modelling and empirical analysis based supply chain literature (Narasimhan & Jayaram, 1998; Johnson & Scudder, 1999; Krause, 1999).

From a modelling standpoint, Lee et al. (1997a) investigated the root causes of the "Bullwhip effect"- a hitherto little understood information distorting phenomena observed by practitioners, and possibly best illustrated by the well-known "beer game". The bullwhip effect is recognised to have catastrophic ramifications upon coordination amongst supply chain partners. Lee et al. (1997a) state that:

> "One important mechanism for coordination in a supply chain is the information flows among members of the supply chain. These information flows have a direct impact on the production scheduling, inventory control and delivery plans of individual members in the supply chain. We study the demand information flow in a supply chain and report on the systematic distortion in demand information as it passes along the supply chain in the form of orders. [The results]...clearly highlight the distortion in demand information. The retailer's orders do not coincide with the actual retail sales...The bullwhip effect refers to the phenomenon where orders to the supplier tend to have larger variance than sales to the buyer (i.e. demand distortion), and the distortion propagates upstream in an amplified form (i.e. variance amplification.)"

They illustrate the bullwhip effect as shown in Figure 2.4.

Figure 2.4 Increasing Variability of Orders up the Supply Chain



Put simply, Lee et al. (1997b) say that "distorted information from one end of a supply chain to the other can lead to tremendous inefficiencies in terms of excessive inventory investment, poor customer service, lost revenues, misguided capacity plans, ineffective transportation, and missed production schedules."

This seminal works of Lee et al. (1997a) and Lee et al. (1997b) identified and reported four root causes of the bullwhip effect:

1. Demand signal processing
2. Rationing
3. Order batching
4. Price variations

To minimise the bullwhip effect Lee et al. (1997a) established that:

> "The combination of sell through data, exchange of inventory status information, order coordination and simplified pricing schemes can help mitigate the bullwhip effect. Traditionally, sales data and inventory status data have been considered to be proprietary to retailers with no obligation or reason to share it with others. But the prescription for overcoming the bullwhip effect demands that the manufacturer be given access to these data."

Lee et al. (1997b) uncover three categories of initiative to combat the bullwhip effect, namely: information sharing, channel alignment and operational efficiency. Each of these categories involves the integration of assets, data and information between supply chain partners, thus supporting the general notion that data and information sharing in the supply chain is desirable in order to avoid operational inefficiencies.

Further model-based research upholds and extends these findings. For example, Cachon and Fisher (2000) investigate the value of shared information in inventory management. They share the general belief that capturing and sharing real-time demand and inventory data through information technology systems such as electronic data interchange (EDI) is one of the keys to improved inventory performance. However their simulation does find that information technology that smoothes the flow of physical goods is more valuable than that which expands the flow of information. Lee et al. (2000) also model the value of integrated demand information. Their simulation shows that information sharing can lead to inventory and cost reduction, especially when the demands are significantly correlated over time.

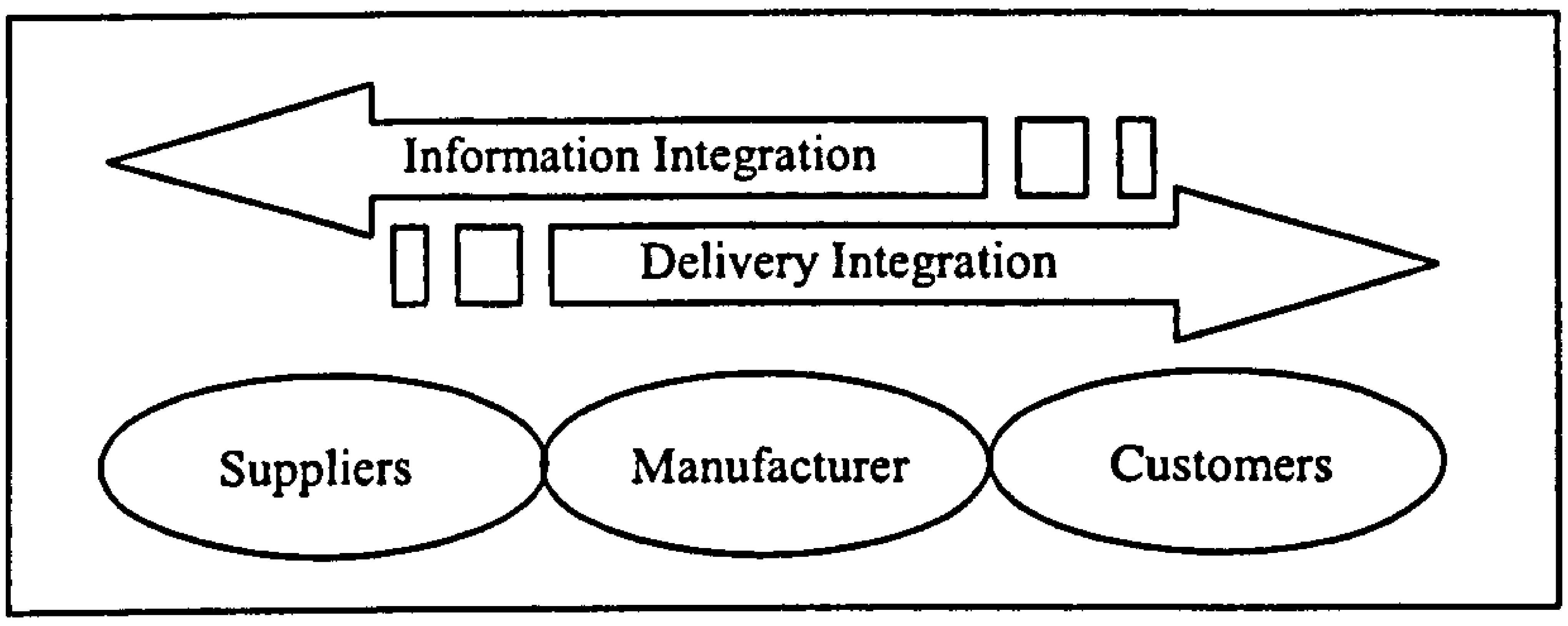
Yet, mathematical modelling approaches are necessarily limited by relatively simplistic dimensions and assumptions. Whilst the discussion around the above analyses alludes to more complex mechanisms of activity coordination and knowledge sharing related activities between downstream and upstream sites, they go no further than considering pure data and information levels.

In this aspect, the empirically based academic work has perhaps gone further- to include more complex dimensions of integration. Armistead and Mapes (1993) conducted a field study of managers in the U.K. to investigate the extent to which greater integration along the supply chain improves quality and operating performance. Strength of integration was measured as a composite index of ratings: 1) extent of shared ownership of production schedules, 2) level of adherence to manufacturing plans, 3) use of job titles spanning functions (e.g. Supply chain manager), 4) extent of integration of information systems, 5) level of visibility and spread of information. The results indicated that increasing the level of integration does increase performance. Narasimhan and Jayaram (1998) conducted a broader empirical study of causal linkages in supply chain integration. They propose a "decisions-oriented" framework for supply chain integration rather than the previously used materials or information flow frameworks. Their analysis supports the notion that an integrated supply chain involves aligning sourcing decisions to achieve manufacturing goals that are set to respond favourably to the needs of customers.

In their empirical analysis, Frohlich and Westbrook (2001) add further support to the supply chain integration view, stating that "in the new millennium upstream and downstream integration with suppliers and customers has emerged as an important element of manufacturing strategy." Quoting Anderson and Katz (1998), and Lummus et al. (1998), Frohlich and Westbrook (2001) reason that the goal of integration is typically to create and coordinate manufacturing processes seamlessly across the supply chain "in a manner that most competitors cannot very easily match."

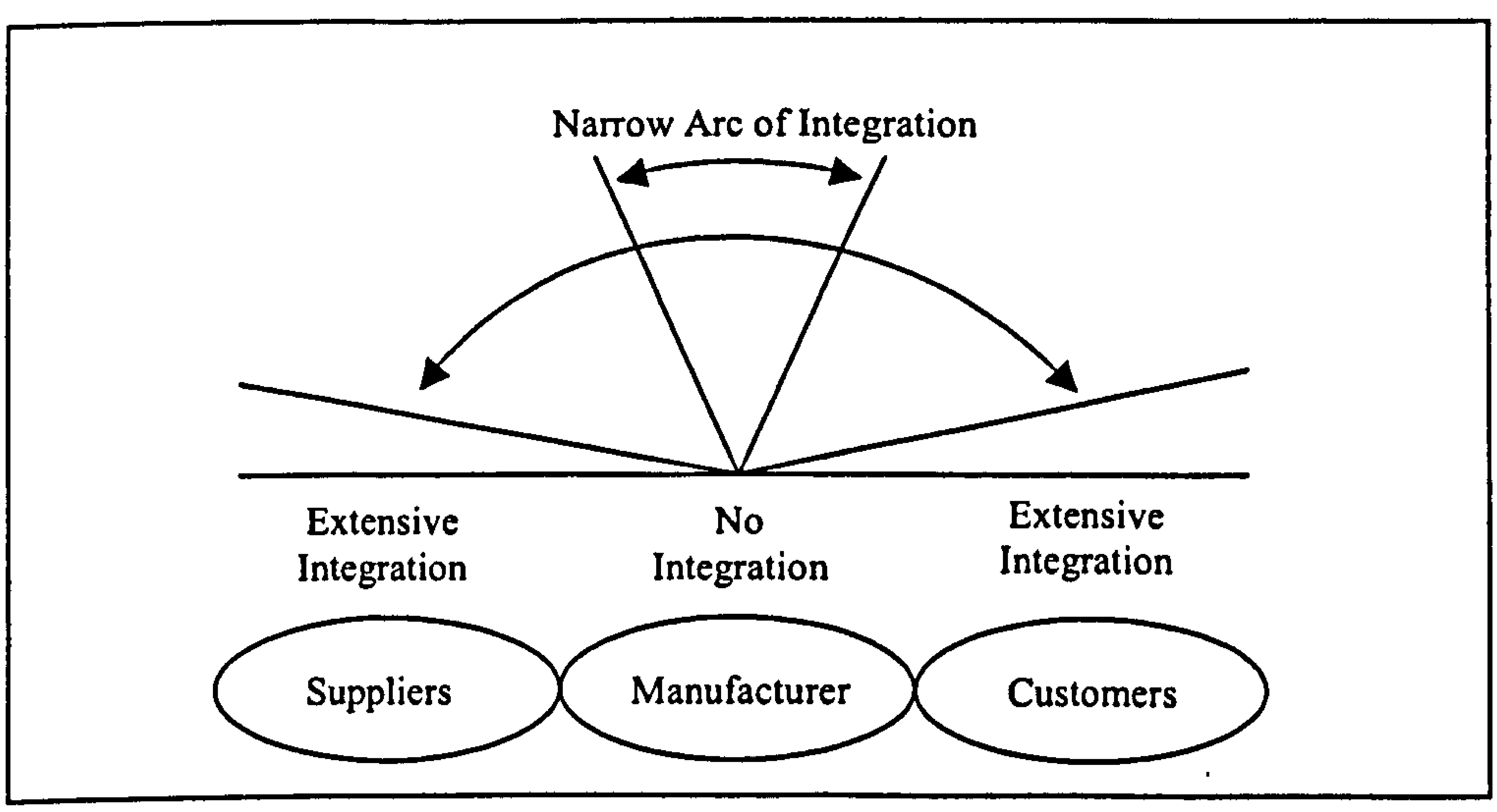
Frohlich and Westbrook (2001) find in the existing literatures two interrelated forms of integration that manufacturers regularly employ at tactical levels: i) "the forward physical flow of asset deliveries between suppliers, manufacturers, and customers"; and ii) "the backward coordination of information technologies and the flow of data from customers to suppliers". They represent this as in the Figure 2.5.

Figure 2.5 Integration in the Supply Chain



The empirical work of Frohlich and Westbrook (2001) in which the direction and degree of supply chain integration are designated as "arcs of integration", finds that higher operational performance is indeed strongly associated with broader arcs of integration. This concept is indicated in Figure 2.6. Thus they find empirical support for the hitherto held view that integration of data and information is beneficial for operational performance- and basically the greater the level of this data and information integration the better.

Figure 2.6 Arcs of Integration



Yet, Frohlich and Westbrook (2001) go further in their concluding discussion, enhancing the pure data and information sharing view of integration to include collaboration:

> "In this millennium, enhanced competitiveness not only in control but also in issues such as product design will require that manufacturers increasingly open out their arcs of integration and collaborate within a network of organisations.

> New technology is already facilitating such developments. The Internet allows any member of a supply chain to connect to any other organisation. In other words, the widest possible arc of integration has rapidly changed from a theoretical concept to an operational reality. Manufacturers can now link to customers using e-commerce on the sell side of the Internet in what is popularly termed the "Dell direct" model. The more information that manufacturers have concerning end consumer's requirements the simpler supply and demand decisions become, and the lower the risks of stockouts or obsolete inventory."

They extend this reasoning to the integration with suppliers, suggesting that:

> "on the buy-side extensive electronic supply base management is increasingly feasible... Internet technology, with its world-wide interconnectivity and ease of access, is far less costly and permits many more suppliers, even quite small ones, to be integrated electronically into a supply chain.
>
> One consequence for supply chain integration of this cheaper, easier Internet communication may be to extend the types of information exchanged. Not only the delivery schedules and billing data of an EDI system, but also new product ideas, on-line product support material, training aids, and technical knowledge can be transferred. Thus, the nature of collaboration may increase in range and intensity, and a broad arc of integration will be defined in terms of more or different variables."

Practitioner-oriented literature has echoed the benefits of wide arcs of integration with supply chain partners- often demonstrating with examples such as Dell the benefits to organisations that are capable of managing the complex processes of transferring and sharing data and information between supply chain partners (Magretta, 1998). The practitioner literature has also been quick to adopt the term supply chain collaboration as an apparent extension to or ideal form of supply chain integration. Yet it is difficult to see exactly "how" collaboration differs from integration- since both terms are usually expressed in terms of sharing and exchanging data and information between supply chain partners. It would appear that the often fairly 'fuzzy' use of the term collaboration simply implies sharing more, and more data faster (Horvath, 2001).

However, Frohlich and Westbrook's (2001) use of the word 'collaboration' goes far beyond the integration of more data and information faster. Their logical development is that degree and extent of supply chain integration technologies and practices is liable to evolve so that "opinions, expertise and knowledge" can be exchanged. Since "in the foreseeable future the logistics process will remain human centric" (Bowersox et al., 2000) there is a lot to be gained from the sharing and coordination of opinions, expertise and knowledge between personnel working in supply chain partner organisations. It is the potential for sharing opinions, expertise and knowledge, facilitated by modern communications, that could open up the possibility for supply chain collaboration.

Horvath (2001) argues that collaborative technology infrastructures (e.g. e-business networks) will go beyond data and information sharing systems. She reasons that such collaborative systems will not only have to include access to order tracking, logistics and billing information, but also include "intelligence" capabilities for issues such as product configuration or joint decision taking. Thus collaboration will go beyond integrated information systems towards a collaborative state whereby competitive advantage will reside in the ability of the business to "leverage the intelligence inherent in the supply chain network".

This move from integration to collaboration that incorporates sharing knowledge and intelligence is also key to the Harland, Lamming and Cousins (1999) concept of supply strategy:

> "Supply strategy relates to the integration of supply activities within firms, in dyadic relationships, in chains of firms and in inter-organisational networks... [It is] 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."

Though according to the Harland, Lamming and Cousins (1999) concept:

> "Collaboration is not defined in a restrictive sense; strategies may range from close interfacing (verging on integration) to marriages of convenience."

Yet, Stank et al. (2001) do define collaboration as:

> "A process of decision making among interdependent parties. It involves joint ownership of decisions and collective responsibility for outcomes... key dimensions are a cross-department (or organisation) scope, a commitment to working together, and some common bond or goal... The success of collaboration depends upon the ability and willingness of managers to build meaningful relationships and create trust."

Stank et al. (2001) continue, stating:

> "At an operating level, collaboration requires significant change from standard business practice, particularly in the area of information exchange."

Thus, an important distinction emerges between the concepts of integration and collaboration. On the one hand integration is widely interpreted as constituting the automatic 'mechanical' exchange of data and information- such as shared order data, inventory level data, logistics and billing information etc. Whereas collaboration apparently requires the more complex, sophisticated and sometimes subtle 'human' intelligence exchanges such as working together, joint decision taking, shared expertise and knowledge. Fawcett and Magnan (2002) clarify the move from integration to collaboration concept:

> "Early adopters of supply chain practice have discovered that real collaboration goes beyond information exchange and are working diligently to establish other integrative mechanisms to enhance coordination with truly important first-tier suppliers and customers."

Fawcett and Magnan (2002) suggest that supply chain collaboration is the ultimate goal of the "integration journey", in a similar fashion to Christopher and Towill (2001) indicating leagility as being the target in developing lean-agile capabilities.

Yet, some uncertainty and inconsistency still prevails. There are still some awkward mixed messages within the literature suggesting that theory and practice have not evolved sufficiently to fully understand the issues surrounding integration- let alone collaboration. In their combined survey and case study interview investigation of supply chain integration Fawcett and Magnan (2002) found that few companies fully understand or are actually engaged in extensive supply chain integration- despite 88% of managers regarding it as an important part of their business strategy and important contributor to organisational competitiveness.

From a practitioner standpoint, Davenport (1998) issues the following warning, citing many top companies such as FoxMeyer Drug, Mobil Europe, Applied Materials and even Dell Computer that have failed in some way due to information integration:

> "If you're not careful, the dream of information integration can turn into a nightmare... Enterprise systems appear to be a dream come true. These commercial software packages promise the seamless integration of all the information flowing through a company... But are these enterprise systems living up to companies' expectations? The growing number of horror stories should certainly make managers pause."

Also, whilst Narasimhan and Kim (2002) empirically demonstrate the importance of "collaborative supply chain integration" to product diversification and differentiation, Fisher (1997) makes clear that a devotion to data and information integration alone is not a supply chain magic wand:

> "Never has so much technology and brainpower been applied to improving supply chain performance. Point-of-sale scanners allow companies to capture the customer's voice. Electronic data interchange lets all stages of the supply chain hear that voice and react to it by using flexible manufacturing, automated warehousing, and rapid logistics. And new concepts such as quick response, efficient consumer response, accurate response, mass customisation, lean manufacturing, and agile manufacturing offer models for applying the technology to improve performance. Nonetheless, the performance of many supply chains has never been worse."

Fisher's (1997) work on product-oriented responsive and efficient supply chains, is closely paralleled by the emerging literature in the lean and agile manufacturing paradigms (and their application to the supply chain context as discussed earlier in Sections 2.1.3 and 2.1.4) Fisher contends that the root cause of the problems plaguing many supply chains is a mismatch between the type of product and the type of supply chain, and that this goes beyond simply sharing data and information with upstream and downstream companies. It is not just demand data that is important, but "the first step in devising an effective supply chain strategy is to consider the nature of the demand for the product's ones company supplies. Many aspects are important- for example, product life cycle, demand predictability, product variety, and market standards for lead times and service."

Furthermore, the question, raised by Fisher (1997), "What is the right supply chain for your product?" cannot be answered by any one company in isolation of its supply chain partners. The decision to match functional products to efficient supply chains or innovative products to responsive supply chains is not one that can be taken without co-operative decision making with partners- certainly way beyond just exchanging data and information. For a supply chain to function in the correct quadrant of Fisher's framework shown above in Figure 2.2 requires a high degree of collaborative thought, planning and action. On the one hand, supply chains for innovative products need to be able to cope with demand uncertainty. This translates to cutting lead times and increasing flexibility in order to produce to order or at least manufacture the product at a time closer to when the demand can be accurately forecast. This calls for high levels of collaboration and knowledge sharing between supply chain partners.

Similarly, efficient supply chains for functional products need to relentlessly pursue cost reductions. Fisher (1997) cites the example of the Campbell Soup Company who, through extensive cooperation, collaboration and knowledge sharing with manufacturers and retailers, has managed to achieve an efficient supply chain for their functional product. In this respect he reinforces the points made by Frohlich and Westbrook (2001) above by stating:

> "Cost reduction is familiar territory, and most companies have been at it for years. Nevertheless, there are some new twists to this old game. As companies have aggressively pursued cost cutting over the years, they have begun to reach the point of diminishing returns within their organisation's own boundaries and now believe that better coordination across corporate boundaries- with suppliers and distributors- presents the greatest opportunities. Happily, the growing acceptance of this view has coincided with the emergence of electronic networks that facilitate closer coordination."

The above discussion indicates that the concepts of integration and collaboration are fundamental to the evolution of supply chain management theory and practice. Yet, it would seem that there are still gaps in understanding. One area where further development of the concepts is apparently needed relates to the "rhetoric and realities of supply chain integration" and the fact that "supply chain practice seldom resembles the theoretical ideal" (Fawcett & Magnan, 2002). Another area of uncertainty surrounds the issue that most supply chain integration research stops at the data and information levels of exchange. Whilst the literature recognises the importance of supply chain collaboration as an ideal- little research has empirically explored the more expansive and sophisticated dimensions (joint decision and risk-taking, working together, knowledge sharing etc.) that distinguish the concept from supply chain integration. This clearly opens up important new opportunities and challenges both for academics and practitioners. (For further explanation of what distinguishes knowledge from simple data and information- see Section 2.2.2.)

The next section moves on to consider current supply practices- as promoted by leading consulting companies and practitioner organisations.

2.1.6 Current 'Good' Supply Chain Practice- The SCOR model

Having conducted a broad review of the formal academic supply chain management literature, a review of current supply chain practice is undertaken here with the aim of informing this doctoral research study and ensuring it is in tune with developments in the business world. Various eminent operations management researchers make a strong case for academics to be well aware of what is happening with practitioners and thus to also consider relevant practitioner publications (Meredith, 2001; Meredith, 2002; Handfield, 2002). Clearly, whilst scanning practitioner publications and consultancy promotional material for current supply chain practices, it is essential to be aware of the significant limitations of such literature. Care needs to taken especially with that practitioner literature that portrays itself as formal, learned literature and 'pure research'. Therefore in reviewing both academic literature and practitioner-oriented publications important caveats should be recognised and applied, including:

1. The standards of scientific method and rigour that are required of formal academic literature do not necessarily apply to practitioner studies. A lack of theoretical foundation, logical reasoning or analytical integrity can result in a tendency of practitioner literature towards over emphasising anecdotal evidence and superficial analysis. Therefore specific findings or recommendations of such practitioner literature should be interpreted with great caution.

2. The standards of ethics and trust that are required of formal academic literature do not necessarily apply to practitioner studies. In most practitioner literature there is an underlying commercial incentive. With such ulterior motives there is a strong possibility of any such investigations and subsequent reporting being distracted from otherwise-noble research aims, erring from impartiality, obscuring possible alternatives and so on, thus detracting from the validity of any potentially biased results, claims or suggestions made.

Nevertheless, whilst extreme caution should be exercised before placing undue confidence in specific findings and recommendations emanating from practitioner literatures, their inclusion in a review of current practices is important to ensure that:

> "As academics we should get ahead of current practice and lead the way for improved, more effective operations in the future, while never losing sight of what is happening in the business world around us." (Krajewski, 2002)

With the above caveats in mind, an overview of practitioner-oriented supply chain literature clearly indicates that practitioners have taken many of the concepts emerging from the academic supply chain literature to heart- including those of supply chain integration and collaboration. This has manifested itself in the development of the Supply Chain Operations Reference (SCOR) model by the Supply Chain Council that is becoming entrenched in supply chain practice (Supply Chain Council, 2004).

The Supply Chain Council website (www.supply-chain.org) provides an impressive list of companies across various sectors that have implemented the SCOR model with apparent success. These include: Alcatel, AT&T Wireless Services, Avnet IMS, Boeing, Borden Chemical, Carter Holt Harvey, Charoen Pokphand Group, Coca-Cola, Compaq, Daimler Chrysler, Fonterra Co-Operative Group, Gensym Corp., Gist Ltd., Gold'n Plump Poultry, Inc., Greene, Tweed & Co., i2, IBM, ICI, Imation, Intel Corporation, Kühne and Nagel Management AG, Lockheed Martin, Logistics Management Institute, Mead Johnson, Nabisco Inc., New Zealand Dairy Board, Philips, Pragmatek, Queensland Rail, Siemens, Sonoco, Systems Solutions, Tilion, Inc., United Space Alliance, United States Department of Defence, US Navy, and USMC.

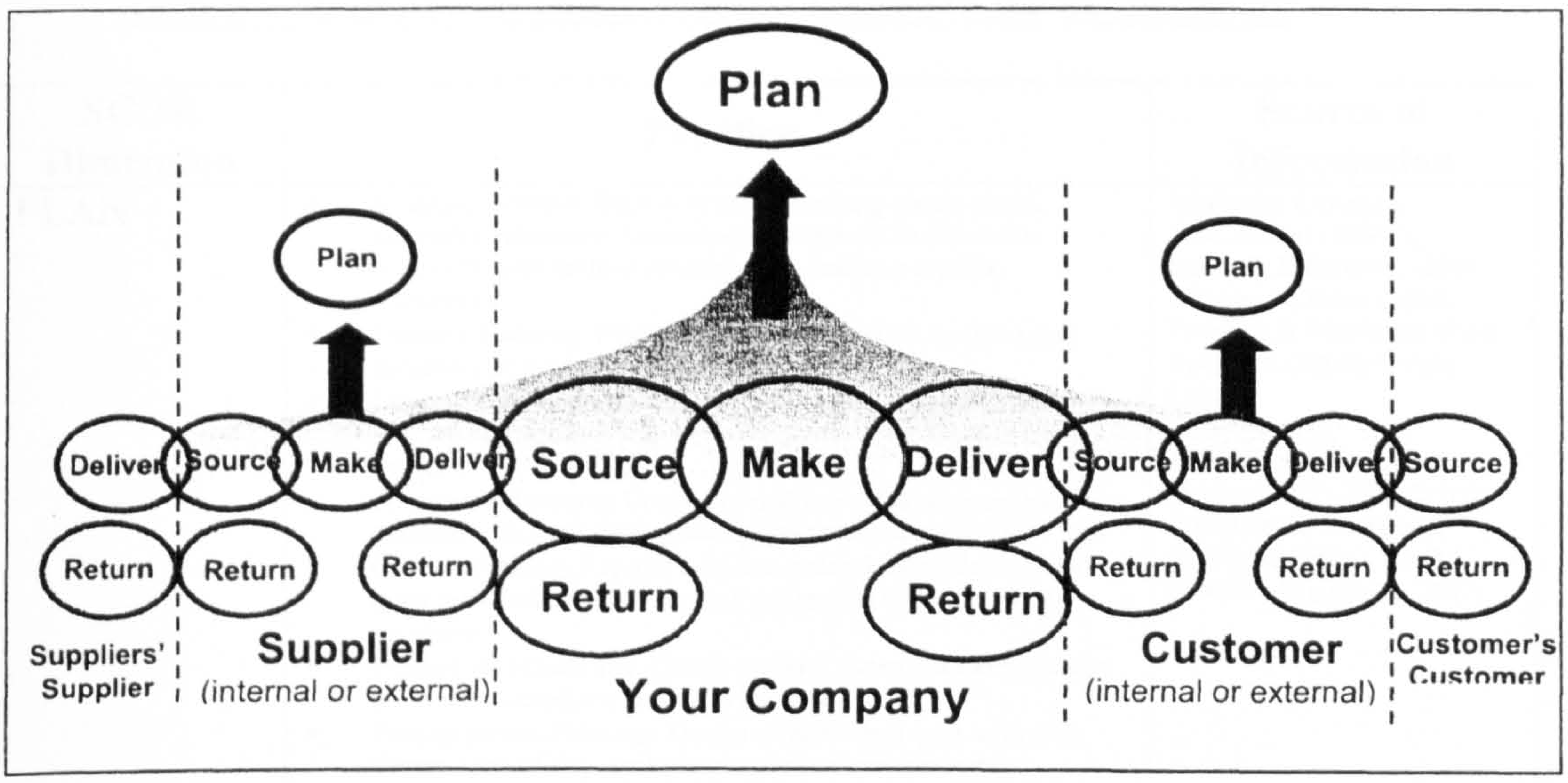
According to the Supply Chain Council website:

> "Companies worldwide are using SCOR to examine the configuration of their supply chains, identify and measure metrics, determine weak links, and achieve best practices in order to increase the efficiency of their operations. The Model is more than a tool for charting supply processes or activities. It is a business process reference model that links process description and definition with metrics, best practice, and technology. While remarkably simple, it has proven to be a powerful and robust tool set for describing, analysing, and improving the supply chain."

The scope of the SCOR model (Supply Chain Council, 2004) includes all elements of demand satisfaction beginning with the initial signal of demand (the order or forecast) and ending with the final signal that demand has been satisfied (final invoice and payment). As shown in Figure 2.7 the boundaries of the model are defined as being "from the supplier's supplier to the customer's customer", and the framework uses a 'building block' approach based on the five management processes of:

* Plan
* Source
* Make
* Deliver and
* Return

Figure 2.7 Diagrammatic Representation of the SCOR Model Version 6.1



The aim is that this allows a supply chain to be 'assembled' across organizations, internal and external, across industry segments, and across geographies. One of the primary uses of SCOR is as a tool for evaluating and improving supply chain integration and collaboration efforts between different companies.

In carrying out a review of supply chain practices, it is also necessary to include the up-to-date work that exists in the commercial consulting literature. Such supply chain consultant companies include Oracle, SAP, JDEdwards, i2, PRTM (Pittiglio, Rabin, Todd & McGrath), and Manugistics.

Along with relevant academic literature that propose good supply chain practises in certain parts of the SCOR model (e.g. Rogers & Tibben-Lembke, 1999; Frohlich & Westbrook, 2001; Narasimhan et al., 2001), a review of consulting company supply chain products and services also indicates the practices that companies are currently trying to adopt under each of the SCOR dimensions of Plan, Source, Make, Deliver, and

Returns (Oracle, 2003; SAP, 2003; JD Edwards/ Peoplesoft, 2003; i2, 2003; PRTM, 2003; Manugistics, 2003). In addition, certain academic literature (e.g. Petersen et al., 2003) and consulting companies suggest that the process of 'New Product/ Service Development' be included within the SCOR management processes. Table 2.6 provides a summary of what is considered to be good practice under each of these SCOR processes, and constitutes a significant review of academic and current commercial consulting literature relating to collaborative supply chain integration best practice.

Table 2.6 Summary of 'Good' Practice Related to the SCOR Model

SCOR Dimension	Practice	Source of Information
PLAN	• Strategic Network Optimisation: Optimising supply chain networks, rationalise business combinations, handle crisis situations, plan tactical sourcing, pre-builds or capacity allocations • Demand Planning: Predict future demand based on historical demand and market intelligence • Demand Consensus: Collaborate with channel partners and internal departments who have insight and/ or influence on demand • Production Planning: Create optimal raw material sourcing, manufacturing and deployment plans across all production sites • Order Promising: Rapidly calculate order delivery dates based upon real-world capabilities and constraints of the multi-site enterprise • Production Scheduling: Create detailed, constraint based factory production schedules and material plans • Transportation Planning: Design effective transport networks; Create optimal shipment plans; collaborative contractual negotiations with carriers; manage entire transportation execution including exceptions; visibility of shipment status; highly utilised transportation assets even during "off-peak" seasons. • Distribution Planning Optimise the levels of finished goods inventory to ensure targeted customer service levels are met; plan replenishment builds, seasonal pre-builds, and inventory movements between stocking locations • Promotions Planning Align the supply chain with sales and marketing activities; optimise promotions to achieve maximum profitability; organise promotions appropriate to the stage of product/ service life cycle; reduce promotional spending whilst monitoring real time results • Service and Parts Management Planning Create a coherent service and parts management planning system aimed at sustaining end customer satisfaction; including service and parts network, part redistribution, part repair forecasting, field service scheduling, service part troubleshooting, customer returns.	Academic Literature: Smaros et al., (2003); Finarelli & Johnson, (2004); Mentzer & Moon (2004); Frohlich & Westbrook (2001; Svensson (2004); Wright (2003) Commercial Consultants: Oracle (2003); SAP (2003); JD Edwards/ Peoplesoft (2003); i2 (2003); PRTM (2003); Manugistics (2003).
SOURCE & DELIVER	• Share capital investment and inventory risks • Share visibility of inventory demand • Nurture long term relationships • Participate in supplier development • Share cost savings • Engage in joint-venture operations • Coordinate agreements/contract management • Participate in on-line auctions • Make use of e-procurement and automated transactions • Make use of exchanges and supplier portals • Use Vendor Managed Inventory (VMI) • Outsource to 3rd Party Logistics (3PLs)	Academic Literature: Akacum & Dale (1995); Disney et al. (2004); Steckel et al. (2004); Narasimhan et al. (2001) Commercial Consultants: Oracle (2003); SAP (2003); JD Edwards/ Peoplesoft (2003); i2 (2003); PRTM (2003); Manugistics (2003).

Table 2.6 Summary of 'Good' Practice Related to the SCOR Model (Cont.)

SCOR Dimension	Practice	Source of Information
MAKE	• Implement information and communications technologies and/ or Enterprise resource planning software. • Implement pull production (e.g. reducing batches, set-up time, using Kanban systems) • Implement programmes for quality improvement and control (e.g. TQM programmes, 6 sigma, quality circles) • Restructure manufacturing processes and layout to obtain process focus and streamlining (e.g. reorganize plan-within-a-plant, cellular layout) (i.e. reengineered business processes from a functional towards process orientation) • Promote actions to increase level of delegation to and knowledge of workforce (e.g. empowerment, training, improvement or autonomous teams) • Dedicated positions for supply chain professionals or "supply chain champions"	Academic Literature: Shah & Ward (2003); Hines et al. (2004); Commercial Consultants: Oracle (2003); SAP (2003); JD Edwards/ Peoplesoft (2003); i2 (2003); PRTM (2003); Manugistics (2003).
NEW PRODUCT DEVELOP-MENT	• Collaborative and interactive product design, and product improvement. • Controlling an integrated paperless engineering change order system throughout a product's lifecycle • Coordinating production capacity for NPD prototypes • Coordinating purchasing for prototypes • Coordinating ramping-up/ priming of the supply chain for product launch • Designing "for" effective supply chain management • Coordinating production of new products	Academic Literature: Petersen et al. (2003) Commercial Consultants: Oracle (2003); SAP (2003); JD Edwards/ Peoplesoft (2003); i2 (2003); PRTM (2003); Manugistics (2003).
RETURNS	• Coordinating collection, sorting and routing of products returned from supply chain partners/ and or end users (due to stock balancing, excess from marketing promotions, end-of-season, end-of-product life or transit damage, due to defective/ unwanted products, warranty returns, recalls, and environmental disposal issues) • Coordinating collection, sorting and routing of products returned from end users • Coordinating collection, sorting and routing of packaging returned from supply chain partners (due to reusable totes, multi-trip packaging, disposal requirements) • Coordinating collection, sorting and routing of packaging from end users (due to reuse, recycling, disposal restrictions) • Ensuring processing capability is sufficient to deal with product/ packaging return levels. • Working to reduce returns inventory held • Identifying and authorising legitimate returns • Working to reduce processing cycle times • Calculating the cost of the returns process • Maintain customer confidence in the returns/ repair process.	Academic Literature: Morton (2003); Tibben-Lembke (2002); Rogers & Tibben-Lembke (1999) Commercial Consultants: Oracle (2003); SAP (2003); JD Edwards/ Peoplesoft (2003); i2 (2003); PRTM (2003); Manugistics (2003).

The dimensions in Table 2.6 are used in subsequent sections to ensure that existing operations practices are included in the empirical investigations.

2.1.7 The Future Evolution of Supply Chains- Mega-Trends

Bowersox et al. (2000) bring the development of supply chain practice back into the academic literature and ask the question:

> "Where are we now in the evolution of supply chains and what has to occur to advance along the continuum?"

They build upon the broadened view of the need for integration and collaboration in different forms of modern supply chains. Their argument is that, in addition to a commitment to operational excellence, and implementation of supply chain management principles and practices, firms need to be aware of the changing environment in and around the firm in order to not be "in the position of doing things extremely well that no-one values." To this end, Bowersox et al. (2000) outline ten "mega-trends". They consider these mega-trends as reflecting:

> "fundamental paradigm shifts exhibited by leading firms as they transform their supply chain capabilities to accommodate the long-term transition from industrial to information technology driven society. These mega-trends imply substantial change in logistics practises between supply chain partners as they struggle to establish efficient, effective, and relevant product/ service solutions for end-customers."

Bowersox et al. (2000) consider the ten mega-trends to be precursors to revolutionising supply chain logistics. They go on to say that:

> "The transitions underlying some of the mega-trends represent the challenges of the emerging decade for logisticians and supply chain executives and identify the direction for change."

They coin the term "supply chain maturity" and give an indication of how well developed firms generally are with respect to each of their outlined mega-trends. In essence, their 1 to 10 assessments of current realisation levels of the mega-trends gives a simplistic "maturity" scale for each- showing how developed or advanced organisations are in terms of implementing practices pertaining to each particular mega-trend. With 1 representing no meaningful implementation and 10 representing total implementation, their scale provides some indication as to where the greatest opportunities exist for the further evolution of the supply chain.

Closer inspection reveals that three of the mega-trends have particularly low maturity scores, and are inter-related. The following text is a summary of the relevant parts of the Bowersox et al. (2000) mega-trends: "Adversarial to Collaborative"; "Information Hoarding to Sharing"; and "Towards Knowledge-Based Learning".

Adversarial to Collaborative

> "In most business relationships today, suppliers sell to customers. Often there is considerable conflict in these buyer/ seller arrangements as each party seeks the

> best financial deal. Neither side fully trusts the other. Vendors must guess customers' needs since the specific demand or planning information is not shared. In such situations, the potential for achieving overall operating efficiency is limited as firms manoeuvre for short-term benefits at the expense of their trading partners. The concept of integrated supply chain management highlights the leveraged benefits of firms collaborating to achieve common goals."

It is clear, however, that 'collaboration' is talked about much more than it is actually practiced (a point that is also made by Fawcett and Magnan (2002) in the previous section.) This mega-trend receives a score of only 2 to 3 on the ten-point maturity scale, and given its widely recognised importance, the move towards collaboration constitutes a major step in the future evolution of supply chains.

As suggested in the previously reviewed literature, central to this collaboration mega-trend is the need for supply chain participants to share information. This issue is outlined in the next mega-trend.

Information Hoarding to Sharing

Amongst academics and practitioners there is an awareness of the benefits of integration and collaboration, and the underlying need to share information. And yet Bowersox et al. (2000) stress:

> "The shift from a need-to-know mentality to relevant information sharing is a difficult transition for old school managers. Most, with years of experience in the trenches, have learned the hard way that information is power. It is becoming increasingly clear, however, that those who hoard information can only exploit it-they cannot leverage it. The immediate gains that are generated from such information hoarding pale in comparison to the cost savings and enhanced service that progressive firms find attainable through sharing relevant information with supply chain partners. The open deployment of information across the supply chain is the catalyst that enables effective integration. It serves as the key that unlocks the power of supply chain integration."

With an average firm maturity level of only 3 to 4 on the Bowersox et al. (2000) ten-point scale, it is clear that information-sharing practices need to be further developed for the continued evolution of supply chain management.

These first two mega-trends clearly identify the need for even more extensive forms of collaboration and information sharing in future supply chains. This is developed further by the third knowledge-based learning mega-trend that emphasises the need to go beyond information sharing between supply chain partners and also share, capture and apply skills, expertise and knowledge.

Towards Knowledge-Based Learning

Bowersox et al. (2000) argue the importance of knowledge and learning to the future evolution of supply chain logistics:

> "In the foreseeable future the logistics process will remain human centric. Effective management of the logistics process, however, is complicated by the fact that over ninety percent of all logistical work takes place outside the vision of the supervisor. No other employees within the typical business enterprise are expected to do so much critical work without direct supervision as those that make logistics happen... There is a critical need in these areas for employees that understand supply chain dynamics and can use information-based tools to develop and implement effective strategies."

With the lowest average industry ten-point scale maturity of 1 to 2 on this dimension, it is clear that moving towards effective skill development, knowledge sharing and organisational learning represents a significant step in the evolution of supply chains.

> "Among all the mega-trends, the development of effective knowledge-based learning may be the least developed. This represents a substantial challenge and opportunity..."

Interestingly, "it is estimated that as little as 20 percent of the scope of a typical logistical change initiative is within the direct control of a firm's logistics organisation". Therefore, it is necessary to collaboratively share information, expertise and knowledge with external supply chain partners in order to control the remaining 80 percent.

Thus the first two mega-trends of Bowersox et al. (2000) indicate that those firms that are fastest in evolving their supply chains in terms of collaborative sharing of information are likely to reap benefits. Furthermore, the third "knowledge-based learning" mega-trend indicates that evolution of supply chains will go beyond the information sharing level towards the collaborative transfer of knowledge and learning. Bowersox et al. (2000) highlight the knowledge issue as essential to the continued evolution of supply chain theory and practice. Yet, as was found from the broader review in Section 2.1.5, the majority of the integration and collaboration supply chain literature has overlooked this since it rarely goes beyond the data and information level of analysis.

Considering the Bowersox et al. (2000) 'thought' work discussion in the light of the previously reviewed supply chain integration and collaboration literature yields interesting insights regarding supply chain evolution. In particular, consideration of the collaborative information sharing and knowledge-based mega-trends leads to three specific conceptual dimensions which can be summarised as follows:

Dimension 1: Collaborative information sharing and knowledge transfer
Dimension 2: Employee and organisational skill and knowledge-based competence
Dimension 3: Level of collaborative practice implementation- or maturity level

Bowersox et al. (2000) identify these collaborative knowledge-based dimensions as being crucial to understanding "what has to occur to advance along the continuum" in the evolution of supply chains and yet as being at a relatively low stage of development in theory and practice. These knowledge dimensions are reviewed in more detail in the next section.

2.1.8 Supply Chain Evolution: Knowledge Transfer, Competence and Maturity

Following the Bowersox et al. (2000) reasoning, the knowledge-based dimensions of knowledge transfer, competence and maturity are likely to determine the operational success of supply chains as they continue to evolve to cope with new business environments and contexts.

Supply Chain Knowledge Transfer

The case put forward by Bowersox et al. (2000) for moves towards more collaboration and knowledge sharing, clearly relies on there being the possibility of knowledge transfer between organisations in the supply chain. They postulate that successful collaboration requires structures, frameworks, and metrics that encourage cross-organisational knowledge transfer. Bowersox et al. (2000) show that these transfers of knowledge may take several explicit forms, including "the exchange of data files and provision of direct access to databases". They also discuss more complex forms by which information and knowledge may be transferred between supply chain partners, including:

a) "shared employees… extend the process by providing a managerial conduit though which information flow between organisations can be coordinated and translated",

b) "through third party logistics suppliers who assign dedicated employees to shipper locations to ensure coordination."

Whilst much of this knowledge transfer is likely to be in explicit or codified forms, a significant proportion is also likely to be of a more tacit nature (See section 2.2). Bowersox et al. (2000) gives an idea of the complexity involved in supply chain knowledge transfer with the following example of a less formal- but no less important, knowledge transfer process between separate supply chain organisations:

> "… an unsupervised truck driver performs almost all the value created by moving a product from a shipping location to a customer destination. Truck drivers in fact, may spend more time face-to-face with key customer representatives than any other company employee. The truck driver may not even be an employee of the firm that is making the shipment to the customer."

This leads to the necessity of developing appropriate employee skills and organisational competences.

Employee and Organisational Competence

In discussing the importance of the knowledge-based learning mega-trend, Bowersox et al. (2000) highlight the importance of employee and organisational skills and competencies. Whilst Bowersox et al. (2000) make no clear distinction between what constitutes skill and competence, Gammelgaard and Larson (2001) differentiate the two within a supply chain context as follows:

> "Skills cover general context-independent knowledge; competencies refer to experience-based and context dependent knowledge. Skills are general tools and rules taught in most logistics classes, which are vital to the practitioner. However, to reach a competence level in the logistics discipline, practitioners acquire context dependent knowledge through organisational experience. Witt (1999) suggests workers must remain on the job to become competent. Dreyfus and Dreyfus (1986) argue that a competent practitioner makes decisions based upon rules and analysis, but with organisational experience can depart from rule-based analysis and make synchronic, intuitive, and holistic decisions."

Regarding employee competence, Bowersox et al. (2000) state that:

> "Training must shift from emphasising individual employee skill training to develop knowledge-based learning. This means that skill development must be placed in the

> context of the overall process in terms of objectives, dynamics and measurements. For example, a truck driver certainly must be skilled in all facets of driving. However, they must also possess knowledge concerning how they fit into the logistical process and how to access expert data warehouses, tracking capabilities, and adaptive decision support systems to resolve and prevent operating problems. Some forms of knowledge generation are as simple as learning how to cooperate. Others may require astute skills to identify emerging trends."

And, furthermore:

> "It is becoming increasingly clear that firms must build the knowledge competencies of key managers and planners. These individuals must be provided the education and experience that enables them to build an understanding of the risks and benefits inherent in supply chain integration... In a world where all logistics and supply chain employees are relatively high paid specialists, the firms that develop and maintain broad-based supply chain managers will exploit the winning formula."

And, similarly they argue that the level of successful collaboration will depend upon organisational competence that manifests itself in "structures, frameworks, and metrics that encourage cross-organisational behaviour." This organisational competence should be sufficient to "clarify leadership roles and shared responsibilities, delineate guidelines for sharing proprietary planning and operational information, and create financial linkages that make firms dependent upon mutual performance. In addition, formal guidelines that define joint operating policies and procedures for handling both routine and unexpected events should be derived." At the same time competence levels should be such that an organisation is "highly sensitive to the potential negative aspects of interlocking agreements."

Level of Supply Chain Maturity

In adopting their supply chain maturity scale, Bowersox et al. (2000) clearly indicate that differences exist between organisations in terms of their development of different collaborative supply chain practices- and especially those related to collaborative information sharing and knowledge-based learning. Additionally, they show that such differences could also exist at a business or industry sector level.

Bowersox et al. (2000) define maturity in terms of level of collaborative supply chain practice implementation. Applying this to the Bowersox et al. (2000) collaborative information sharing and knowledge-based learning mega trends leads to a conceptual construct corresponding to the level of collaborative knowledge sharing concerning 'best' (or most 'appropriate') supply chain practice implementation. Thus their knowledge-based maturity scale is essentially a measure of level of collaborative two-way communication to ensure "shared vision and objectives among customers and suppliers about interdependency and principles of collaboration". Similarly, knowledge-based maturity therefore indicates the level of mutual effort regarding "the adoption of integrative supply chain management operating practices" between supply chain partners.

Bowersox et al. (2000) stop short of elaborating a full schedule of potentially relevant multi-firm collaborative supply chain practices. Nevertheless, they do give examples such as "collaborative planning", " forecasting and replenishment", " Internet connectivity", and "other state-of-the art practices... built upon an extremely well-knit set of basic supply chain management principles designed to succeed today."

Therefore one possible useful operationalisation of the knowledge-based supply chain maturity construct could comprise levels of collaborative communication and knowledge sharing regarding implementation of appropriate supply chain practices- such as those of the Supply Chain Council SCOR model outlined above.

In essence, the underlying proposition of Bowersox et al. (2000) is that companies and sectors can improve their supply chain performance by increasing levels of supply chain maturity. In turn this implies increased levels of collaborative information and knowledge sharing across a range of recognised and appropriate supply chain integration and collaboration practices. Hence high levels of maturity reflect fundamental shifts already "exhibited by leading firms as they transform their supply chain capabilities". Conversely, low maturity levels are likely to be observed in 'laggard' companies or sectors.

There are many reasons as to why some organisations or sectors will be more mature than others in certain supply chain practices. The example of employee training indicates how problems may be incurred in trying to implement supply chain practices. Any given company may be "having problems finding the time and the appropriate methods to effectively train employees. Training time is difficult to find due to the manpower reductions that have been forced on firms. It is difficult to find the appropriate training approaches as they must integrate across a number of functional areas and incorporate multiple technologies." (Bowersox et al., 2000). Therefore, those organisations that operate in fortunate contexts, or that manage to overcome the difficulties, can achieve higher levels of collaboration and knowledge-sharing with supply chain partners and develop appropriate practices faster, thus attaining higher levels of supply chain maturity sooner.

Whilst related aspects of knowledge transfer, competence and knowledge-based maturity emerge from the literature as being important areas of research, it appears that there is limited existing work on these related themes. A review as to whether these issues correspond to acknowledged gaps in the supply chain literature is carried-out in the following section.

2.1.9 The Need for Further Supply Chain Research

2.1.9.1 Conceptual Gaps in Supply Chain Research

The need for further research involving knowledge-based dimensions is made clearer by the comprehensive critical literature review of Croom et al. (2000). Their work has already been introduced in Section 2.1.2, but is further analysed here with respect to identifying specific conceptual literature gaps.

Croom et al. (2000) set out to define a framework for classifying and critically analysing the large number of contributions on supply chain management. They explore the underlying phenomena and processes embodied within the contrasting yet complementary bodies of literature in order to develop a taxonomy for supply chain researchers. This taxonomy divides according to two criteria:

1. The content-oriented criteria
2. The methodology-oriented criteria

As they state: "this is very helpful not only in developing a literature review with a critical perspective, but also in assessing gaps in current theorising, methods and empirical finding in the field."

The methodology related criteria- and the need for good quality empirical research in this area is discussed in greater detail in Chapter 4.

In addressing the content of the existing supply chain literature, Croom et al. (2000) adopt a two-dimensional approach: firstly considering "level of analysis", and secondly considering the "element of exchange".

In the existing literature they found essentially three levels of analysis:

a) Dyadic level: considering the single two party relationship between supplier and manufacturer or manufacturer and distributor/ retailer.

b) Chain level: which encompasses a set of dyadic relationships, including a supplier, a supplier's supplier, a customer and a customer's customer

c) Network level: concerning a network of upstream, downstream or total operations.

Building upon the work of Hakansson (1982), Croom et al. (2000) consider networks composed of actors, resources and activities, and create a second dimension relating to the nature of exchange or transaction between actors and networks. They use this second dimension of element of exchange to classify literature according to 'what' is exchanged in terms of material assets, financial assets, human resource assets, technological assets, information and knowledge. They are careful to point out that in terms of 'what' is exchanged it is important to consider both the static (e.g. which actor owns an asset and where it is located), and the dynamic aspects (e.g. materials, information, financial, technology, and knowledge flows between actors.)

Particularly interestingly, Giannakis and Croom (2004) augmented the earlier extensive literature analysis of Croom et al. (2000), combining the level of analysis and element of exchange dimensions to create a two dimensional content analysis matrix that summarises the location of publications found and the keywords used in them. This is shown in Table 2.7 (which is modified from Table 2.2, clarifying the extent of 'Knowledge'-related literature gaps.)

Table 2.7 Apparent Conceptual Gaps in Supply Chain Literature Content

Level of Analysis		Element of exchange considered			
		Assets	**Information**	**Knowledge**	**Relationships**
Dyadic	**Suppl. Manuf.**	Transaction cost (specificity of assets)	Information technology support	Collaborative design	Outsourcing/ subcontracting
		Transportation routes rationalisation	Tools for analysis of information flow	Guest engineer	Trust/ power/ commitment
		Exchange of technology	Interplant planning and logistical integration (EDI)	HR Development	Supplier development
		Redesign HR organisational incentives			Transaction cost approach
	Manuf. Distr.	Distribution channel redesign	Information technology support	Product teams	Logistic partnership (with logistic service providers)
		Facilities location (warehouses, etc.)	Interplant planning and logistical integration (EDI)	*GAP?*	Trust/ power/ commitment
		Transportation routes rationalisation	Communication processes		Outsourcing/ subcontracting
Chain	**Suppl.-Manuf.-Distr.**	Quick response, ECR, etc.	Industrial dynamic approach	Supply chain councils	Scenarios good for supply chain management
		Industrial dynamic approach	Information Technology support		Opportunism/ trust/ power/ commitment
		Reverse supply chain management	Structured systems analysis and design method	*GAP?*	Positioning in the supply chain
		Total cost of ownership	Modelling the information flow		Influence of product technology on supply chain relationships
		Value system analysis	Communication processes		
Network	**Upstream**	Supply network sourcing	Information technology support	Suppliers meetings	Partnership sourcing
		Transportation routes rationalisation	Supply Network communication processes		Lean supply
		Supply network structure	Interplant planning and logistical integration (EDI)		Network sourcing
		Redesign HR organisational incentives			Supply base integration
	Down stream	Transportation routes rationalisation	Information technology support		Trust/ power/ commitment
		Distribution channel redesign	Supply network communication processes	*GAP?*	Logistic partnership (with logistic service providers)
		Facilities location (warehouses, etc.)	Interplant planning and logistical integration (EDI)		Opportunism/ trust/ power/ commitment
		Design for supply chain management			Outsourcing/ subcontracting
	Whole	Business Network redesign approach	Information technology support		Value stream analysis
		Value system analysis	Business network redesign approach		Supply network partnership
		Design for supply chain management	Supply network communication processes		Trust/ power/ commitment/ opportunism
		Industrial dynamic approach			

Brief analysis of the content matrix indicates that there is considerable existing supply chain management literature that deals with the first element of exchange- assets at all levels of analysis. Croom et al. (2000) state that:

> "The literature is very rich [in considering asset inventory and transportation management] in part because these are the seminal subjects of logistics, but probably also because cost and delivery time pressures require that attention has to be paid to managing stocks and transportation modes. These subjects summarise both the static dimension of supply chain management (where to position inventories along the supply chain, in which physical form, how much stock at each point, how many tiers or warehouses to use, to eliminate local inventory stocking points and to centralise inventories, to relocate consolidation/ de-consolidation points, to ad regional warehouses or to use warehouses for specific customers, etc.) as well as the dynamic ones (which form of shipment to use, whether to consolidate transportation routes and logistics service providers, to use faster modes of transportation like air freight, express delivery, etc.)

Similarly, a large amount of literature exists concerning the second element of exchange; information "both in the form of information flows that permit quick inter-organisation payments between supply chains members, and in the form of information accumulated, coded, and stored in firm database structures." Many contributions to the literature have concentrated upon information technology that has provided new opportunities through electronic commerce. These issues are also dealt with at all levels of analysis. In particular, it can be seen from the supply chain literature content matrix that the interplant planning and logistical integration issues, already considered in Section 2.1.5, are prevalent at virtually all levels of analysis.

Regarding the fourth element of exchange- relationships between actors it is clear from Table 2.7 that substantial important research has been conducted at all levels of analysis.

> "Relationships have been considered by the literature both at the level of the market (macro) and at the level of the single organisations (micro). From a macro point of view the arguments for supply chain management begin with the firm theory of Coase (1937) and the transactional economics work of Williamson (1975)... inter-organisational relationships of writers such as Van de Ven et al (1975), which led theorists to identify the concepts of "networks" as opposed to supply chains (Lamming 1996). In this perspective supply chain management is viewed as an alternative to different types of relationships such as integrated hierarchy and pure market" (Croom et al., 2000).

From the 'micro' perspective: "an increasing number of organisations are finding it profitable to adopt strategies that require the development of closer ' partnership' relationships with their major suppliers. This is leading to an attitudinal shift in behaviour towards suppliers that Lamming (1993) defined as lean supply."

Nevertheless, while the other elements (assets, information and relationships) are "relatively well understood and widely considered by the literature, the third element, knowledge necessary for supply chain management is not so clearly or consistently presented." From the supply chain literature content matrix, it can be clearly seen that in their wide literature search, Croom et al. (2000) found very little literature relating to the important topic of "knowledge exchange in supply chain integration". This is particularly apparent beyond the dyadic level of analysis, where the literature apparently becomes very sparse. This is indicated in Table 2.7 by the sections outlined "*GAP?*"

Thus there do appear to be significant gaps in the literature, particularly in terms of considering the knowledge element of exchange beyond the simple dyadic level of analysis. This presents exciting opportunities for doctoral research especially in the light of the previously reviewed literature and particularly that of the mega-trend 'thought' work of Bowersox et al. (2000).

For further explanation of what distinguishes the knowledge element of exchange from simple data and information- see Section 2.2.2.

Croom et al. (2000) go on to raise the related issue of competence, stating that "another important subject of research about knowledge for supply chain management is the analysis of ... individual competence, organisational competence and network competence."

They point out that while a very rich literature does exist on the links between organisational competence and corporate strategy, they found only one piece of work that highlights the links between organisational competence and individual competence (Knight, 1998), and none relating to the individual and organisational competence required for good supply chain management.

> "The links between the competence of individuals and organisation performance and between the competence of organisations and network performance is an area of importance (Cox, 1997), but one that is not particularly well understood."

Thus almost precisely those areas identified in the previously reviewed literature as being important for the continued evolution of supply chain management correspond to apparent significant gaps in the existing literature- as identified by recent comprehensive critical literature reviews (Croom et al., 2000; Giannakis & Croom, 2004). This clearly presents important opportunities for doctoral research and beyond.

2.1.9.2 The Need for New Cross-Functional Conceptual Perspectives

Further to the apparent 'knowledge' conceptual gaps in the supply chain literature, there have been calls from distinguished researchers in the field to bring new perspectives into the field. For example Stock (1997) suggests that researchers in the supply chain field may benefit from borrowing theories and insights from other disciplines such as economics, strategic management and marketing. Amundson (1998) recommends that operations management researchers should consider theories from other disciplines so as not to "reinvent the wheel" and to view phenomenon or issues through a different cognitive "lens".

Croom et al. (2000) also recognise the importance of multi-disciplinarity in the development of our understanding of supply chain management. They note that the importance of transactional cost economics and inter-organisational theory has been recognised by a number of researchers (Lamming, 1993; Harland, 1996; Croom, 1996). Croom et al. (2000) go on to encourage supply chain researchers to bring new insights from "some of the hybrid fields such as marketing or strategic management, then it is apparent that the subject is being explored from a multiplicity of perspectives." They conclude that:

> "Of significance, we feel is the need for researchers to be aware of complementary studies outside their own 'normal' domain of expertise."

As Dietrich (1994) pointed out, future developments in theory concerned with business to business phenomena may require a more cosmopolitan approach, incorporating a combination of contrasting social and technical disciplines.

Returning to the Bowersox et al. (2000) question regarding the continued evolution of supply chains, the most apparent conceptual development gaps in supply chain management literature appear in terms of the "knowledge-learning" dimensions. Thus new perspectives throwing light into specifically these areas could prove to be particularly useful. In fact, Amundson (1998) specifically argues that:

> "A relatively new theoretical perspective from the field of management that possesses substantial potential for integration with OM is Organisational Learning."

In light of this and the previously reviewed literature I propose that fresh perspectives could be obtained through consideration of appropriate concepts and frameworks from the Organisational Learning- and in particular the Knowledge Management streams of strategic management literature. Under the 'umbrella' field of Organisational Learning, Knowledge Management has emerged as a relatively young research stream more or less in parallel with that of supply chain management. One of the basic premises of the Knowledge Management stream is that organisational evolution, learning and knowledge are inextricably linked (March, 1991). Concepts and frameworks from this emerging field of research are addressed in Section 2.2. Also Section 2.3 reviews the limited research that has investigated knowledge management/ organisational learning issues within supply chains.

2.1.9.3 Contextual Gaps in Supply Chain Research

As can be seen from the above review, in the last 15 years there has been an intense interest in academia and among business circles about supply chain management. Over the course of this period the concept has been investigated by many researchers (Houlihan, 1988; Womack et al., 1990; Ellram, 1991; Christopher, 1992; Lamming, 1993; Hines, 1995; Harland, 1996) establishing its theoretical and operational bases as we know them today. As the previous sections of literature review indicate, it has been widely and constantly claimed that supply chain management as a concept could be a major source of competitive advantage. The mechanisms of supply chain and the competitive advantages it bestows, have largely been explored against the "competing through manufacturing" concepts and frameworks set out in the manufacturing stream of literature (Hayes & Wheelwright, 1984; Skinner, 1974; Clark, 1996; Hayes & Pisano, 1996;).

For example, the major benefits that are widely considered to come from effective supply chain management tie-in precisely with those manufacturing competitive trade-off priorities of Hayes and Wheelwright (1984). The experience of companies such as Dell has been taken as evidence supporting Ferdows and De Meyer (1990) that trade-offs are not inevitable and that each of the Hayes and Wheelwright (1984) competitive dimensions can in fact be achieved with application of supply chain principles:

- Low cost
- High flexibility
- High dependability
- High quality

Nevertheless, this close link of the supply chain literature with the manufacturing literature has received criticism. Giannakis (2001) contends that the vast majority of academic and practitioner supply chain work is based upon the notion that companies have much the same type of structure and utilise the same resources and operational processes as one might expect in manufacturing firms- and especially large automotive companies (Slack &Bates, 1997).

> "It is true that these [manufacturing] companies provide a rich field for research and development of theories in business management, however... the success of these models in contexts such as the supply and delivery of services has not been tested thoroughly." (Giannakis, 2001)

Harland et al. (1999) also agree that supply chain literature related to services is rare compared to that on manufacturing:

> "The intangible nature of services and the [assumed] lower significance of materials and their management within services than in manufacturing are likely causes of this lack of attention to the supply side issues."

With the following table, Giannakis (2001) illustrates that the following contextual research gaps exist in the field of supply chain management:

1. Research relating to the exchange of services in service sectors,
2. Research relating to the exchange of services in manufacturing sectors,
3. Research relating to the exchange of goods in the service sector.

Table 2.8 Contextual Research Gaps in the Supply Chain Literature

	Exchange Offering	
Sector	**Goods**	**Services**
Manufacturing	Conventional	***GAP?***
Services	***GAP?***	***GAP?***

These apparent contextual gaps shown in Table 2.8 are despite considerable efforts going into investigating the benefits of 'carrying-over' managerial concepts and practises from manufacturing to services. As Levitt (1976) stated:

> "The managerial rationality embodied in the practical imagination we see exercised so effectively everywhere in manufacturing can, given the effort, be applied with similarly munificent results in the service industries."

Bowen and Youngdahl (1998) argue against the tendency in the late 1980's and 1990's of the management literature disagreeing with the transfer of hitherto largely manufacturing concepts to services. They make the case that manufacturing logic can and should transfer to service operations.

Recent research within the service operations stream (Voss, 2003) has sought to apply concepts originally conceived and developed within manufacturing contexts- such as the 'sand cone model' of manufacturing capabilities (Ferdows & De Meyer, 1990) and manufacturing strategy 'order qualifiers' and 'order winners' (Hill, 1993). In developing their classification of service processes, Silvestro et al. (1992) draw heavily from the manufacturing and production literature. Thus the transfer of supply chain concepts from traditional manufacturing contexts to evolving service contexts could also be an area of potential interest to both practitioners and researchers.

This debate is given more weight considering the fact that service industries have replaced industrial markets in the role of economic growth as service activities represent two thirds of the national products in developed countries and at least 50% of the final value of a manufactured product is made up by services. In the European Union over 60% of the workforce and over 76% of the workforce in the USA is engaged in services. Furthermore, the increasing phenomenon of 'servitisation' of manufacturing companies (i.e. those which include services in their offerings as well) would suggest that research in services could be of substantial importance (Giannakis, 2001).

Certainly the list of companies on the Supply Chain Council website (www.supply-chain.org) that have worked to implement the SCOR model includes many companies from service sectors. Thus service companies are clearly interested in supply chain issues and therefore expanding the literature to cover these evolving service contexts is both relevant and necessary.

A further review of the literature considering the opportunities for transferring relevant supply chain concepts and practices between manufacturing and service operations is carried-out in Section 2.4.

2.2 CONCEPTUAL PERSPECTIVES FROM KNOWLEDGE MANAGEMENT LITERATURE

The previous sections of this chapter have broadly reviewed the supply chain management literature and identified specific conceptual and contextual gaps. This section moves on to consider alternative literature streams, identified for their possible insightful conceptual perspectives regarding the continued evolution of supply chain theory and practice. In particular it is felt that fresh perspectives could be obtained by exploring appropriate concepts and frameworks from the knowledge management stream of literature (and other closely associate bodies of literature, such as organisational learning.) Knowledge management has emerged as a relatively young cross-functional research field more or less in parallel with that of supply chain management. As indicated by the previous review sections knowledge management and supply chain management streams apparently have elements in common but research linking the two fields has been somewhat scarce.

The intention of the literature review in this section is not to give a comprehensive account of knowledge management and related literature streams- but rather to identify potentially useful insights, concepts and frameworks with which to address the identified knowledge dimension gaps in the supply chain literature and in general terms the Bowersox et al. (2000) question:

> "Where are we now in the evolution of supply chains and what has to occur to advance along the continuum?"

One of the basic premises of the knowledge management field is that organisational evolution, learning and knowledge are inextricably linked (March, 1991). Section 2.2.1 of the knowledge management review therefore outlines the importance of knowledge and learning to organisational (and supply chain) evolution.

Section 2.2.2 goes on to overview the scope of knowledge management research- firstly addressing important overall issues regarding what constitutes organisational knowledge. Then this sub-section hones in upon knowledge management concepts that could prove relevant and insightful in addressing the specific supply chain evolution issues identified earlier; namely- knowledge creation, knowledge adoption, knowledge transfer and knowledge evolution.

2.2.1 The Importance of Knowledge and Learning to Organisational Evolution

Only relatively recently have supply chain researchers (Bowersox et al., 2000; Croom et al., 2000) identified the importance of knowledge and learning to the continued evolution and development of supply chain theory and practice. Nevertheless, researchers in other knowledge management related literature streams, such as economics, strategic management and organisational learning have recognised the importance of learning and knowledge issues in the evolution of organisations for decades. The previous literature review demonstrates that the supply chain can be viewed as form of extended organisation- and thus knowledge and learning are likely to be just as important to supply chain evolution.

Evolutionary economics constitutes a significant business research field in its own right, contributing considerably to organisational theories and to the knowledge management stream. Seminal academic works in the field recognise the importance of knowledge and learning to organisational evolution. For example, at the heart of the organisational evolutionary theory proposed by Nelson and Winter (1982) is that any organisation's survival, prosperity and development is dependent to some degree upon its production set (i.e. the things it knows how to do) and organisational capabilities (i.e. the things it can do) at any given time. The production set and organisational capabilities are, in turn, clearly determined by that organisation's "state of knowledge". Several of the economic concepts supporting the centrality of knowledge and learning to organisational evolution are consonant with the traditions of economic theorising going back to the likes of Adam Smith in "The Wealth of Nations" (Smith, 1776).

Nelson and Winter (1982) argue that the evolution of an organisation is thus linked to its "indefinite boundary of knowledge"- whereby "firms can augment their own knowledge by reaching out into the environment- into their industry or society." They raise several questions that go beyond orthodox economic theory... such as: Where does knowledge reside in an organisation? What is the nature of this knowledge? What dictates the state of individual and organisational knowledge? How does the knowledge possessed by one organisation relate to that possessed by others?

Nelson and Winter (1982) go on to identify the importance of individual and organisational skills, abilities and competences to the evolution of organisations. In fact they refer to individual behaviours, such as learning, as a metaphor for organisational behaviours, stating the idea that "individuals are complex organisations too". Nelson and Winter (1982) suggest that an organisation may learn and develop competences in a similar manner to an individual becoming skilled in serving a tennis ball, becoming competent in carpentry, becoming an able computer operator etc. Thus, in the same vain, supply chains can be considered extended organisations with similar knowledge and behavioural learning mechanisms.

Regarding skill development, Nelson and Winter (1982) refers to the organisational learning distinction between explicit and tacit knowledge (Polyani, 1966)- further cementing the inextricable links between the themes of organisational evolution, organisational learning and knowledge management literatures.

Similarly, in another evolutionary approach investigating the fundamental question as to why organisations exist Postrel and Rumelt (1992) identify the "mechanism of learning" as being a key to developing "good habits" within organisations. Winter (1984) extends Schumpeterian evolutionary models and investigates issues such as sources of new knowledge in the organisation's external environment. March (1994) states that:

> "theories of evolution have become well-recognised frames for organisational analysis... including theories of experiential learning... theories of the development of knowledge."

Clearly therefore, as seminal organisational evolution literature identifies learning and knowledge as key conceptual evolutionary issues, the next sub-section moves on to review knowledge management and related literatures for potentially insightful perspectives to address the supply chain evolution question raised by Bowersox et al. (2000).

2.2.2 An Overview of Relevant Knowledge Management Research

Knowledge Management is a rapidly expanding body of literature seeking to apply a knowledge-based perspective to business issues, and focusing upon knowledge as a key competitive asset. It is not yet a coherent field of research in itself, but has its roots largely in the social sciences and psychology- drawing from various different areas of literature primarily organisational learning. (In fact, Argote (1999) describes organisational learning as an "umbrella" for knowledge management.) This emerging field can broadly be divided into two thematic research areas:

1. That literature that deals with the question 'What is knowledge?'- investigating the dimensions of knowledge and learning. This sub-field addresses the knowledge content related issues such as information, expertise, skill, competence, as well as knowledge and learning process issues such as knowledge creation, acquisition and transfer (Huber, 1991).

2. A growing body of literature that seeks to apply the 'knowledge lens' in researching the effect of knowledge upon performance within the context of organisations. As such this sub-field of the knowledge literature is more applied than the first, and much of it lies within the broader strategic management related literatures.

The field of knowledge management is relatively young, yet there are many developing lines of research dealing with major knowledge-based issues in organisations in both of the above thematic research areas. Much of this work is developing in parallel, from different functional areas and with no apparent unifying framework. Thus the task of classifying the literature into robust, coherent content-oriented groups is complex and beyond the scope of this literature review. Furthermore, such a comprehensive review would detract from the primary aim of identifying potentially useful concepts with which to apply the 'knowledge lens' to the gaps and issues identified in the earlier supply chain literature review. The following sub-sections therefore provide an orientative overview of several areas of the developing knowledge management literature. Some of the main emerging concepts are summarised within a preliminary speculative content classification aligned to the purposes of this doctoral investigation. In no way is this section intended to constitute a complete synthesis of the existing knowledge management literature.

In such a rapidly developing literature stream, some of the following citations could be wrongly perceived as being 'out-of-date'. In fact, works by the likes of Polyani (1966), Argyris and Schon (1978), Levitt and March (1988), Cohen and Levinthal (1990), March (1991), Epple et al. (1991), Kogut and Zander (1992), and Levinthal and March (1993) are seen as 'classics' by a considerable body of recent multi-functional knowledge management literature. This pays testament to the robustness of the concepts and frameworks developed by such earlier works. Recent important academic research that is based upon theories conceived by the above academics include: Boone and Ganeshan (2001); Lovelace et al. (2001); Tsai (2001); Schulz (2001); Skilton and Dooley (2002); Knight (2002); Bessant et al. (2003); Edmondson et al. (2003); Hult (2003); Sorenson (2003); Carlile and Rebentisch (2003) and Argote et al. (2003). The earlier knowledge management and organisational learning works are therefore still potentially relevant and valid for application in this doctoral research.

Subsequent chapters adopt appropriate perspectives from the following research areas in order to apply the 'knowledge lens' to appropriate supply chain settings (following guidelines proposed by Amundson (1998). See Chapter 3- The Research Framework).

Organisational Knowledge

The seminal work of Kogut and Zander (1992) considers knowledge in an organisational context:

> "Knowledge is held by individuals but is also expressed in regularities by which members cooperate in a social community (i.e. group, organisation, network) If knowledge is only held at the individual level, then firms could change simply by employee turnover. Because we know that hiring new workers is not equivalent to changing the skills of a firm, an analysis of what firms can do must understand that knowledge is embedded in the organising principles by which people cooperate within organisations."

Regarding the question 'what is knowledge?' they identify two knowledge categories:

1. Information (declarative) – "Knowledge which can be transmitted without loss of integrity once the syntactical rules required for deciphering it are known. Information includes facts, axiomatic propositions, and symbols." This form of knowledge implies "knowing what something means."

2. Know-how (procedural) – "is the accumulated practical skill or expertise that allows one to do something smoothly and efficiently... know-how must be learned and acquired." This form of knowledge implies "knowing how to do something."

To further explain these forms of knowledge, Kogut and Zander (1992) use the example of inventory- thus linking their relevance to a supply chain context. Information (or declarative) knowledge provides a state description- such as the inventory level is 100. Know-how (or procedural) knowledge relates to a process- such as the method by which inventory is minimised. They reason that:

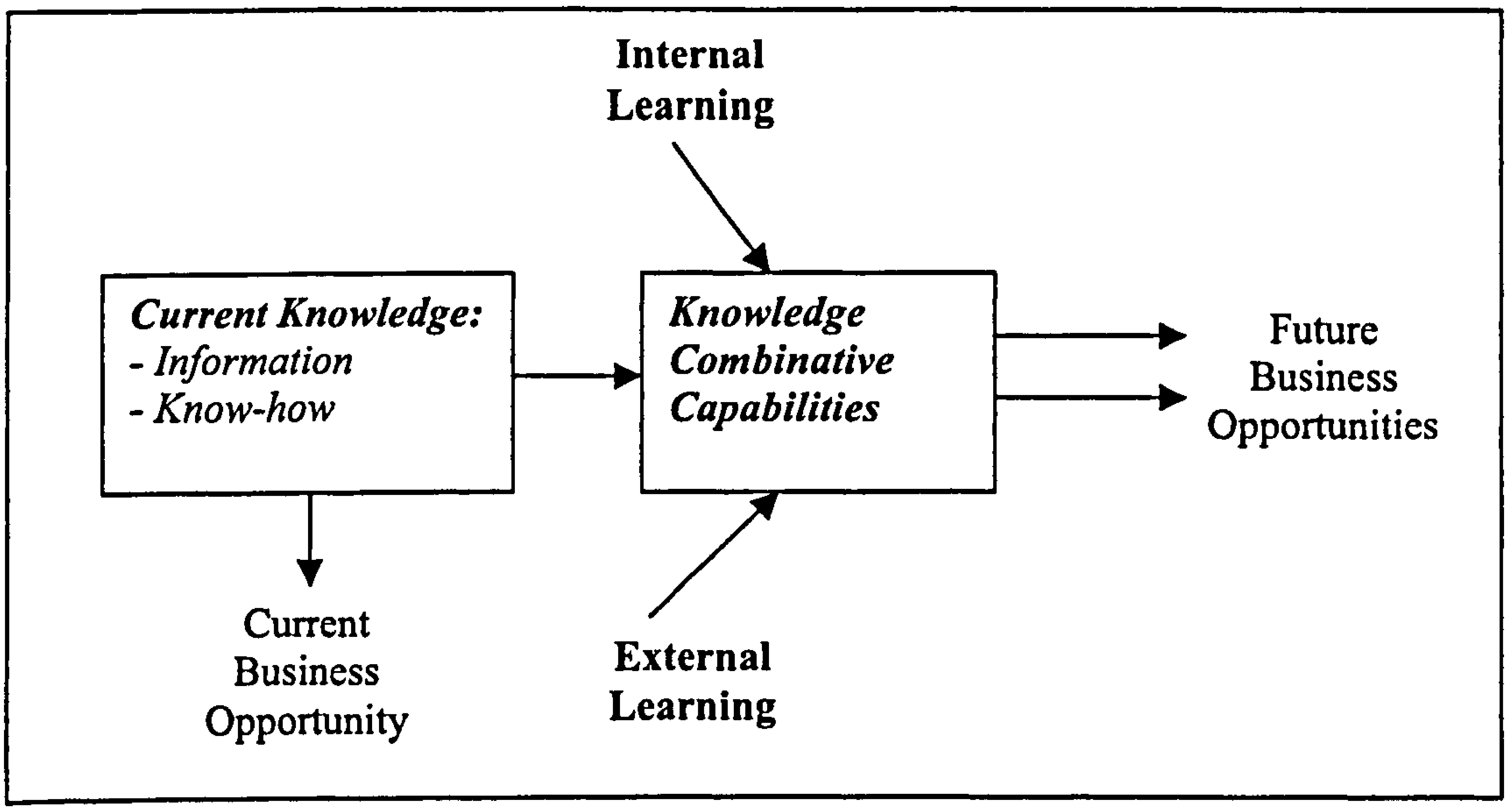
> "Know-how, like procedural knowledge, is a description of what defines current practice inside a firm."

This 'know-how' component is what clearly distinguishes the knowledge element of exchange from the simple data and information levels that have been explored within the supply chain integration literature to date (see Sections 2.1.5 and 2.1.9.1.) Zack (1999) further clarifies the distinction:

> "Knowledge is commonly distinguished from data and information. Data represent observations or facts that are, therefore, not directly meaningful. Information results from placing data within some meaningful context, often in the form of a message. Knowledge is that which we come to believe and value on the basis of the meaningfully organised accumulation of information (messages) through experience, communication or inference (MacKay, 1969; Churchman, 1971; Bruner, 1973; Bobrow & Collins, 1975; Matchlup, 1980; Dretske, 1981). Knowledge can be viewed as a thing to be stored and manipulated and as a process of simultaneously knowing and acting- that is applying expertise (Dretske, 1981; Kogut and Zander, 1992). As a practical matter, organisations need to manage knowledge both as object and process."

Thus "organisations 'know' something", and this knowledge has "persisting effects" upon the relative performance and competitive opportunities available. One of the keys is the concept of 'cumulative knowledge' which can be built-up over time (leading to issues of 'knowledge improvement' and 'knowledge evolution' as addressed below) through the synthesis of current and acquired knowledge. Underlying this creation and build-up of knowledge are processes related to internal and external learning (also see 'knowledge creation' below). This knowledge improvement and evolution can lead to new business opportunities. Kogut and Zander (1992) illustrate this growth of firm knowledge by the "roadmap" represented in Figure 2.8.

Figure 2.8 Growth of Knowledge of the Firm



Further consideration of the 'what is knowledge?' question leads to another clear distinction in the literature between tacit versus explicit (codifiable) knowledge (Polyani, 1966; Brown & Duguid, 1991; Nonaka, 1994; Romer, 1995). The underlying feature behind tacit knowledge is that individuals and organisations appear to know more than they can explain. This problem of explanation leads to difficulties when it comes to codifying and transmitting the knowledge. Codifiability refers to the structuring of knowledge into a set of identifiable rules and relationships that can be easily communicated. Tacit forms of knowledge- that usually relate to the more complex 'know-how' are often particularly unamenable to codification. For example, "drafting a recipe for the manufacturing of a musical instrument is unlikely to capture the requisite skills of a craftsperson" (Kogut and Zander, 1992). Usually (but not always) the information-declarative knowledge lends itself more to explicit codification. Zack (1999) explains the difference:

> "Tacit knowledge is subconsciously understood and applied, difficult to articulate, developed from direct experience and action, and usually shared through highly interactive conversations, storytelling, and shared experience. In

> contrast, explicit knowledge is more precisely and formally articulated, although removed from the original context of creation or use (e.g. an abstract mathematical formula derived from physical experiments or a training manual describing how to close a sale.)"

Szulanski (1996) relates the above organisational knowledge issues to the development of distinct competences and the dissemination of best practices (i.e. organisational capabilities). He states that:

> "Practice refers to the organisation's routine use of knowledge and often has a tacit component, embedded partly in individual skills and partly in collaborative social arrangements."

Four stages are identified by Szulanski (1996) in the intra-firm transfer of practices: initiation, implementation, ramp-up and integration. Clearly, some firms find the intra-firm knowledge transfers needed to spread best practices harder than others- and the impediments such firms face are captured by the concept of "internal stickiness".

Knowledge Creation

This body of literature deals with how knowledge is formed in organisations, and brings together research from areas of learning behaviour, innovation and teamwork. For example, Edmondson (1999) investigates learning behaviour in work teams within manufacturing companies. She discusses the fact that the organisational learning literature views learning in two ways: as an outcome or as a process. She cites Dewey (1938) and Argyris and Schon (1978) in prescribing to the conceptualisation of learning as a process and using the term learning behaviour to avoid confusion with learning outcomes such as greater understanding. Edmondson (1999) states that:

> "Examples of learning behaviour include seeking feedback, sharing information, asking for help, talking about errors, and experimenting. It is through these activities that teams [and organisations] can detect changes in the environment, learn about customers' requirements, improve members' collective understanding of a situation, or discover unexpected consequences of their previous actions."

In other words, Edmondson (1999) prescribes to the view that knowledge creation (or acquisition), increased knowledge, skills and competencies are outcomes of the learning process. Huber (1991) reviews the organisational learning literature and identifies five main learning processes through which knowledge is acquired by organisations. The first three of these learning processes are particularly relevant to the supply chain context:

1. **Congenital learning:** "Organisations do not begin their lives with clean slates... An organisation's congenital knowledge is a combination of the knowledge inherited at its conception and the additional knowledge acquired prior to its birth." In other words, congenital learning leads to an organisation's "starting knowledge".

2. **Experiential learning:** "After their birth, organisations acquire some of their knowledge through direct experience". Such "learning by doing" leads to the development of higher levels of individual and organisational competence (Levitt & March, 1988). Also related to experiential learning are issues of appraisal and feedback and "single-loop" and "double-loop" learning (Argyris & Schon, 1978). Another important area of research into experiential learning is related to learning curves- see below in Knowledge Evolution.

3. **Vicarious learning:** "Acquiring second-hand experience... borrowing from other organisations is one form of organisational learning." The process of vicarious learning often underlies issues such as the diffusion of technologies and practices. This learning process is very relevant to collaborative knowledge sharing between supply chain partners- though vicarious learning by imitation is perhaps less so.

Another potentially useful example of the knowledge creation and acquisition literature is McGrath (2001), which investigates exploratory learning and innovative capacity. Similarly, she characterises one perspective of learning as "a process that is amenable to ex ante planning and control". McGrath (2001) argues that exploratory learning behaviour results in the creation of new organisational knowledge that should counteract the presence of "core rigidities" (Leonard-Barton, 1992)- "routines that actually inhibit an organisation from innovating."

Also of potential interest to the evolution of supply chains is the work of Nohria and Gulati (1996) who investigate the role of organisational "slack" in the creation of innovative knowledge. Their central research focus is: "if slack is a form of inefficiency but also essential for innovation, organisations run the risk of eliminating slack to a point that undermines their capacity to [create knowledge]." Nohria and Gulati (1996) find strong support for an inverse U-shaped relationship between slack and innovation that reconciles perspectives that argue for and against slack. Two related mechanisms are therefore proposed: "slack fosters greater experimentation but also diminishing discipline over innovative projects." (Clearly this concept of slack has implications for lean supply chain issues relating to elimination of waste or 'muda' (Lamming, 1993).)

Knowledge Adoption

This area of literature specifically focuses upon how organisations adopt knowledge that is developed outside their own realms. In this area the work of Cohen and Levinthal (1990) is widely cited. They argue that the "ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends is critical to its innovative capabilities." They label this capability a firm's "absorptive capacity" and suggest that it is largely a function of the firm's prior related knowledge. Cohen and Levinthal (1990) use a technique often employed in the knowledge management literature of first focusing on the cognitive basis for an individual, and then characterise the factors of influence at an organisational level. They state that "outside sources of knowledge are often critical" regardless of the organisational level at which it is defined. Citing March and Simon (1958), they state that: "at the organisational level, most innovations result from borrowing rather than innovation." One of the keys to absorptive capacity is that learning is cumulative, thus enabling the building-up of a "rich knowledge structure" and high levels of individual and organisational competence:

> "To integrate certain classes of complex and sophisticated technological knowledge successfully into a firm's activities, the firm requires an existing internal staff... who are both competent in their fields and are familiar with the firm's idiosyncratic needs, organisational procedures, routines, complementary capabilities... As a consequence, such critical complementary knowledge is acquired only through experience within the firm."

Conversely, a failure to develop sufficient absorptive capacity to learn from the external environment, and thus failing to proactively reinforce the competence knowledge structure can result in what Schumpeter (1942) terms "the process of creative destruction" or what Tushman and Anderson (1986) refer to as "competence destroying technical change."

Almeida (1996) tracks knowledge adoption in terms of learning and sharing activities of multinationals. They found strong evidence for two-way knowledge exchange, whereby foreign multinationals both benefit from local knowledge and contribute to it. Thus, in order to acquire an appropriate knowledge base, collaboration in some form is essential and "learning without contributing may not be possible".

Another insightful area of work in terms of knowledge adoption, considers interfirm collaboration and the issue of "alliance dynamics". For example, Dussuage et al. (2000) combines an evolutionary perspective with the resource-based view and transaction cost economics to find empirical support for levels of knowledge adoption, learning and competence base development being higher between organisational partners which are part of a "link alliance"- i.e. an interfirm partnership to which partners contribute different capabilities or "asymmetric knowledge". Dussuage et al. (2000) explicitly cite a customer-supplier relationship as an example of a link alliance. Dussuage et al. (2000) note that organisational theorists " have long recognised that no one business can create all resources needed to prosper and grow. Instead, collaboration among businesses that possess complementary resources is often necessary for survival and growth, and provides a means of combining resources held by different firms in order to exploit new business opportunities."

Inter-firm Knowledge Transfer

In light of the literature review in Section 2.1 and issues raised in the above knowledge creation and adoption overview, the area of inter-firm knowledge transfer is liable to offer considerable new insights and concepts with which to address gaps in the supply chain literature. The inter-firm knowledge transfer literature, which is often closely linked to that of knowledge adoption, considers how knowledge is transferred between companies. This area of research is particularly suitable for application to the supply chain context.

Ingram and Baum (1997) investigate the relative competitive benefits an organisation can accrue through learning from either its own experience or learning "vicariously" from the broader experience of other firms in the external environment. In other words, they explore the merits of "learning by doing" (as promoted by the learning curve literature- see "Knowledge improvement" below) versus "learning from others". Their study is based upon the risk of organisational failure of hotel chains, and finds that internally-focussed organisational learning is beneficial up to a point, but beyond that it can be detrimental and further knowledge needs to be sought from outside the organisation:

> "Organisations initially benefit from their own experience, but are harmed in the long run... as organisations can become constrained by their own experience."

On the other hand, organisations benefit from learning "vicariously from the experience of others in their industry". Furthermore, Ingram and Baum (1997) indicate that not all vicarious knowledge is equal: some can be beneficial in terms of internal operations and some in terms of external competitiveness.

Ahuja (2000) empirically study the impact of collaborative network structure and position upon organisational outcomes and the effectiveness of knowledge flows through such networks. He builds-upon the organisational literature by arguing that:

> "Interorganisational linkages and the resulting collaborative networks are key vehicles through which firms obtain access to external knowledge."

Ahuja (2000) considers the influence upon knowledge flow and performance of three dimensions of a firm's network structure: 1) direct ties, 2) indirect ties, and 3) the degree to which a firm's partners are linked to each other. In a supply chain context, these dimensions would relate to the extent of collaboration between for example: 1) a manufacturer and 1st tier customers/ suppliers, 2) a manufacturer and 2nd tier customers/ suppliers and 3) any supply chain partners. Ahuja (2000) outline the relevance of these dimensions as follows:

> "A firm's direct ties potentially provide both resource-sharing ['know-how sharing'] and knowledge spill-over benefits. Indirect ties do not entail formal resource-sharing benefits but can provide access to knowledge spillovers. Finally, the degree of connectivity [or lack of 'structural holes'] between a firm's partners influences both resource-sharing and access to novel information, albeit in contradictory ways."

Ahuja (2000) find empirical support for the knowledge flows associated with both direct and indirect ties having positive impact upon performance. But they find 'structural holes' have a negative effect upon collaborative performance. This is analogous to the empirical evidence in favour of supply chain collaboration.

Mowery et al. (1996) empirically examine inter-firm collaborative knowledge transfers within strategic alliances. They reflect upon a 'capabilities acquisition' view of firm strategy that focuses on the acquisition of new capabilities through organisational learning- but were surprised to find a substantial subset of firms more interested in "accessing rather than acquiring capabilities" from partner companies. Furthermore, Mowery et al. (1996) find that inter-firm knowledge transfers are more limited with 'unilateral' contract based partnerships- whereby knowledge is more tightly 'packaged', than in more collaborative 'bilateral' arrangements such as technology sharing or joint development agreements. These findings have direct relevance to supply chain contexts.

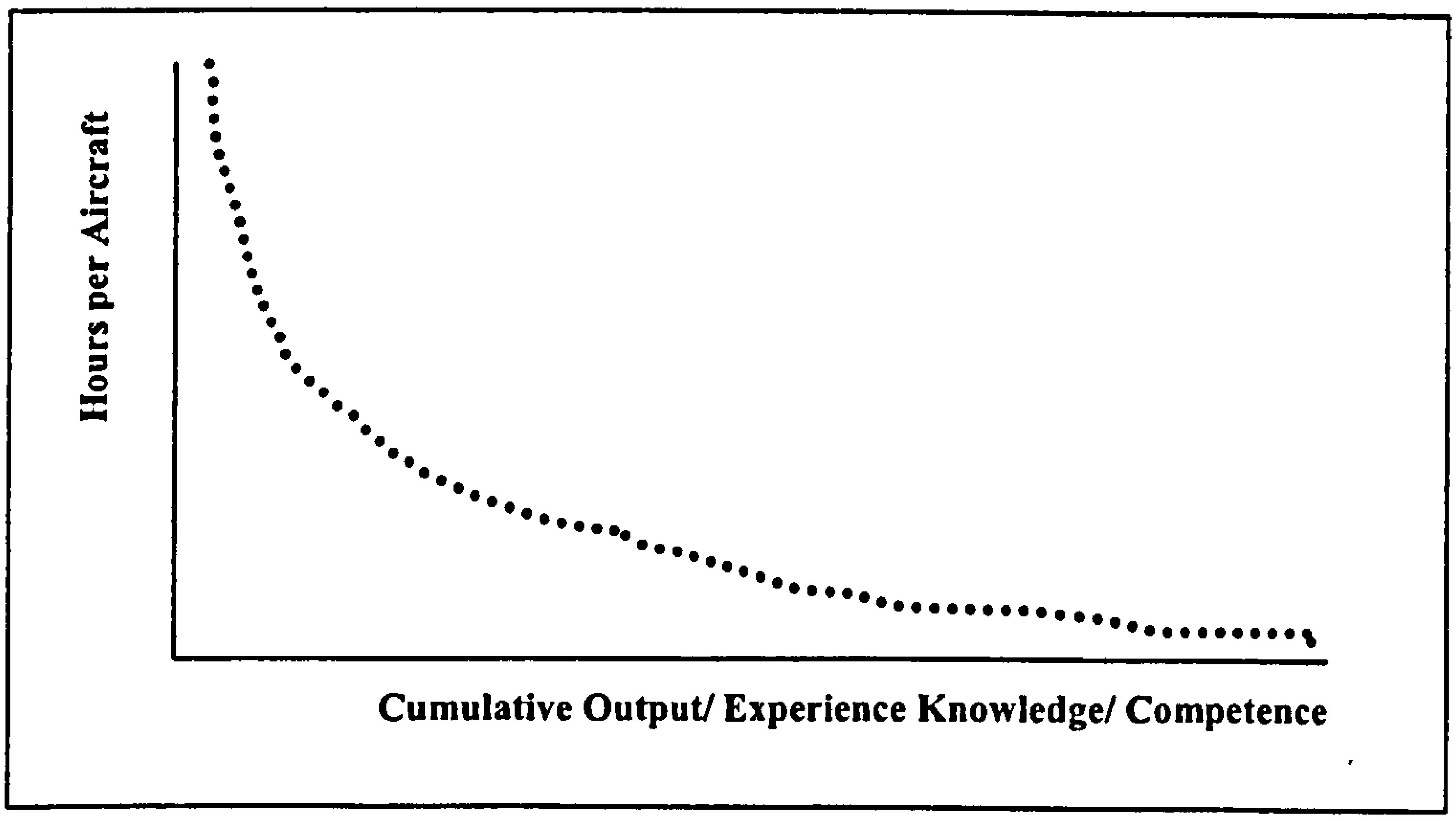
Knowledge Evolution

Knowledge is not static once it has been created, acquired, transferred or adopted- it evolves through use. Of course, there are two ways that knowledge and/ or its benefits can evolve over time- it can improve or deteriorate.

One of the clearest indications of the phenomenon of knowledge improvement is the organisational 'learning curve' or 'experience curve' whereby improvements in the way things are done (e.g. faster, less errors, improved quality) are the result of cumulative 'learning by doing' and associated development of context specific, experience-based competences (Epple et al., 1991; Argote, 1999). Argote (1999) illustrates this with the example of aircraft production. From the first aircraft, the number of labour hours required to produce each subsequent aircraft reduces as experience is gained. Argote (1999) clarifies that the learning curve framework usually uses a cumulative output measure or time "as a proxy variable for the knowledge acquired through experience" or "competence".

The 'rate of learning' however diminishes over time until a minimum number of hours per aircraft is achieved- indicating possible diminishing returns in continuing knowledge investment. This learning curve pattern is found in many organisations, and is shown in Figure 2.9- though the rates of organisational learning can vary considerably between organisations. An extension of this reasoning behind diminishing rates of learning leads to the concepts of 'knowledge depreciation' and 'organisational forgetting'- whereby knowledge can actually be lost over the longer term and performance worsens Argote (1999).

Figure 2.9. The Learning Curve



Some literature in this area warns of greater dangers of over-optimising knowledge than simply diminishing returns. In "Challenger: Fine-tuning the odds until something breaks" (Starbuck & Milliken, 1988) examine the organisational learning issues within NASA that led to the catastrophic failure of the space shuttle 'Challenger' in 1986. They state:

> "Past successes and acclimatization alter decision makers' beliefs about probabilities of future success. Fine-tuning processes result from engineers and managers pursuing partially inconsistent goals while trying to learn from their experiences. Fine-tuning reduces probabilities of success, and it continues until a serious failure occurs."

Thus there are limits to the benefits that can be obtained through learning and knowledge acquisition. March (1991) introduced the famous trade-off between 'exploiting' existing knowledge, and 'exploring' new knowledge. (March, 1991) states:

> "The essence of exploitation is the refinement and extension of existing competences, technologies and paradigms. Its returns are positive, proximate and predictable. The essence of exploration is experimentation with new alternatives. Its returns are uncertain, distant, and often negative... Such features of the context of adaptation lead to a tendency to substitute exploitation of known alternatives for the exploration of unknown ones, to increase the reliability of performance rather than its mean. This property of adaptive processes is potentially self-destructive."

In other words, due to uncertainty surrounding the organisational knowledge exploration process many companies are more inclined to opt for the apparent 'sure thing' of exploiting existing internal organisational knowledge to improve relative performance and competitive advantage. Given limited resources, mechanisms of 'mutual learning' between organisation and individual, and 'ecologies of competition', companies make explicit and implicit choices to invest in exploiting short-term known alternatives rather than exploring new ones in the race to gain relative competitive advantage. However:

> "By refining exploitation more rapidly than exploration, [organisations] are likely to become effective in the short term but self-destructive in the long term... certain common organisational practices ameliorate that tendency." (March, 1991)

Additionally:

> "Organisations that engage in exploitation to the exclusion of exploration are likely to find themselves trapped in suboptimal stable equilibria. As a result, maintaining an appropriate balance between exploration and exploitation is a primary factor in system survival and prosperity."

Related to this need to carefully balance internal exploitation and external exploration is the research on 'competitive inertia'. Miller and Chen (1994) argue that inertia is driven by "managers' incentives to act, their awareness of action alternatives, and the constraints on their capacity to act." In essence, Miller and Chen (1994) find that good past performance contributes to competitive inertia. Miller and Chen's (1994) argument and empirical study very much parallels the learning curve and exploitation/ exploration arguments above- indicating that applying existing internal knowledge is likely to lead to organisational performance improvements in the short-term. Nevertheless, these performance improvements can lead to complacency and decreased incentives for continued knowledge evolution and organisational learning. Thus whilst Miller and Chen (1994) find limited evidence that competitive inertia is associated with short-term performance- they find that in the long-run it makes the firm more 'rigid', and "retards adaptation in contexts that pose a wide variety of competitive threats." Yet, they conclude that more 'mature' organisations could avoid such problems as "inertia would be less influenced by short-term performance."

Also linked to the theme of "knowledge development is good up to a point..." is the important concept of 'competence traps'. In "The Myopia of Learning" Levinthal and March (1993) recognise that although on the one hand applying existing knowledge may make the organisation better, on the other hand it may also make it 'myopic' to the long-run and larger picture:

> "Recent examinations of learning as an adaptive process have raised questions not only about the confusions of experience but also about the ways in which learning is self-limiting. The effectiveness of learning in the short-run and in the near neighbourhood of current experience interferes with learning in the long run and at a distance. Knowledge and the development of capabilities improve immediate performance, but they often simultaneously reduce incentives for and competence with new technologies or paradigms. Learning has its own traps."

Of particular interest, Levinthal and March (1993) address the issues of myopia that lead to 'competence traps':

> "An organisation develops better skills in some parts of the organisation, in some markets, in some technologies, and in some strategies than in others. The mechanism is one of mutual positive feedback between experience and competence. Organisations engage in activities at which they are more competent with greater frequency... These distinctive competencies invite utilisation, which furthers their additional development. The self-reinforcing nature of learning makes it attractive... to sustain current focus. The result is that distinctive competence is accentuated, and organisations become specialised to niches in which their competencies yield immediate advantage.
>
> Learners become increasingly removed from other bases of experience and knowledge and more vulnerable to change in their environments... knowledge about and use of old competences inhibit efforts to change."

Despite such negative mechanisms, Levinthal and March (1993) still believe that organisational knowledge and learning are important and can be beneficial- as long as their management maintains "an appropriate balance between exploitation and exploration". They conclude: "imperfections of learning are not so great as to require abandoning attempts to improve the learning capabilities of organisations, but that those imperfections suggest a certain conservatism in expectations."

Clearly, in light of the preceding literature review, many of the above knowledge management concepts are pertinent to supply chain management- and in particular to the key concepts of integration and collaboration with external supply chain partners. The knowledge management stream has conducted research, often in considerable depth, in areas that remain to be addressed in the supply chain management literature. Therefore it would appear appropriate and valuable to apply the 'knowledge lens' in supply chain contexts.

A limited number of academics have recently realised the benefits of applying knowledge management and organisational learning concepts and frameworks within the supply chain literature- and these are considered in the following sub-section.

2.3 KNOWLEDGE MANAGEMENT IN THE SUPPLY CHAIN CONTEXT

Further to the overviewed literature in Section 2.2 above, knowledge management and organisational learning academics have explored many aspects of inter-firm learning and knowledge development related to issues such as shared product development projects (Bozdogan et al., 1998), complex product system configuration (Miller et al., 1995) and technology fusion (Tidd, 1997). Yet explicit exploration of organisational learning and inter-firm knowledge management specifically between supply chain partners is apparently limited. Also, despite clear parallels, cross-fertilisation between supply chain and knowledge management literatures appears to be rare.

As Giannakis and Croom (2004) identify (see Section 2.1.9.1 and Table 2.7 above), beyond the dyadic level some broader operations management literature has recognised the importance of knowledge and learning to the *kyoryokukai* – or supplier associations of Japanese manufacturers in the second half of the twentieth century (Cusumano, 1985; Hines, 1994; Dyer & Nobeoka, 2000). Such knowledge sharing and learning was reported as contributing to sustainable growth and development- particularly in engineering and automotive sectors (Hines et al., 1999). With regard to product development in Japanese manufacturers Imai (1987) observes:

> "... an almost fanatical devotion towards learning- both within organisational membership and with outside members of the inter-organisational network."

Similarly, as already noted in the review in Section 2.1, the lean manufacturing literature recognises the importance of knowledge sharing and learning as a key feature, linking it with innovation in supply relationships (Lamming, 1993).

Nevertheless, apart from this work on supply chain councils and supplier meetings, Giannakis and Croom (2004) indicate a distinct lack of supply chain management academics who have specifically set-out to investigate knowledge-based issues beyond the dyadic level in supply chains. Those few that have ventured into these new 'murky waters' have produced valuable tasters and reconnaissance as to what lies beyond, but have incurred distinct research limitations. This early work on knowledge and learning in supply chains broadly falls into two groups:

A. Exploratory studies without the conceptual depth required to grasp the fundamental underlying mechanisms or identify generalisable frameworks (e.g. Fynes and Ainamo, 1998); Hyland et al., 2003).
B. Empirical studies focused upon specific supply chain functional areas within companies- such as Purchasing (e.g. Hult et al., 2000).

With regard to addressing broader knowledge and learning issues within the supply chain management stream of literature Bessant et al. (2003) is one of the few academic works to pick-up on the literature gaps previously discussed in Section 2.1.9. They combine both knowledge management and supply chain perspectives to explore knowledge and learning beyond the boundaries of the individual firm. In their study of 'supply chain learning' they state that:

> "As firms struggle to cope with an increasingly turbulent and uncertain economic environment there is a widespread recognition of the importance of organisational learning. One option is to look at the potential of shared learning between firms, where common interests and interdependence provide motivation for experience sharing and other forms of synergy in learning. A particular version of inter-firm learning is the use of supply chains as a mechanism for upgrading and transferring 'appropriate practice'..." (Bessant et al., 2003).

Bessant et al. (2003) go on to point out that manufacturing is no longer simply a business of transforming inputs into outputs through the use of standard equipment and techniques but that:

> "... sustainable growth depends on the ability to master the knowledge content in production and this can only be achieved by developing the capacity to learn along the whole spectrum of economic activities... This places considerable emphasis on the ability of the firm to learn and to continue to learn to keep pace with an environment filled with competitive threats and new technological opportunities. However, the challenge does not stop at the boundaries of the firm. It is becoming clear that firms operate within value streams involving many firms in supply chains within a supply network, and that the competitive performance of the value stream depends upon learning and the development of the whole systems, not just the leading players."

Thus, they reason that leveraging the supply chain represents an effective vehicle for inter-firm knowledge transfer and learning given that:

1. There is commonality of interest between supply chain partners, focussed on delivering value to a particular customer,
2. As a consequence of increased global competition, there is growing motivation for supply chain partners to share knowledge and learn from each other,
3. There are potential benefits to sharing knowledge and the learning experience, including risk reduction, transfer of ideas, shared experiment, etc.

Nevertheless, a recent UK government report indicates that:

> "Learning is not a natural feature of business networks. It is unlikely to thrive unless it is part of the emergent new models for inter-company collaboration which stress trust, cooperation and mutual dependence" (DTI, 2000).

The exploratory research of Bessant et al. (2003) thus reinforces the mega-trend work of Bowersox et al. (2000) and accentuates and fine-tunes the knowledge related supply chain literature gaps identified by Giannakis and Croom (2004). In concluding, Bessant et al. (2003) emphasise the importance that knowledge management and organisational learning will have upon building and sustaining future supply chain competitiveness. Yet they state that progress with these issues:

> "... is still at an early stage and being made with faltering steps. There is clearly a need for more research in the field... towards developing firm and sector-specific models."

Bessant et al. (2003) highlight the following themes requiring more detailed analysis and development:

1. The importance of implementing supply chain knowledge management on a platform of 'good practice' (or 'appropriate practice').
2. The role of facilitation, and the skill sets and 'enabling toolkit' which permit effective supply chain knowledge management.
3. The process through which a shared learning agenda (and related 'curriculum', assessment frameworks, etc.) can be developed. Early evidence suggests this needs to take place at a sector or supply chain level.

These themes are investigated in Chapters 5, 6 and 7 of this thesis.

2.4 CONTEXTUAL CONSIDERATIONS IN MANUFACTURING AND SERVICE OPERATIONS

2.4.1 The Manufacturing and Service Operations Debate

The relevant Standard Industry Classification (SIC) definitions indicate some major contrasting issues that are involved in 'transferring' supply chain practices from manufacturing to services contexts:

- Manufacturing (SIC Division D): Those organisations engaged in the mechanical or chemical transformation of materials or substances into new products,
- Services (SIC Divisions E-I): Those organisations engaged in providing a wide variety of services for individuals, businesses and government establishments, and other organisations.

In the light of these differences, over the last 30 years there has been considerable discussion as to whether it is justifiable to transfer concepts and practices from a manufacturing to a service context (Giannakis, 2001). Many authors have disputed the validity of applying manufacturing models to services. For example Davis (1983) concludes that :

> "Using industrial models to manage service based corporations makes as little sense as using farm models to run factories."

Several 'peculiar' characteristics of services potentially complicate the transferral of concepts from manufacturing-conceived fields such as supply chain management (Giannakis, 2001). In the service operations literature there have been attempts by several scholars to outline the definitive characteristics of services (Sasser et al., 1979; Lovelock, 1983; Normann, 1991; Groonos, 1990). Despite debate concerning the several approaches, Fitzgerald et al. (1992) conclude that all researchers concede to one central characteristic of services- the notion of intangibility. Some research claims that it is this intangibility that is the key to determining whether or not an offering is a service or a good (Zeithaml & Binter, 1996). As to the general differences comparing services to manufacturing, McColgan (1997) points–out that:

> "The literature has long noted important differences between manufacturing and services firms."

Nie and Kellogg (1999) explain that service operations have unique characteristics that are rarely found in manufacturing including: participation, intangibility, inseparability of production and consumption, heterogeneity, perishability and labour intensity.

Expanding upon these points, Frohlich and Westbrook (2002) summarize the differences between manufacturing and services that emerge from the literature:

- The direct participation of customers in the service process adds complexity that is generally not found in manufacturing (Chase & Tansik, 1983). And furthermore, direct customer participation means that service firms tend to have many more physical sites than manufacturers along with the unique challenges presented by wide geographic dispersion.
- Intangibility is cited as a fundamental difference between goods and services since a service cannot be seen, touched or tasted in the same manner as a manufactured product (Fitzimmons & Fitzimmons, 1997).
- Services also tend to have higher heterogeneity and thus can be either deliberately or accidentally customised in comparison to the greater process standardisation of a typical manufacturer's production.
- Services are likewise more perishable than physical products given that unused capacity is lost forever. This perishability leads to difficulties in managing demand, utilising capacity, planning services and scheduling labour.
- Finally, services are typically more labour intensive in comparison to manufacturing (Heskett, 1986) and hence manufacturers can often realise more productivity gains through technological innovations (Quinn & Gagnon, 1986).

Giannakis (2001) explains that in manufacturing supply chains the notion of value added is relatively easy to grasp as it is related to the transformation of raw materials into finished products. Each company in the supply chain consecutively adds value to the product by processing the materials and information that "flow" from the upstream suppliers. In the context of services however, such a notion is apparently not so relevant because services cannot be transformed, transported, or inventoried in the same way as in manufacturing. As Frohlich and Westbrook (2002) state:

> "Services are simultaneously produced and consumed and cannot be inventoried."

Thus academics could be led to assume that the motivation for service organisations to implement supply chain management practices is low. This, in combination with the conceptual difficulties regarding such issues as service intangibility, is perhaps why relatively few researchers have investigated supply chain phenomena within service contexts.

Nevertheless, several academics support the seminal work of Levitt (1976) arguing that it is not only appropriate to transfer models and concepts from manufacturing contexts to services, but it is an imperative. For example, Bowen and Youngdahl (1998) posit that the defining characteristics of manufacturing and services nowadays have blurred- and with the increasing "servitisation" of manufacturing companies will continue to blur. While it is tempting to look simply at the supply of services as being distinct from the supply of goods, in fact very few business exchanges involve purely services alone. And, similarly very few exchanges involve purely goods (Bailey et al., 1994). In reality, most exchanges are a bundle that includes goods and services.

Bowen and Youngdahl (1998) conclude that the emphasis of the challenge will shift towards identifying and analysing the contingencies that exist in different contexts when a particular construct is transferred to a different setting. This has been recognised by several researchers who have investigated the transfer of theories and methodologies from TQM (Silvestro, 1998), and group technology (Sihra & Lutz, 1997) between manufacturing and service contexts.

Similarly, Voss (2003) considers manufacturing-service contingent issues in adopting a sequence dependent manufacturing capabilities 'sand cone' type model (Ferdows & De Meyer, 1990) for developing Internet-based service quality. Regarding the potential of transferring theories specifically from supply chain management, Voss (2003) recognises a broad spectrum of services that range from providing pure services (e.g. computer service, status information), to selling information (e.g. 'infomediaries'), to selling a bundle of service and goods (e.g. PCs such as Dell), to selling goods (e.g. selling CDs). Toward the "selling goods" end of this service operations spectrum, levels of service quality dimensions such as 'reliability' and 'responsiveness' (Parasuraman et al., 1988) directly correspond to issues identified in the manufacturing-oriented supply chain management literature (See Section 2.1). Voss (2003) emphasises the importance of 'fulfilment and delivery' to the first 'foundation' stage of the sequence-dependent service sand cone model, citing examples of service failure due to poor coordination of the flow of physical goods as a result of ineffective supply chain management. Voss (2003) states that:

> "Sequence dependency implies that unless the first stage is managed to high enough levels of quality, it will not be possible for companies to exploit the more sophisticated and value added aspects of service".

And thus, for any non-pure services supply chain management issues relating to fulfilment and delivery of physical goods are likely to be crucial for business survival and success. Furthermore, as the literature review in Section 2.1 outlines, supply chain management goes far beyond the consideration of physical assets alone. From the supply chain management taxons of the Croom et al. (2000) analytical framework it is reasonable to contend that the appropriate exchange of assets, information, and knowledge are just as important in service exchanges as in the case of manufacturing exchanges. As with manufacturing supply chains, all services (even 'pure' ones) will require the management to some degree of asset, information and knowledge exchanges between supply chain partners with the ultimate goal of satisfying the end customer.

The above academic considerations could explain why so many service-oriented companies apparently see the benefits of supply chain management and are members of organisations promoting supply chain practices (for example Chartered Institute of Purchasing and Supply, 2003; Supply Chain Council, 2004).

Hence, despite the likes of Davis (1983), there is considerable literature support for the validity of transferring supply chain management concepts from manufacturing contexts, where they have largely been developed, to service environments.

2.4.2 Potential for Further Supply Chain Research in Service Contexts

The above section indicates that despite the relative lack of academics investigating supply chain issues within service contexts there are good reasons and opportunities for doing so. This sub-section turns to identifying specific relevant areas where this doctoral study might contribute.

Those academics that have ventured to investigate specific supply chain related issues within service environments have largely considered downstream issues from the perspective of the customer. Such examples include the concepts of value analysis (Normann, 1991) and lean service (Bowen & Youngdahl, 1998). There is also an abundance of researchers that stress the importance of managing the 'inter-organizational relationships' that are developed with the exchanges of services (Normann, 1991; Paulin et al., 1997; Tyler et al., 1998; Gadrey & Gallouj, 1998; Hart & Hogg, 1998). Yet these researchers only consider the downstream relationship with the customer. In his review of the services management literature regarding supply chain management issues, Giannakis (2001) finds that:

> "The literature in guiding managers and transferring the principles, concepts, methodologies and tools of supply chain management to the context of service industries has been scarce, focusing mainly on the dyadic relationship between the service provider and the end consumer of that service from the perspective of the customer... Therefore it is contended that more research needs to be done that considers other aspects of supply chain management in a service context."

Few works have considered the upstream level of the service supply chain focusing on relationships between the focal company and its suppliers (see for example Gallouj, 1997; Fitzimmons et al., 1998). As Giannakis (2001) states:

> "The management of the upstream side of the supply chain, or the management of the entire chain (or network) of services supply has been markedly absent from the literature."

Frohlich and Westbrook (2002) support this claim, recommending that future research into supply chain issues in service contexts should consider upstream supply issues that may lead to bullwhip-type effects. Thus the analysis of upstream supplier-oriented issues represents a very interesting literature gap in which this doctoral study could make a valuable contribution. This importance of upstream supply chain integration of service companies with their materials suppliers is underlined by Watson's (2001) study of insurance companies. He finds that whilst downstream customer integration is straightforward, upstream integration:

> "... remains little more than an unfulfilled desire".

Furthermore, there is a particular lack of research that directly compares supply chain constructs across manufacturing and service contexts within a single piece of work. This is despite arguments put forward above (and earlier in Section 2.1.9.3) to consider such comparative issues. Frohlich and Westbrook (2002) is one of the few notable exceptions to this dearth of research applying supply (and demand) chain principles to both manufacturing and service contexts in a single piece of work. One of the main motivations behind the Frohlich and Westbrook (2002) study of Internet-enabled supply chain integration strategies was that:

> "We know little about what differentiates manufacturers and services regarding demand-driven supply chains."

They find important distinctions in supply chain integration strategies and impacts upon performance between manufacturing and service contexts. Higher levels of demand chain management and supply integration led to significant increases in performance for manufacturing, but there were few such signs in the service company sample which overall appeared to lag behind manufacturing. However, Frohlich and Westbrook (2002) state that their lack of significant findings regarding service contexts could have been due to their service sample data comprising a wide variety of non-homogenous services. They suggest that future research should use a more focussed, richer service sample classification.

Section 2.1.9.3 identified three 'exchange' related research opportunities for investigating supply chain management within service contexts, namely: the exchange of services in service sectors; the exchange of services in manufacturing sectors; and the exchange of goods in the service sector.

Addressing all three of these opportunities is beyond the scope of this doctoral research. In light of the above discussion, it would appear that the third contextual gap relating to the exchange of goods in the service sector represents the most interesting and feasible research challenge for this study. In particular, conducting research relating to the upstream supplier-oriented exchange of goods in the service sector is relevant, and will lead to direct manufacturing-service comparative opportunities as well as detailed sector-specific exploration. Thus, subsequent chapters of this study shall focus on the following contextual issues:

1. Comparative investigation of upstream supplier-oriented constructs in manufacturing versus service contexts. More specifically, the combination of this contextual research gap with the conceptual 'knowledge-lens' outlined in Section 2.2 leads to

the investigation of 'Purchasing Competence' (Narasimhan et al., 2001). For this investigation, the financial services sector has been identified as offering good opportunities for comparative research with manufacturing (Roth & Jackson, 1995).

2. Sector-specific supply chain research into upstream product suppliers of a service provider. In particular the healthcare service sector has been identified as being dependent upon the supply of goods in order to offer a service, thus offering good opportunities for such study (National Health Service, 2002).The combination of this contextual gap with a 'knowledge-based' perspective leads to the development of the 'Supply Chain Maturity' concept (Bowersox et al., 2000).

2.5 A NOTE ON EXISTING DOCTORAL RESEARCH

Having identified relevant gaps within the published supply chain management literature, further steps were taken in attempting to ensure that this doctoral study makes an original and valuable research contribution. In addition to the normal publication channels, a significant body of relevant and up-to-date research resides in recent doctoral theses. This research often remains unpublished for some time, and thus could be missed in a 'normal' literature review.

Thus to avoid duplicating other doctoral work a review was also conducted of recent related PhD theses. A library search was carried-out using the extensive London Business School and Inter-Library services for UK and international (largely US) doctoral theses investigating similar supply chain and knowledge management issues raised in the above published literature review.

Several supply chain and knowledge management related doctoral theses were found corresponding to the period 1998 to 2004, indicating that these are considered to be contemporary areas worthy of research. In addition, the fact that several doctoral students have recently been actively researching in related areas, would suggest that addressing knowledge management issues within supply chains is a possible emerging theme of research.

Examples of related doctoral research theses include:

- Investigating the combined concepts of market orientation and supply chain management as a way of pursuing customer value creation through capturing, sharing and responding to market knowledge. This work researches the interfunctional nature, and contribution to corporate strategy made by both concepts (Soonhong, 2001).
- There are several doctoral theses concerned with building models and algorithms for collaborative planning and scheduling problems that arise in the supply chain. Apparently motivated by the globalisation of supply chains these works solve complex problems addressing issues such as enterprise resource planning (ERP), and electronic data interchange (EDI). Examples of such work are Anand (1998), De Bontridder (2001), and Yu (2002).
- An examination, through modelling, of the processes by which skills are created and deployed within firms and along a supply chain, "focusing particularly on helping firms design employment and supply systems which create and capture knowledge to the firm's advantage". (Parker, 1998)
- Developing a model for decision making processes within a supply chain as well as modelling uncertainty and risk (Blackhurst, 2002).
- The development of e-business through information integration of supply chains using the Internet (Chi, 1999; Chao, 2001).
- An examination of the relationships between dimensions of "supply chain management knowledge" and elements of organization structure (Christensen, 2000).
- Developing and empirically testing a theoretical framework that examines the informational role of the Internet in increasing supply chain transactions and product-distribution efficiency (Rabinovich, 2001).
- An investigation of the inter-organisational information systems (IOS) phenomenon in the supply chain by combining IS competence and supply chain relationships, which are based on competence and transaction costs views (Shi, 2001).
- Empirically investigating information integration, via ERP systems, for supply chain management in manufacturing (Stratman, 2001).
- An empirical study seeking to contribute to the knowledge management literature by considering: the implementation of knowledge management programmes; the

facilitation of knowledge transfer between ship manufacturers and shipyard suppliers; factors facilitating team knowledge sharing (Shin, 2003).

- Empirical investigation of the impact of scientific management, knowledge management and supply chain management methods on local US manufacturing company performance (Harris, 2003).
- Empirically based study of the integration of supply chain management, knowledge management and social capital to provide a "glimpse of the nature of knowledge resource based partnerships required to compete in electronic commerce" (Malhotra, 2000).

Of all the related dissertations found, the last three doctoral studies (Malhotra, 2000; Shin, 2003; Harris, 2003) perhaps come closest to the doctoral research scope proposed in this study- especially in terms of bringing a knowledge perspective to supply chain management (or vice versa). Nevertheless, whilst those doctoral investigations are also empirically based, and there is a certain degree of commonality with this study, their respective emphases are very different. Only Shin (2003) explicitly addresses one of the same knowledge-based conceptual constructs (knowledge transfer) as this investigation, but focuses largely on inter-team knowledge sharing and does not address dimensions relating to competence or maturity. Neither is impact upon performance addressed. None of these doctoral theses apparently investigate contextual manufacturing versus service-oriented supply chain issues raised in this study.

Therefore, whilst recent doctoral work has progressed in similar areas, none of it was found to constitute a significant contribution to the specific conceptual and contextual gaps revealed in the preceding literature review. Hence, the proposed research focus identified by this study is considered worthy of study, remains largely unaddressed and constitutes original scholarly work.

2.6 SUMMARY

This chapter is written with a view to informing the direction of research in this study, and to identify potential gaps in the literature. Four main literature streams are considered relevant to the research focus of this study: Supply Chain Management, Knowledge Management, Manufacturing Operations and Service Operations. The main emphasis of the review is on the supply chain management literature. The other streams are reviewed in the light of identified deficiencies in the supply chain literature, and in terms of distinct insights and new dimensions they could add.

2.6.1 The Supply Chain Literature

Supply chain management is an important area of research. In light of the managerial challenges of coordinating the supply chain, the subject has received considerable attention from multidisciplinary academic communities over the last two decades. As a result, supply chain theory and practice have developed to the extent that supply chains and not single companies are now seen as units of competition. Nevertheless, supply chain management is still conceptually not well understood- and nor are future trends. Therefore, this review has explored traditional, current and potential future developments in the evolution of supply chain theory and practice with the aim of contributing to the scientific development of a coherent discipline.

Several bodies of literature have contributed to the evolution of supply chain management theory and practice to date. Many investigations have focused upon differing elements of exchange, at various levels of analysis and from diverse perspectives. The particular research focus for this study was attained by commencing with an historical overview of the challenges of coordinating supply chains through the 20^{th} century. The 'real world' problems encountered in the automotive industry during this period led to the emergence of the lean supply paradigm in the late 1980s. Continued competitive pressure through the 1990s led to the conception and development of agile supply. By the late 1990s supply chains were finding they needed to combine the cost and service level advantages of both paradigms, resulting in the emergence of the leagile supply chain.

At the very heart of these evolutionary philosophies lie the inter-related, yet only partially understood, concepts of supply chain integration and collaboration. Prominent and influential theories and frameworks have been developed to further understand the need for and mechanisms underlying these concepts. Significant mathematical modelling and empirical evidence has built-up indicating their benefits in terms of operational performance. And yet, considerable uncertainties still remain regarding these core issues despite their fundamental role in the future evolution of supply chains.

Modelling investigations of phenomena such as the 'bullwhip effect' supports supply chain integration through partners working to share and coordinate flows of assets, data and information. This body of work also alludes to, but goes little further in analysing, the need for more complex mechanisms of coordination. Empirical 'arcs of integration' work has gone further by suggesting that the continued evolution of supply chain theory will require going beyond asset, data and information levels of integration to encompass 'human centric' issues of collaborative sharing and development of expertise and knowledge. Further literature echoes this message, citing companies that have implemented asset, data and information integration, but have been unable to sustain performance improvements. A few successful companies, however, indicate that continuing competitive advantage can be gained by going beyond simple integration-towards leveraging collaborative knowledge sharing and development with supply chain partners.

Whilst the theoretical mechanisms behind collaborative supply chain integration are not fully understood, current 'good' supply chain practice reflects the importance managers place on these concepts. This has manifested itself in the development of practitioner frameworks such as the Supply Chain Operations Reference (SCOR) model that extols the virtues of close integration and collaborative practices across several supply chain dimensions.

Regarding the future of supply chains, the thought piece of Bowersox et al. (2000) brings together academic and practitioner viewpoints and asks the question:

> "Where are we now in the evolution of supply chains and what has to occur to advance along the continuum?"

Their 'mega-trends' represent key aspects in the future evolution of supply chains to cope with new business environments and contexts. In essence, the most important mega-trends summarise and reiterate an emerging theme from the previous literature review: a need for mechanisms that extend beyond the integration of assets, data and information, towards collaborative development and sharing of knowledge-based dimensions. In particular, three specific conceptual dimensions emerge that warrant further investigation: knowledge transfer, supply chain competence, and supply chain maturity.

2.6.2 Gaps and Opportunities for Further Research

Despite the need for clearer conceptual understanding of these important knowledge-based dimensions, little academic work has been done in this area. Academics have identified such knowledge-based dimensions as representing a significant gap in the field- especially beyond the dyadic level of analysis and considering impacts upon performance. This knowledge dimension gap, combined with calls from distinguished researchers to bring new cross-functional conceptual perspectives into supply chain literature, presents an important opportunity for doctoral investigation.

The emerging field of Knowledge Management has been identified by this study as a potential source of valuable insights with which to address the knowledge dimension conceptual gap in supply chain literature. Knowledge management related literatures have recognised for decades the basic premise that the inter-related issues of knowledge and learning are crucial to the evolution of organisations. This adds cross-functional weight to the argument for investigating knowledge dimensions pertaining to the future evolution of extended supply chain organisations- and to adopting a knowledge-based perspective. An overview of streams of literature within the knowledge management field identifies several potentially relevant theories, concepts and frameworks with which to apply the 'knowledge lens' to supply chain contexts. Illuminating concepts emerge from themes such as: the constituents of organisational knowledge; the creation of knowledge; the transfer and adoption of knowledge; and the evolution of knowledge. The very limited recent supply chain literature that has considered such knowledge management concepts confirms their appropriateness and relevance, and suggests possible 'fine-tuning' for application within supply chain contexts.

Further to the knowledge dimension conceptual gap, supply chain researchers have also identified important contextual gaps. The evolution of supply chain management theory and practice to date has largely occurred within manufacturing contexts. However, organisations from different sectors are now also keen to exploit the benefits, and supply chain theories and practices are being transferred to evolving service-oriented contexts. Nevertheless, supply chain research within these new contexts is scarce. Given the rising importance of services to economic growth and the increasing servitisation of manufacturing organisations this represents an important contextual gap in the supply chain literature and another opportunity for this doctoral research. A brief overview of manufacturing and service operations literatures indicates that, despite significant operational differences there is, indeed, potential for investigating supply chain management theory and practice in service contexts. Specific opportunities exist for:

1) Comparative investigation of upstream supplier-oriented constructs in manufacturing versus service contexts, and
2) Sector-specific research into upstream product suppliers of a service provider.

To further assess the originality and potential value of addressing the literature gaps and new perspectives outlined above, a review is conducted of existing, unpublished doctoral research. Whilst, several related studies are found- indicating that these issues are contemporary areas worthy of research, none consider the same conceptual and contextual issues addressed here. Thus it is concluded that the precise research focus proposed for this study constitutes a significant and original contribution to existing supply chain knowledge.

The next chapter builds upon the issues identified in the literature review to formulate the research framework for this doctoral investigation.

CHAPTER 3 – THE RESEARCH FRAMEWORK

> "Research begins with a question or problem. Problems initially chosen almost always require more precise formulation to be amenable to research... The best ideas on how to refine the problem are likely to be found in the scientific literature... Once the problem has been clearly formulated, the researcher must develop an overall plan or framework for the investigation... he or she must, in effect, anticipate all of the subsequent stages of the research project..." (Singleton & Straits, 1999, p. 92)

In line with the above quote and other established business and social science research guidelines (e.g. Remenyi et al., 1998), this chapter seeks to build upon the previous literature review to explore and develop the research question and formulate a research framework in preparation for subsequent research design. In effect, this chapter addresses the first two of Bryman's (1988) seven generic research process steps:

1. To identify a broad area of study, based on a mapping of the literature,
2. Having an idea of gaps in the literature, select the topic of research and appropriate research questions.

Steps 3 to 7 are addressed in subsequent chapters.

Section 3.1 identifies the literature-derived motivation for exploring the evolution of supply chain theory and practice, and in the light of conceptual and contextual gaps in understanding, articulates the central research question and scope of this doctoral study. With a view to addressing this central question, the field of knowledge management is seen as a potential source of new insights. Research issues considering the management of knowledge in supply chains are considered in Section 3.2. Firstly, the application of the knowledge perspective or 'knowledge lens' to supply chains is reviewed in 3.2.1. Then Section 3.2.2 formulates a unifying framework for managing knowledge in supply chains. Section 3.2.3 ensures the key dimensions are consistently used across supply chain and knowledge management literatures and articulates working definitions for this study.

Section 3.3 specifies the conceptual research framework for this study; identifying broad research questions and outlining three consecutive essays addressing knowledge transfer, supply chain competence and supply chain maturity. Section 3.4 then develops the research questions so that they are more contextually specific, and provides reasoning for limiting the scope of this study. Finally, the three consecutive essays are framed for subsequent development in Chapters 5, 6 and 7.

3.1 THE RESEARCH QUESTION AND SCOPE OF STUDY

The directional impetus for this research is motivated by the 'mega-trend' work of Bowersox et al. (2000), and in particular their crucial question:

> "Where are we now in the evolution of supply chains and what has to occur to advance along the continuum?"

The previous literature review goes some way to answering the 'where are we now' aspect of this question in terms of both supply chain theory and practice. The literature review mapped the evolution of supply chain management through the 20th century, from the development of lean supply, through the incorporation of agile supply concepts, to the emergence of the leagile supply chain paradigm. Underpinning this evolution has been the closer integration between supply chain partners, and moves towards more collaborative ways of working together. A closer examination of the supply chain integration literature revealed that the current level of understanding extends to the asset, data and information levels of exchange.

Yet, academics and practitioners have expressed the need for greater conceptual understanding beyond asset, data and information integration levels. More specifically, the literature identifies the need to encompass the sharing of opinions, expertise and knowledge needed for true collaboration between supply chain partners. There is currently little conceptual foundation for such knowledge-based constructs within the supply chain literature. Whilst the benefits are often expressed, the literature suggests that truly collaborative supply chains will remain elusive until knowledge-based issues are more fully comprehended.

Thus a first step in addressing the 'what has to occur to advance' aspect of the Bowersox et al. (2000) evolutionary question, should be research aimed at building-up such a knowledge-based conceptual base within the supply chain literature.

Furthermore, academics and practitioners have noted that the evolution to date of supply chain theory and practice has largely taken place within manufacturing contexts. Little work has been done to consider supply chain theories and practices in other business contexts, and research in service contexts is especially scarce. Thus understanding regarding the relevance and applicability of supply chain concepts and frameworks in service contexts is low. This is despite service organisations also being keen to exploit the benefits of supply chain management. In addition, services are increasing in economic importance and the process of servitisation is continuing within manufacturing organisations.

Therefore, a second step in addressing 'what has to occur to advance' is identified by the serious literature calls for research into the relevance and applicability of supply chain concepts and frameworks within developing service contexts.

Hence, to go some way towards addressing the above Bowersox et al. (2000) evolving supply chain question, this doctoral research seeks to contribute to two important literature gaps:

Conceptual Gap 1: Consideration of knowledge dimensions in supply chains, Contextual Gap 2: Consideration of manufacturing AND evolving service contexts.

In order to gain new insights with which to contribute to these gaps, alternative perspectives are considered from other literature streams. Firstly, the field of knowledge management is identified as a body of literature offering considerable potential for offering illuminating conceptual insights. Literature streams associated with knowledge management have long associated the importance of knowledge dimensions to the evolution of organisations. Considering supply chains as a form of extended organisation, it is felt that applying the 'knowledge lens' in supply chain contexts will raise fundamental issues and valuable observations. Secondly, a combination of manufacturing and service operations literatures sheds light upon the similarities and differences between these two distinct contexts. Hence further understanding as to the application of concepts and practices in these contexts can be achieved.

Bowersox et al. (2000) identify one further essential component for future supply chain evolution- "enhanced supply chain performance." This critical issue needs to be considered to gain a sound understanding regarding the 'how?' and 'why?' managing knowledge dimensions is important to the evolving supply chain. To make any detailed judgement regarding what has to occur to advance along the continuum of supply chain evolution, it is necessary to consider the impacts of knowledge dimensions upon performance in respective contexts.

This synthesis of relevant literature, leads to a rearticulation of the evolving supply chain question in the light of identified gaps. The following research question therefore emerges as being one possible key to understanding the future evolution of supply chain theory and practice:

> "What is the impact of knowledge dimensions in manufacturing and service supply chains?"

Three particularly relevant knowledge dimensions come out of the current supply chain management body of knowledge as warranting more detailed study:

- Supply chain knowledge transfers
- Supply chain competence
- Supply chain maturity

Whilst each of these knowledge dimensions could (and possibly should in due course) be investigated in detail in both manufacturing and service contexts, the scope of this doctoral study is limited to an ambitious, yet realistic target. Figure 3.1 indicates where this study shall focus in order to address both conceptual and contextual literature gaps. More focused articulation of the above research question for each conceptual knowledge dimension is expressed in Section 3.3. The reasoning behind focusing upon specific knowledge dimensions within respective manufacturing and/or service contexts is clarified in Section 3.4 of this chapter.

Figure 3.1 The Scope of this Doctoral Research

		Supply Chain Context	
		Manufacturing	**Services**
Conceptual Knowledge Dimension	**Supply Chain Knowledge Transfer**	✓	-
	Supply Chain Competence	✓	✓
	Supply Chain Maturity	-	✓

Regarding the specific knowledge dimensions, corresponding theories and constructs have been found within the knowledge management literature that could serve to add conceptual depth to their interpretation and understanding within supply chain management. The previous literature review indicates that the adoption of the knowledge-based perspective has been successful in other research areas. Nevertheless, care needs to be exercised whenever theories and constructs are embraced from outside a body of literature to ensure appropriate, consistent and reliable application. That such concepts and constructs have universal application cannot be assumed. The next section therefore considers several fundamental theory building and research design issues concerning the unifying of knowledge management and supply chain management constructs.

3.2 MANAGING KNOWLEDGE IN THE SUPPLY CHAIN

3.2.1 Applying the 'Knowledge Lens' to Supply Chain Management

When theories and new perspectives are imported from outside operations management, Amundson (1998) suggests that it is helpful to adopt the *'lens'* metaphor, whereby the notion of a theory/ perspective as a lens extends the understanding of our awareness and cognitive processing. Amundson (1998) states:

> "Human beings, faced with chaotic, disorganised stimuli, develop cognitive frames to organise their environment. Apparently unimportant stimuli are screened out and patterns are created to make sense of the environment (Dubin, 1978).One can view this as implicit theory building, where the 'lens', which has the capability of bringing clarity and focus to the environment, is analogous to a theory. The lens model adds additional understanding and dimensionality to the process of cognitive framing that both precedes and constitutes theory building."

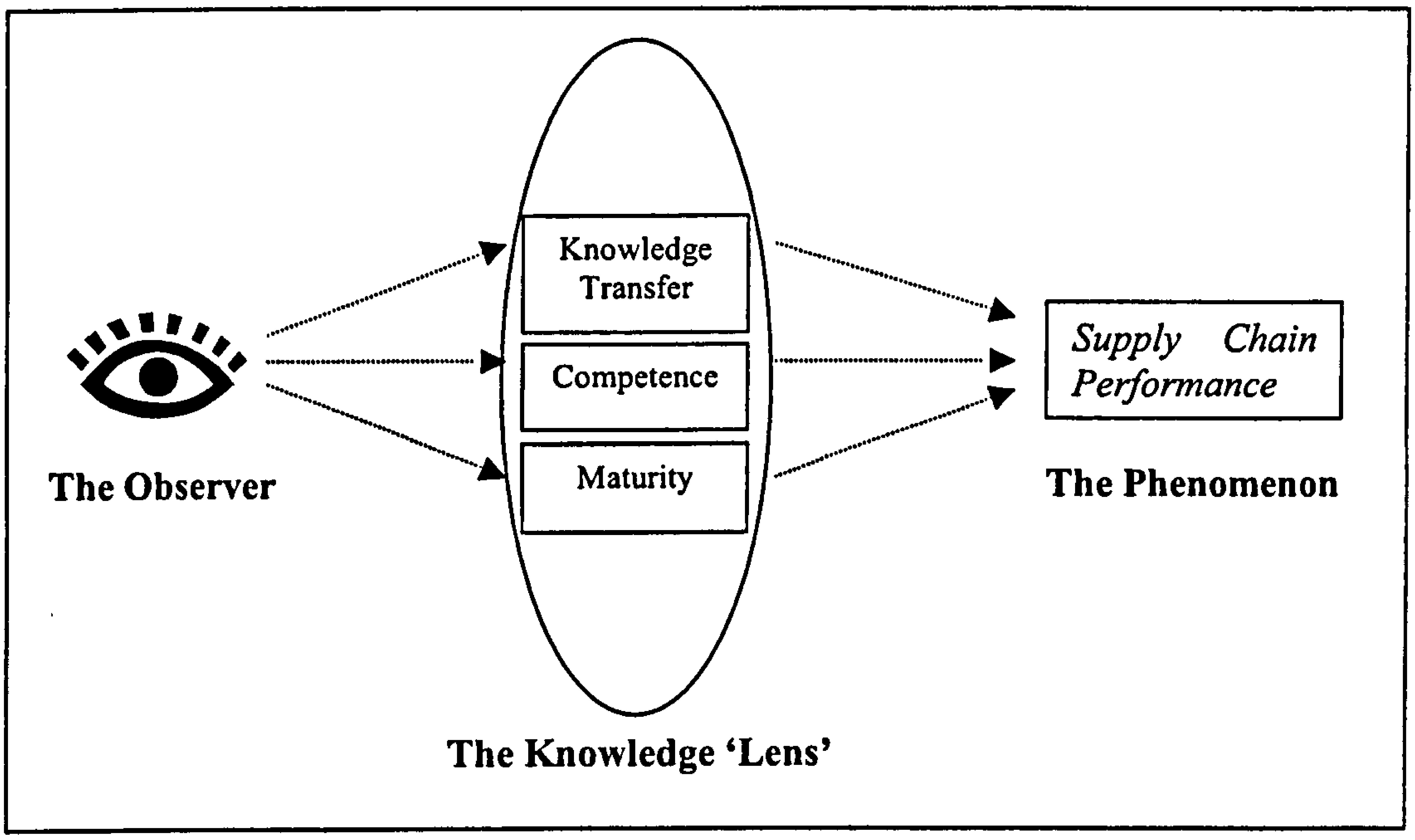
Having identified the knowledge management literatures as potentially adding fresh perspectives, Figure 3.2 illustrates the Amundson (1998) lens as applied to the specific knowledge dimensions and supply chain issues previously identified.

Amundson (1998) outlines the main benefits, limitations and cautions of applying the metaphorical lens model to theory building in operations management:

> "Several properties of a physical, optical lens have their analogs in the abstract world of the creation of scientific knowledge. First, a lens is directed towards an object; if the orientation of the lens shifts, the phenomenon being studied changes, and a different [phenomenon] is brought into view. Secondly, lenses

may have characteristics that affect the manner in which objects are viewed. For example, a lens may add colour... may focus near or far... or may illumine particular objects, excluding others. Thirdly, a lens is capable of capturing only a portion of the environment potentially available to an observer at any given moment... And lastly, the characteristics of the lens must be matched to the needs of the observer.

Figure 3.2 Applying the Knowledge Lens to Supply Chains



To ensure that the new perspectives offered by a lens are beneficial to theory building Amundson (1998) proposes four criteria for the importation of theory from other fields into operations management, namely:

1. Is the phenomenon being studied in the imported theory reasonably consistent with the operations management issues being addressed? Is there a logical argument as to why the imported theory applies to the phenomenon of interest to operations management?
2. Are the concepts being used by the imported theoretical perspective consistent with and meaningful in the field of operations management?
3. Do the concepts used in the proposed theory have significant explanatory power? Are they important concepts to managers, so that research outcomes will be of interest and use in practice?
4. Are the underlying assumptions of the theoretical perspective being employed consistent with those of operations management theoretical perspectives?

Amundson (1998) reviews these criteria with regard to importing and using in operations management theory-driven empirical research theories from the literature stream of organisational learning (the "umbrella" literature for knowledge management (Argote, 1999).) In general, she finds that:

> "Theoretical perspectives on organisational learning exhibit many characteristics ideally suited to integration with important issues in operations management."

For example, Amundson cites Roth and Giffi (1995) in discussing the process by which knowledge-based competencies are built within manufacturing organisations.

Amundson concludes that assumptions inherent in knowledge management/ organisational learning are consistent with views in operations management. For example, organisational learning assumes a dynamic perspective, where organisations are continuously changing. In addition, the organisational learning literature emphasises the concept of routines- virtually identical to the operations management concept of processes. Thirdly, organisational learning distinguishes between knowledge or learning that is local versus architectural (Henderson, 1996)- concepts from the field of architectural product design. Also, organisational learning discusses phenomena consistent with the levels of analysis of organisational units studied within operations management and supply chain management. Organisational learning is concerned with the organisation or the routine, which is generally at a similar level with phenomena studied by operations management (process, plant, SBU, internal and 'extended' organisations- such as supply chains.)

Thus the above criteria are met on a general 'broad brush' level for importing knowledge management/ organisational learning concepts and theories to the operations management literature- and more specifically to the supply chain management literature.

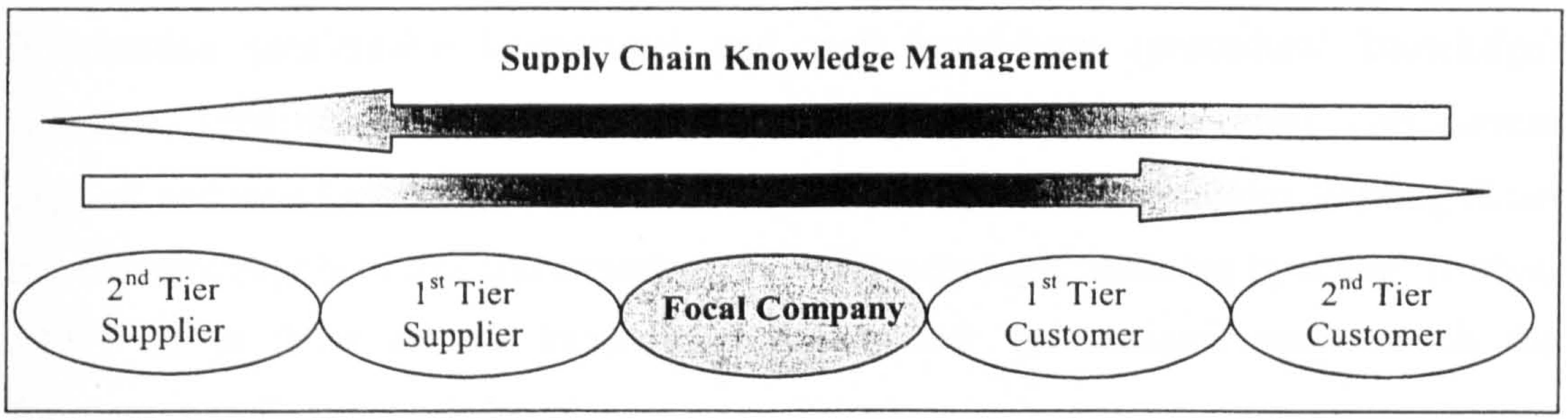
In order to address Amundson's (1998) criteria for the importation of theory from other fields, the following steps are addressed in turn in subsequent sections:

1. Formulating a unifying framework for managing knowledge in supply chains,
2. Ensuring that the specific constructs of knowledge transfer, competence and maturity being addressed in this study are consistently defined across the knowledge management and supply chain literatures.

3.2.2 A Preliminary Framework for Supply Chain Knowledge Management

This section considers the knowledge management concepts identified in the previous literature review within the integrated supply chain context of Figure 3.3. The following discussion is based upon the perspective of the Focal Company, which constitutes the unit of analysis in subsequent investigation.

Figure 3.3 Managing Knowledge in the Supply Chain

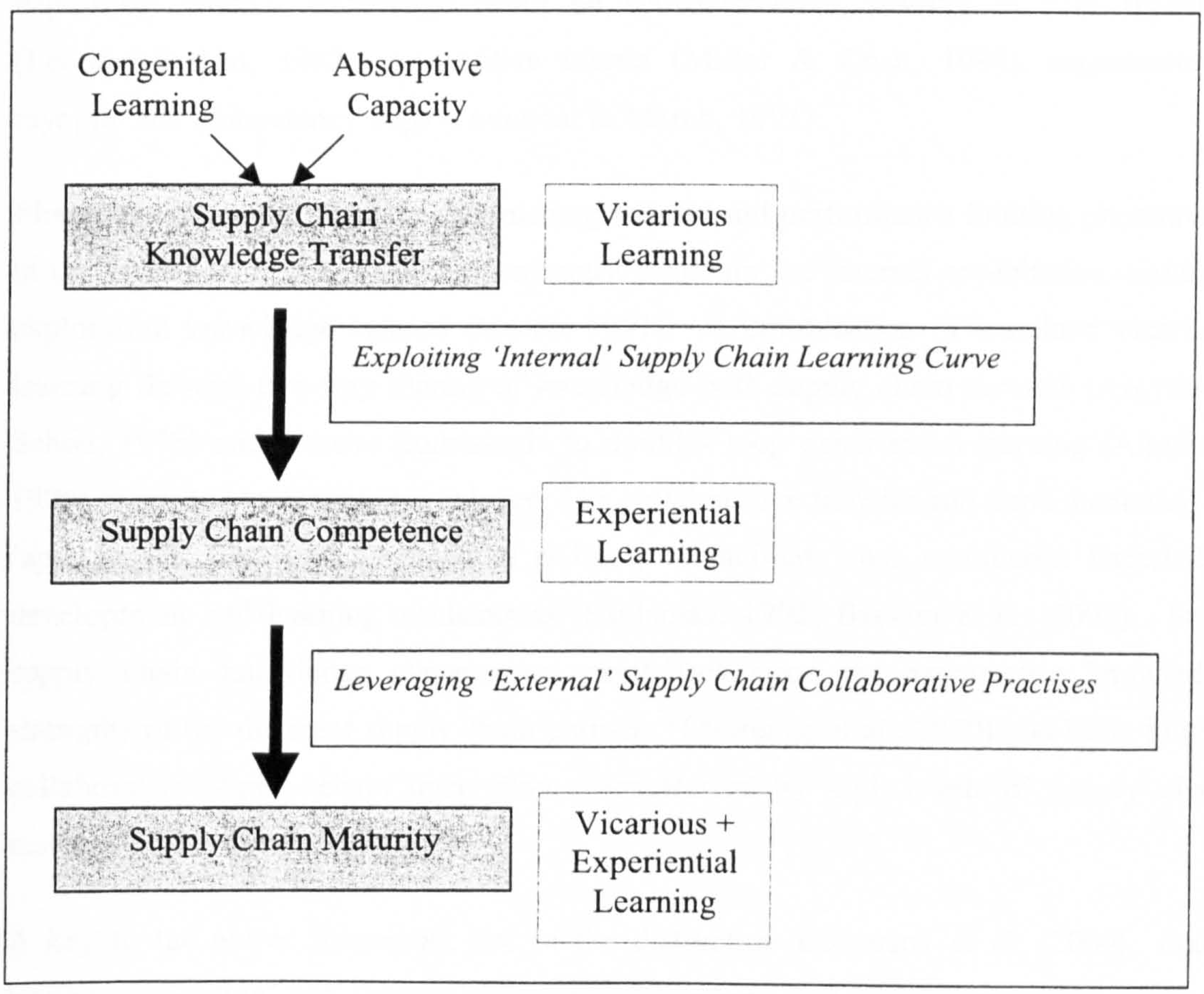


A clarifying note regarding unit of analysis: At this point it is worth emphasising that the unit of analysis for this study is the Company. The collaborative supply chain integration literature (e.g. Frohlich & Westbrook, 2001) suggests that knowledge development across the supply chain should benefit *all* members. This combined with knowledge management/ organisational evolution literature relating to the "boundary of knowledge" (e.g.Nelson & Winter, 1982) could lead to the conclusion that the unit of analysis should be broadened beyond the single company to total supply chain knowledge management. Whilst this could be a valid aim for future research (see discussion in latter chapters), such an extension is beyond the scope of this study. To maintain consistency with the majority of research in both fields, this study concentrates on supply chain knowledge management issues from the perspective of the Focal Company. Correspondingly, the shading of the arrows in Figure 3.3 indicates an increased 'utility' of that knowledge developed within or close to the focal company. These issues will be further addressed in subsequent chapters.

The following discussion represents a preliminary effort to formulate a unifying framework for knowledge management in supply chains. Apparently, no such framework currently exists in the literature. The aim of formulating this framework is to aid in the theoretical understanding of the linkages between appropriate knowledge management concepts and their relevance to the supply chain setting. Figure 3.4 emerges from this discussion and literature synthesis, and represents one possible unifying framework that could be used to characterise the development of supply chain knowledge management.

In accordance with knowledge management literature, this study considers supply chain learning behaviour to be a process that results in the development of supply chain understanding and knowledge from which the focal company can potentially benefit (Dewey, 1938; Argyris & Schon, 1978; Edmondson, 1999). Congenital learning behaviour leads to the creation of an initial knowledge base composed of both explicit information (declarative knowledge) and tacit know-how (procedural knowledge) (Polyani, 1966; Kogut & Zander, 1992 ; Nonaka, 1994; Zack, 1999). This current explicit and tacit knowledge base can be augmented via further vicarious learning (from the external supply chain) and experiential learning through 'learning by doing' (Huber, 1991). It is these further knowledge development mechanisms upon which the framework in Figure 3.4 is based.

Figure 3.4 A Unifying Framework for Supply Chain Knowledge Management



The above framework proposes three distinct phases of supply chain knowledge management:

Phase 1: In a supply chain context vicarious learning leads to knowledge transfer from supply chain partners (Mowery et al., 1996; Ingram & Baum, 1997). Levels of previous congenital knowledge and absorptive capacity determine level of adoption of external knowledge transfers by the focal company (March & Simon, 1958; Cohen & Levinthal, 1990;. Higher levels of absorptive capacity are likely for those knowledge transfers emanating from closer or more direct supply chain ties- such as 1st tier suppliers and customers (Ahuja, 2000).

Phase 2: Continued experiential learning within the focal company leads to the improvement of the knowledge base and development of supply chain competence (Levitt & March, 1988). This knowledge evolution and experience-based supply chain competence will to lead to learning curve operating performance improvements in the short term (Epple et al., 1991; Argote, 1999). Nevertheless, in the longer-term over-exploiting internal knowledge could be self-destructive, leading to core rigidities (Leonard-Barton, 1992), competitive inertia (Miller & Chen, 1994), organisational myopia and competency traps (Levinthal & March, 1993).

Phase 3: To combat potential diminishing returns and performance limiting phenomena in the longer term, the focal company must maintain the internal exploitation- external exploration knowledge balance (March, 1991). A combination of sustained vicarious learning through two-way sharing of knowledge with supply chain partners (Argyris & Schon, 1978) and a move from single to double- loop experiential learning (Almeida, 1996) is needed to sustain this balance. The collaborative transfer and implementation of 'appropriate' supply chain practices is likely to facilitate such continuous knowledge development and learning mechanisms (Szulanski, 1996; Bessant et al., 2003) . Such supply chain knowledge management capitalises upon the asymmetric knowledge strengths of the different supply chain partners (Dussuage et al., 2000) and leads to true collaborative supply chain integration characterised by high levels of supply chain maturity.

A key to the above framework lies in the distinction Bowersox et al. (2000) make between 'hoarding' and 'leveraging'. A focal company that hoards knowledge can only exploit the internal learning curve in the short-term. Those that engage in collaborative efforts to share knowledge and implement 'appropriate' supply chain practices (Bessant et al., 2003) , on the other hand, can leverage benefits deriving from the entire supply chain.

Another important point regarding the framework concerns the explicit and tacit forms of knowledge. Initial knowledge transfers between supply chain partners will primarily occur in the form of explicit codified knowledge- such as inventory levels, production plans and demand forecasts, delivery schedules, and kanban. As knowledge evolves into internal functional competencies through learning by doing, the tacit knowledge component will increase (Kogut & Zander, 1992). Through active communication and working with supply chain partners regarding the implementation of supply chain practices the collaborative knowledge sharing between supply chain partners will also acquire a tacit component (Szulanski, 1996). As a result, this study focuses primarily on explicit codified knowledge forms for investigation of knowledge transfer, but broadens the investigation to include tacit elements of 'know how' within the supply chain competence and maturity constructs.

The above three-stage framework extends the two components of supply chain learning identified by Bessant et al. (2003) . Citing Teece (1998) and Prahalad and Hamel (1994) they specify the first component to be "the accumulation and development of a core knowledge base- the 'core competence" deriving from "the systematic and purposive learning and construction of a knowledge base". This corresponds to a combination of Phases 1 and 2 in the above framework. Citing Senge (1999), Garvin (1993), Leonard-Barton (1995), and Bowen et al. (1994), Bessant et al. (2003) specify the second component of supply chain learning as "the long-term development of a capability for learning... and the growing emphasis on 'learning organisations'". This corresponds to the increasing supply chain maturity levels in Phase 3 in the above framework.

The above framework for supply chain knowledge management is further supported by comparison with personal, or individual, learning and knowledge development. Personal level metaphors are widely used in the knowledge management literature to explain and support the argument for organisational learning and knowledge development mechanisms. Many of the fundamental concepts of organisational learning and knowledge management originated from studies of individuals at personal and group levels. For example, Knight (2002) has shown that principles of personal knowledge development and learning can be usefully extended to inter-organisational contexts. The active participation of others in the process of challenge and support is recognised as a powerful enabling resource at the personal level and was developed into the widely used approach of 'action learning' (McGill & Warner-Weill, 1989). This stresses the value of experiential learning and the benefits that can come from gaining different forms of learning support from others. Part of this vision involves the idea of "comrades in adversity", working together to tackle complex and open-ended problems (Revans, 1980). Also, Bessant and Tsekouras (2001) and Dent (2001) have recognised the usefulness of drawing links between personal concepts and inter-firm learning.

Therefore a useful metaphorical comparison can be made with the above framework for supply chain knowledge development, and the personal development of a qualified professional- such as an engineer, lawyer, banker etc.:

Personal Development Phase 1: Assuming an adequate level of absorptive capacity an aspiring professional will acquire knowledge through classroom education. Knowledge transfers from teacher to pupil. The graduate will leave university with raw context-independent knowledge in the form of general important skills (e.g. producing and reading engineering drawings, understanding legal jargon, general understanding of banking principles etc.)

Personal Development Phase 2: As most employers of recent graduates are aware, their knowledge is still raw and needs to be contextualised and developed into real professional competence that is of benefit to both individual and organisation within a particular business situation. This competence is developed through learning by doing and develops with time and practical 'on-the-job' experience. Nevertheless, over time, if there is no exposure to fresh challenges and new ways of seeing things, boredom, complacency and overconfidence can creep into ways of working- with corresponding detrimental effects upon personal development and performance. Therefore the move to Phase 3 is important.

Personal Development Phase 3: It is essential for the continuing professional development of an individual to be exposed to different contexts and ways of doing things. Individuals are rarely successful working in isolation of others. Successful professional development involves a continuous balance between exploiting existing competencies, and identifying and developing new ones through appraisal and training.

Throughout this process the combination of feedback from others and continuing exposure to up-to-date 'best' practices is essential. It is only through such continuous personal development efforts that an individual can attain professional maturity.

3.2.3 Working Definitions of Supply Chain Knowledge Dimensions

Defining Learning and Knowledge Transfer

According to The Oxford English Dictionary and The Collins English Dictionary, 'learning' and 'knowledge' are defined as follows:

> "Learning: Verb: To gain knowledge of (something) or acquire a skill in (some art or practice). To commit to memory. To gain by experience, example etc. To become informed." (Collins English Dictionary)

Or: "Learning: Verb: Acquire knowledge of or skill in (something) through study or experience or by being taught. Become aware of by information or from observation. Memorize. Origin from Old English 'lore'." (The Oxford English Dictionary)

> "Knowledge: Noun: The facts or experiences known by a person or group of people. The state of knowing. Consciousness or familiarity gained by experience or learning. Erudition or informed learning. Specific information about a subject." (Collins English Dictionary)

Or: "Noun: Information and skills acquired through experience or education. The sum of what is known. Awareness or familiarity gained by experience of fact or situation." (The Oxford English Dictionary)

In terms of adopted working definitions, the concepts of learning and knowledge transfer are consistent between knowledge management and supply chain literature streams. These dimensions are clearly defined in the knowledge based literature (e.g. Ingram & Baum, 1997; Gupta & Govindarajan, 2000) which explicitly consider the flow of knowledge between the firm and external supply chain partners. Furthermore, to explain the forms of knowledge, Kogut and Zander (1992) use the example of inventory-directly linking their relevance to a supply chain context.

Furthermore, combining the 'what is knowledge?' definitions of Kogut and Zander (1992), Zack (1999) and Albino et al. (1999) with supply chain management definitions from Handfield and Nichols (1999), Hill (2000), and Chase et al. (2001) suggests two components of knowledge transfer in the supply chain:

- The first involves the structural elements of sharing knowledge related to issues such as inventory levels, production plans, delivery frequencies, and Kanban systems.
- The second knowledge transfer component involves the procedural elements of coordinating, planning, and forecasting between partners in the supply chain.

Thus, knowledge transfer is a consistent construct across the literature streams. Furthermore, in the light of these definitions it is clear that knowledge is present in supply chains, that it is transferred between supply chain partners and that it is important to successful supply chain management (Bowersox et al., 2000).

Defining Supply Chain Competence

According to The Oxford English Dictionary and The Collins English Dictionary, 'competence' is defined as follows:

> "Competence: the condition of being capable; ability. Competent: having sufficient skill, knowledge etc.; capable. Suitable or sufficient for the purpose." (Collins English Dictionary)

Or: "Competency/ competence: the quality or extent of being competent. Competent: having the necessary skill or knowledge to do something useful. Origin from Latin competere in the sense 'be fit or proper'. (Oxford English Dictionary)

Whilst being more complex than the working definitions for knowledge, 'competence' is still uniformly adopted across knowledge management and supply chain streams. Thus it is appropriate to study 'competence' from commonly held perspectives in both operations management and knowledge management literature streams.

From the knowledge management perspective, Levinthal and March (1993) contend that individuals and organisations develop competence through a "mechanism of mutual positive feedback" with experience and improving knowledge and learning. This developed competence manifests itself in better skills and ways of doing things. This conforms to the general usage of the term 'competence' within the operations and supply chain management literatures.

Gammelgaard and Larson (2001) differentiate skills and competencies within a supply chain context as follows:

> "Skills cover general context-independent knowledge; competencies refer to experience-based and context dependent knowledge. Skills are general tools and rules taught in most logistics classes, which are vital to the practitioner. However, to reach a competence level in the logistics discipline, practitioners acquire context dependent knowledge through organisational experience. Witt (1999) suggests workers must remain on the job to become competent. Dreyfus and Dreyfus (1986) argue that a competent practitioner makes decisions based upon rules and analysis, but with organisational experience can depart from rule-based analysis and make synchronic, intuitive, and holistic decisions."

In the operations management literature 'competence' is sometimes confused with 'competitive priority'. Yet within the manufacturing literature, Corbett and Van Wassenhove (1993) stress the 'internal' nature of competence development as opposed to the 'external' dimensions of competitiveness. Their work builds upon the 'focused factory' work of Skinner (1974), which emphasises the importance of developing core competences that are properly aligned with competitive positioning. They state:

> "Given a particular competitive stance (i.e. specific marketing mix), a manufacturing strategy should ensure that the right competences are developed... good manufacturing practice means focusing on a limited subset of competences."

Voss (1995) identifies one paradigm of manufacturing strategy whereby the underlying argument is that "aligning the capabilities of manufacturing with the key success factors will maximise the competitiveness of a firm." Corbett and Van Wassenhove (1993) use 'capability' and 'competence' synonymously, supporting the Ferdows and De Meyer (1990) concept of cumulative competence building- otherwise known as the 'sandcone' model. Corbett and Van Wassenhove (1993) formulate the whole task of manufacturing strategy, and therefore of the manufacturing manager, as linking "the competences developed internally and the competitiveness required in the market." And they elaborate:

> "By building these competences carefully and cumulatively, he or she will be better prepared for the continuously increasing demands from the marketplace... this means that one should build a set of competences compatible with the prevailing competitive requirements and adapt those competences to changing market demands."

The above seminal works show that a significant body of operations management research has considered the development of capabilities and competences in various contexts.

Specifically regarding supply chain research, Narasimhan et al. (2001) state that:

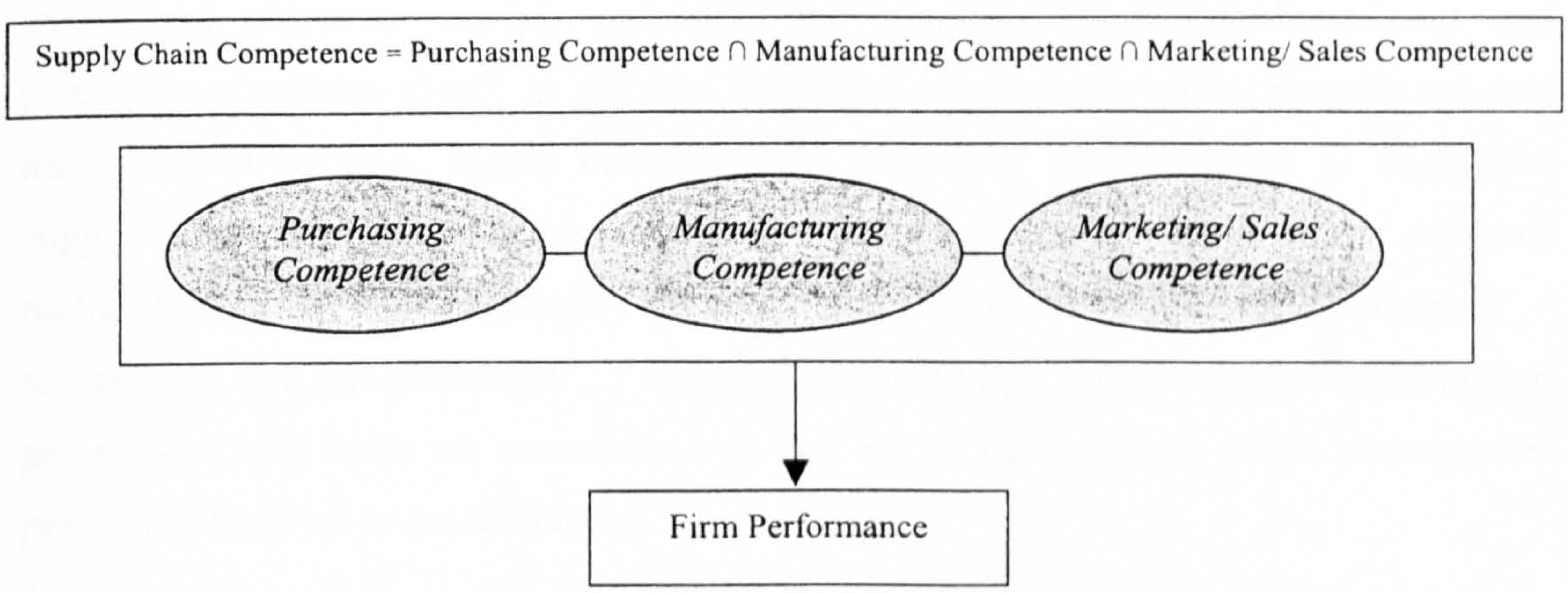
> "Competencies are developed through a process of managing decisions across the supply chain."

They add:

> "A synthesis of [strategic management and operations management] literature suggests that pursuit of functional strategies yield functional competencies, which in turn influence firm performance. This paper presumes a unifying framework that places different functional competencies along the supply chain as components of supply chain competence, which is hypothesized to influence firm performance."

More specifically, Narasimhan et al. (2001) perceive the 'supply chain competence' construct as comprising the interaction of functional competencies such as 'purchasing competence', 'manufacturing competence', and 'marketing/ sales competence'. They illustrate this construct and its impact as in Figure 3.5.

Figure 3.5 Framework of Supply Chain Competence (Narasimhan et al., 2001)



This doctoral study thus adopts a working definition of competence that is consistent with previous knowledge management and supply chain research. The 'supply chain competence' dimension in this research considers the acquisition and improvement of created and/ or transferred knowledge into specific individual and organisational experience-based, context specific competences. This use of the term 'supply chain competence' is consistent with that of Narasimhan et al. (2001)- whereby different functional competences are components of overall supply chain competence.

Defining Supply Chain Maturity

According to The Oxford English Dictionary and The Collins English Dictionary, 'maturity' is defined as follows:

> "Maturity: Noun: the state, fact or period of being mature. Mature: Adj.: Fully-grown or physically developed; adult. Like an adult in mental or emotional development. (Of thought or planning) careful and thorough. Verb: to become mature. Origin: Latin **maturus** 'timely, ripe'". (The Oxford English Dictionary)

Or: "Mature: Adj. Relatively advanced; grown-up. Fully grown or aged; adult e.g. a mature animal. Fully considered; perfected (plans, theories etc.) Fully developed or differentiated." (Collins English Dictionary)

This study adopts a definition of 'supply chain maturity' so as to maintain consistency with the thought work of Bowersox et al. (2000). As discussed in Section 2.1.8, their knowledge-based supply chain maturity scale indicates level of development towards the goal of collaborative supply chain integration. To evolve along the immature to mature continuum in a supply chain context requires two-way communication to ensure "shared vision and objectives among customers and suppliers about interdependency and principles of collaboration". In addition, development of supply chain maturity requires mutual effort between supply chain partners regarding "the adoption of integrative supply chain management operating practices". Bowersox et al. (2000) do not elaborate on the question of 'what practices', but give examples such as "collaborative planning", " forecasting and replenishment", " Internet connectivity", and "other state-of-the art practices... built upon an extremely well-knit set of basic supply chain management principles designed to succeed today."

One possible operationalisation of this knowledge-based supply chain maturity construct therefore comprises levels of collaborative knowledge sharing regarding the implementation of 'appropriate' supply chain practices- such as those of the Supply Chain Council SCOR model. Thus the concept of developing maturity coincides with the Bessant et al. (2003) ideal of sustaining continuous organisational learning "using supply chains as a mechanism for upgrading and transferring 'appropriate practice'".

'Supply chain maturity' therefore corresponds to the level of evolution of a company in terms of collaborative knowledge sharing with supply chain partners relating to implementation of up-to-date and appropriate supply chain practices. Thus, a 'mature' organisation is defined as one that engages in extensive collaboration across a 'wide arc' of supply chain partners in order to implement appropriate integrative practices. Conversely, an 'immature' organisation exhibits a combination of low levels of collaboration, with limited supply chain partners and across a limited range of supply chain integration practices.

This use of an organisational maturity term is consistent with the knowledge management aims of a 'learning organisation' that seeks to balance the internal exploitation of existing knowledge with the exploration of new external knowledge possessed by supply chain partners. Hyland et al. (2003) suggest that this is liable to be a continuous process. Hence the emphasis on the development of supply chain maturity is upon the sustained combination of continuous experiential and vicarious learning through the development and sharing of knowledge on appropriate supply chain practices. Also Miller and Chen (1994) suggest that more "mature" organisations could reduce problems associated with "competitive inertia" through prolonged internal knowledge exploitation and external exploration. Thus, in essence this maturity construct constitutes the long-term combination of regularly up-dated competence levels with the use of the correct tools for the circumstances. Furthermore, as practices evolve supply chain maturity corresponds to increasing levels of 'know-how' as defined by Kogut and Zander (1992), and therefore captures both explicit and tacit elements of knowledge:

> "Know-how, like procedural knowledge, is a description of what defines current practice inside a firm."

3.3 THE CONCEPTUAL RESEARCH MODEL

As the framework in Figure 3.4 indicates, the knowledge dimensions of knowledge transfer, supply chain competence and supply chain maturity represent a logical progression from creation/ transfer, through acquisition/ improvement, and finally to evolution of knowledge in the supply chain. The first two knowledge dimensions of knowledge transfers and supply chain competence are purely derived from mechanisms of knowledge and skill development in the supply chain. Supply chain maturity, on the other hand combines knowledge evolution in the supply chain with the implementation of appropriate supply chain practices.

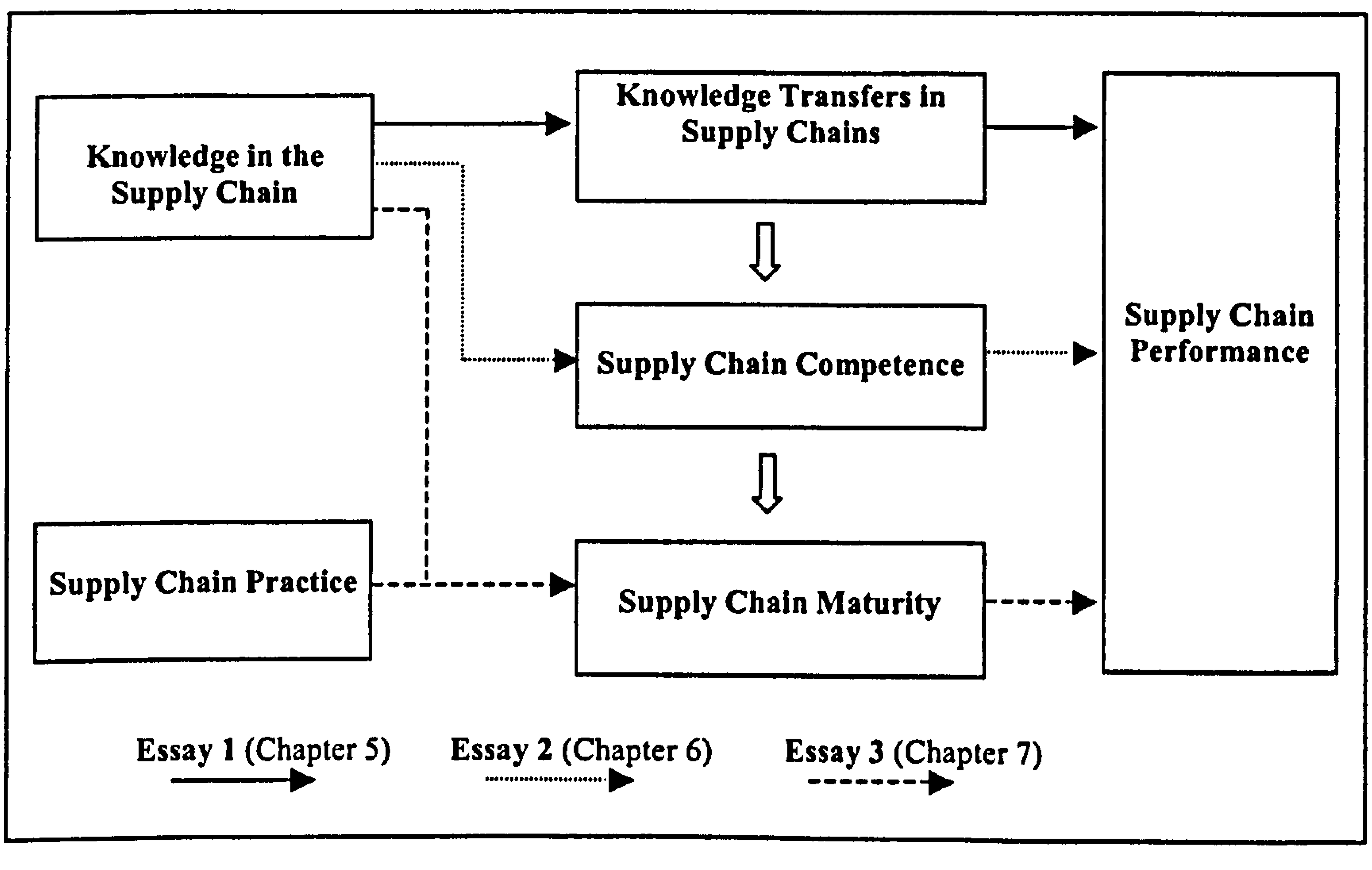
These three issues have been identified as potential drivers of performance that warrant further empirical study in supply chain contexts. Hence the overall research question from Section 3.1 can be broken-down into the following more meaningfully articulated research questions:

1. What is the impact of supply chain knowledge transfer upon performance?
2. What is the impact of supply chain competence upon performance?
3. What is the impact of supply chain maturity upon performance?

These three research questions address the first knowledge dimension evolutionary gap. The aim is to tackle each of these knowledge dimension research questions in the three sequential essays in Chapters 5, 6 and 7.

The conceptual research model in Figure 3.6 outlines the logical development of the three essay chapters. This research model captures the links between the knowledge dimension areas of this study and the individual research questions outlined above. It also indicates the particular knowledge dimensions that will be investigated by each of the three sequential essays.

Figure 3.6 The Conceptual 'Knowledge Dimension' Research Model



It should be noted that the above model only addresses the conceptual first literature gap stated in Section 3.1. With a view to contributing to the contextual second literature gap, the next section goes on to link the specific conceptual knowledge dimensions of 'knowledge transfer', 'supply chain competence', and 'supply chain maturity' to appropriate manufacturing and evolving service-oriented supply chain contexts. Furthermore, it frames the three sequential essays that are developed in Chapters 5, 6 and 7.

3.4 INVESTIGATING KNOWLEDGE DIMENSIONS IN MANUFACTURING AND SERVICE SUPPLY CHAIN CONTEXTS

The second evolutionary gap- pertaining to manufacturing and evolving service supply chain contexts is best addressed by investigating the above knowledge dimension research questions in those contexts that are most useful, appropriate and interesting. This section therefore has three aims:

1. It develops the above conceptual research questions from Section 3.3 so that they are more contextually specific.
2. It provides the background reasoning to limiting the scope of the study to those elements shown earlier in Figure 3.1.
3. It frames the three consecutive essays for subsequent development in Chapters 5, 6 and 7.

The literature review in Chapter 2 identified specific areas for investigating supply chain management theory and practice relating to service contexts. Above all, there is clear opportunity for:

i) Comparative investigation of supplier-oriented constructs in manufacturing versus service supply chain contexts, and
ii) Sector-specific research into product suppliers of a service provider.

These two opportunities are considered in Sections 3.4.2 and 3.4.3 respectively, and constitute the basis for Essays 2 and 3. Before continuing with investigations of knowledge dimensions in evolving service supply chains, however, an exploratory study into supply chain knowledge mechanisms is needed. This is the thrust of the first essay, for which more established manufacturing supply chains provide the ideal research context as outlined in the following Section 3.4.1.

3.4.1 Investigating Explicit Knowledge Transfer in Manufacturing Supply Chains

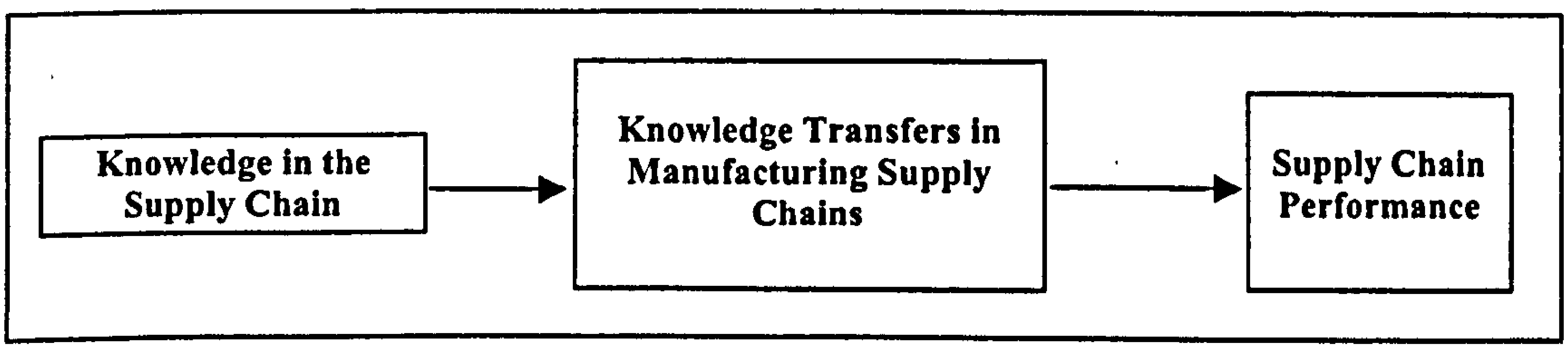
From previous discussion it makes sense to follow the logical progression of the knowledge dimensions shown in Figure 3.4, and commence with an exploratory study of the knowledge transfer dimension. In addition, investigating explicit knowledge transfer in manufacturing supply chain contexts provides a good empirical 'point of departure' for this doctoral study. An exploratory study of such established supply chains will result in a research base from which to proceed to the next steps. A strong reason for not conducting an initial exploratory study in service supply chain contexts concerns the uncertainties and the potential confounding effects that could result from the more complex service operations characteristics. Furthermore, there is a higher likelihood that findings from an exploratory study in service contexts would be non-generalisable.

Therefore, given the research objectives, this study commences with an exploratory investigation of knowledge transfers in the context of manufacturing supply chains. Thus the first broad research question can be contextually refined to:

RQ1: What is the impact upon performance of knowledge transfer in manufacturing supply chains?

This primary research question is addressed by the first essay and corresponds to the framework shown in Figure 3.7.

Figure 3.7 The Research Framework for Essay 1



The knowledge management and supply chain literatures parallel each other in the general proposition that external knowledge is transferred between supply chain partners, and that this knowledge transfer can significantly benefit organizational efficiency. Both streams appear to echo the Frohlich and Westbrook (2001) finding that the "widest degree or arc of integration with both suppliers and customers [has] the strongest association with performance improvement". The supply chain integration literature consistently notes the benefits of sharing data and information with and coordinating activities between supply chain partners in order to improve performance (e.g. Davis, 1993; Fisher et al., 1994; Fisher, 1997; Lee et al., 1997a; Magretta, 1998).

From the knowledge management literature there is abundant evidence that organizational knowledge is an important determinant of higher performance and competitiveness (e.g. Brown & Duguid, 1991; Kogut & Zander, 1992). Several studies have demonstrated the beneficial value of knowledge transfers from beyond the boundaries of the organization (e.g. Cohen & Levinthal, 1990; Hagedoorn & Schekenraad, 1994; Mowery et al., 1996).

Thus from the combined supply chain and knowledge management literature the following proposition can be made:

Proposition 1: Knowledge transfer between supply chain partners will enhance supply chain performance.

This proposition warrants analysis to identify mechanisms of external knowledge transfer in the supply chain, and links with improved organizational efficiency.

Whilst there are similarities between knowledge management and supply chain management literatures, there are also differences. For example, there is no 'fine-tuning' as to the relative benefits depending upon where knowledge transfers emanate from. The knowledge management literature recognises that not all knowledge creation, capture, and distribution are equal (e.g. Levinthal & March, 1993; Miller & Chen, 1994; Ingram & Baum, 1997) yet makes no distinction between upstream, downstream or integrated supply chain external knowledge sources. Similarly, the benefits of supply chain integration have not yet been demonstrated at the knowledge level of exchange. Thus adequate exploration of the above primary research question and literature derived proposition can also lead to valuable insights and answers to the following secondary research questions:

RQ1a: Is the concept of an integrated supply chain supported from a knowledge perspective?

RQ1b: Where does the 'richest' knowledge in a supply chain emanate from?

A further point of consideration in this first exploratory essay concerns the type of knowledge to investigate. A full consideration of tacit knowledge would represent a significant increase in complexity to an initial exploratory investigation. Thus, whilst this doctoral research as a whole recognizes the importance of managing both tacit and explicit knowledge in organisations (Polyani, 1966; Brown & Duguid, 1991; Nonaka, 1994; Romer, 1995), the first essay will concentrate upon the codified, explicit form for two reasons:

1. Explicit knowledge plays an increasingly general role in modern organizations,
2. It is more precisely formulated and articulated than tacit knowledge thus enabling accurate and focused empirical analyses (Zack, 1999).

Investigating explicit knowledge is thus ideally suited to an exploratory study. Results are more likely to be accurate and generalisable to other contexts in subsequent investigations. In contrast, including the more complex and context specific tacit 'know-how' could be detrimental to such focus and generalisability. Furthermore, the knowledge literature (Kogut & Zander, 1992) specifically suggests that mechanisms behind the inter-firm transfer of tacit knowledge are poorly understood and thus potentially confounding for a study aimed at laying the groundwork upon which subsequent research stages may build.

Essay 1: "Investigating Explicit Knowledge Transfer in Manufacturing Supply Chains" further explores the above lines of research in Chapter 5 by developing and empirically testing focused literature-derived hypotheses.

3.4.2 Comparing Supply Chain Purchasing Competence in Manufacturing and Service Contexts

As discussed in Chapter 2, supply chain concepts that have been developed and observed in manufacturing contexts are being extended and implemented in new contexts such as service operations. These evolving service supply chain contexts pose new challenges both to practitioners and to researchers, and present interesting manufacturing-service comparative research opportunities. Hence a comparative study follows the above exploratory investigation of knowledge transfer mechanisms in supply chains. Of interest, in comparing manufacturing and evolving service supply chain contexts are the mechanisms of knowledge development in the supply chain. These mechanisms correspond to the development of supply chain competence. Therefore, the second study is aimed at contributing to the literature by investigating whether a supply chain competence construct is equally applicable and valid across manufacturing and service contexts.

In order to draw comparisons between the distinct manufacturing and service operations, it is necessary to pin down what supply chain competence constructs are in effect and in which parts of the supply chain. The previous literature review indicates that the downstream side of manufacturing and service supply chains can differ considerably in terms of what is delivered to the end customer and how it is delivered. Therefore there are limited grounds for comparison here. On the upstream- supplier side however, there are significant operational similarities. In the same way that manufacturing requires the supply of raw materials and component products, services often also rely on the provision of physical goods from upstream suppliers.

Krause et al. (1998) point out that many companies- both manufacturing and services, seek the advantages of supply-side competences that results in improvements in delivery and cost. Handfield (1993) notes that supply-side coordination typically means "obtaining frequent deliveries in small lots, using single or dual sources of supply, evaluating alternative sources on the basis of quality and delivery instead of price, establishing long term contracts with suppliers, reducing buffer inventories and eliminating formal paperwork." Clearly, this offers considerable benefits to purchasing functions in both manufacturing and service organisations. In fact, previous studies consistently link upstream supply chain competence to benefits in terms of:

- Reduced costs and lead times (Ansari & Modaress, 1990)
- Improved supplier reliability (Carr & Pearson, 1999)
- Improved communications (Freeland, 1991)

The literature consistently contends that these benefits in turn lead to improved operational performance in manufacturing organisations (Chapman & Carter, 1990; Akinc, 1993; Lawrence & Hottenstein, 1995; Agrawal & Nahmias, 1997; Tan et al., 1998). Yet these benefits would clearly also be appreciated by most service organisations that undertake purchasing of physical goods.

As long as common knowledge related dimensions are used- valid comparisons may be made. In this respect, Narasimhan et al. (2001) define supply chain competence as a function of purchasing competence, manufacturing competence and marketing/ sales competence. Their work goes on to identify the underlying dimensions of supply chain purchasing competence, and, in the light of the above discussion, this appears to provide a firm foundation for comparison of upstream manufacturing and service-oriented supply chain contexts.

Thus, this second study adopts the supply chain purchasing competence construct that Narasimhan et al. (2001) empirically identified for manufacturing, and aims to replicate and cross-validate it across manufacturing and service companies. The following research question therefore emerges for investigation in the second study:

RQ2: Is supply chain purchasing competence equally valid for manufacturing and evolving service supply chains?

Since Narasimhan et al. (2001) developed their supply chain purchasing competence construct there have been relentless advances in upstream supply chain management- particularly in IT. In light of this, the following research question also warrants analysis in the second study:

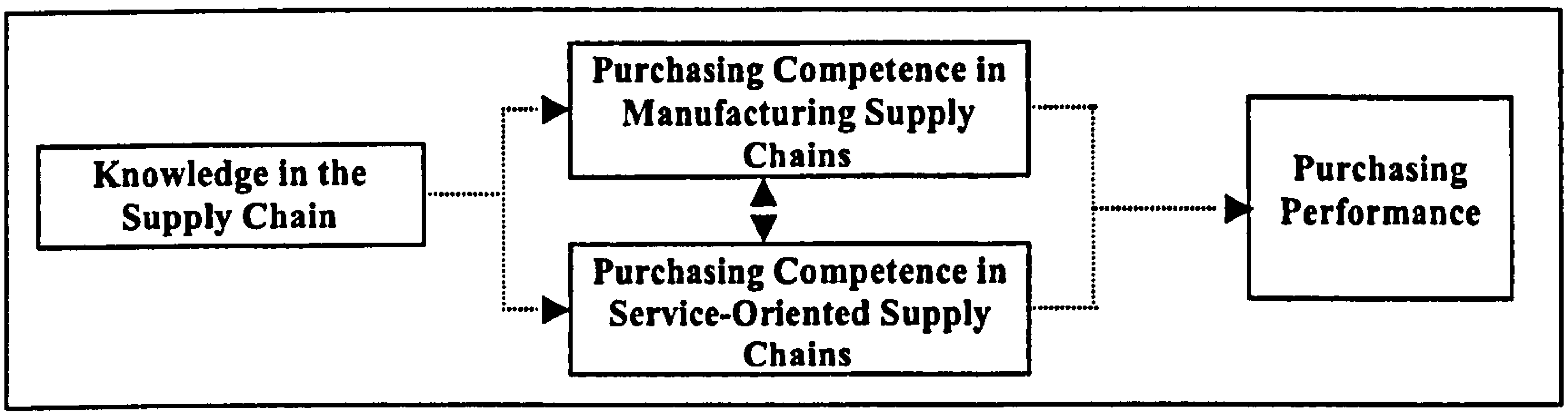
RQ2a: Is it appropriate and valid to extend the Narasimhan et al. (2001) supply chain purchasing competence construct- to include an underlying dimension for IT competence?

To investigate impact upon performance of supply chain purchasing competence in manufacturing and service contexts, common scales of performance need to be used. In this respect, Chao (1993) identified the most important multi-sector purchasing performance measures, thus providing a basis upon which to study the following research question:

RQ2b: What are the impacts upon performance of supply chain purchasing competence dimensions in manufacturing and service contexts?

These research questions are developed and investigated by the second essay, corresponding to the framework shown in Figure 3.8.

Figure 3.8 The Research Framework for Essay 2



Regarding the impact of supply chain competence upon performance, both supply chain and knowledge management literatures propose the potential beneficial impact of competence development upon performance. The combined supply chain and knowledge management literatures thus lead to the following proposition:

Proposition 2: Supply chain purchasing competences will have significant impact in manufacturing and evolving service supply chains.

Nevertheless, whilst the supply chain literature simply proposes a significant positive impact, the knowledge management literature also recognises the potential for significant negative impact of competence development upon performance. Work on 'learning curves' in organisations (Epple et al., 1991) indicate possible diminishing returns, and some literature warns of the dangers of over-optimising knowledge (Starbuck & Milliken, 1988). Performance trade-offs have been identified between exploiting existing competences and exploring new knowledge (March, 1991). Also, the research on 'corporate inertia' and 'competency traps' recognises that on the one hand applying existing knowledge-based competence may be beneficial, on the other hand it may also make an organisation 'myopic' and 'rigid' (Levinthal & March, 1993; Miller & Chen, 1994).

The above research questions, proposition and emerging issues merit investigation and are developed and empirically analysed in Chapter 6- Essay 2: "Comparing Supply Chain Purchasing Competence in Manufacturing and Service Contexts".

3.4.3 Investigating Supply Chain Maturity in an Evolving Service Context: Healthcare

Following a comparison of supply chain competence in manufacturing and service contexts, this doctoral study moves on to investigate supply chain maturity in a specific evolving service supply chain context. The term supply chain maturity was coined by Bowersox et al. (2000), and in keeping with their usage, is considered in this doctoral study as the level of collaboration with supply chain partners pertaining to appropriate supply chain practice implementation.

The literature review in Chapter 2 indicates that maturity levels differ between companies and sectors. Generally, the manufacturing sector is considered to be comparatively mature since on the whole it has widely implemented supply chain practices and worked to share knowledge with supply chain partners for many years. On the other hand, however, supply chain practices and collaborative knowledge sharing are comparatively new in certain evolving service supply chains.

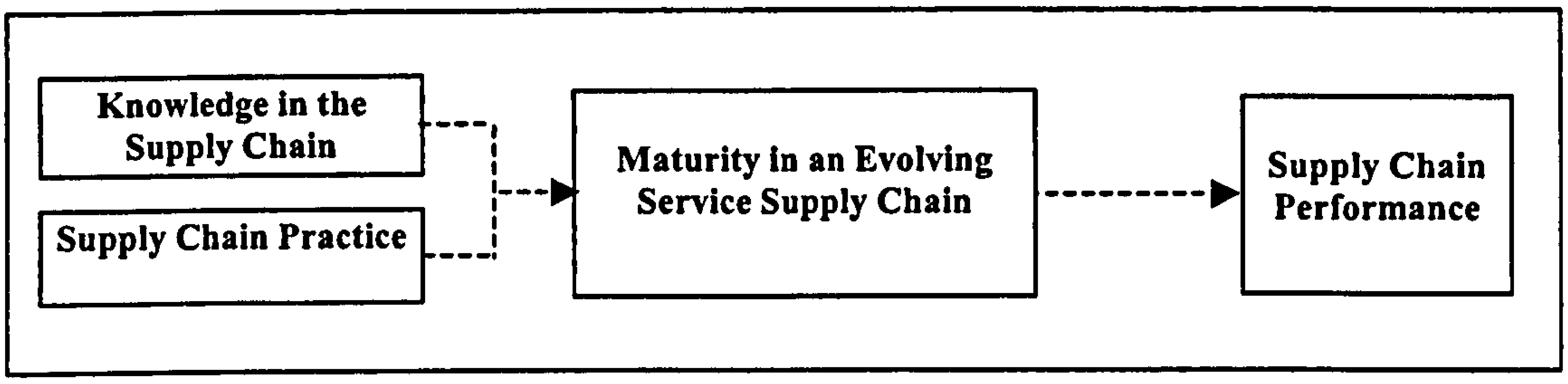
As such, there is likely to be greater spread in supply chain maturity levels between 'fast adopter' and 'laggard' service organisations. This likely increased spread in maturity makes evolving service supply chain contexts particularly interesting arenas for further investigation. As previously discussed, a significant contribution could be made to the literature by assessing the impact of supply chain maturity upon operational performance in a specific sector whereby a service provider depends upon product suppliers.

Thus the third broad research question is contextually refined to:

RQ3: What is the impact upon performance of supply chain maturity in an evolving service context?

This research question is developed and investigated in the third essay, corresponding to the framework shown in Figure 3.9.

Figure 3.9 The Research Framework for Essay 3



Previous discussion establishes that evolving service supply chain contexts are particularly appropriate for investigating the supply chain maturity dimension. In particular, high profile efforts are currently being made by the UK National Health Service to improve operational performance relating to its product supplier base. This indicates that the UK Healthcare sector is an ideal evolving service supply chain context in which to investigate the impact of supply chain maturity (National Health Service, 2002).

Given that the maturity dimension is composed of both knowledge and practice components, particular care needs to be taken in its formulation. Despite an extensive review of the literature, no formal operationalisation of the supply chain maturity concept was found in adequately detailed form for the purposes of this study. Therefore Essay 3 seeks to develop a new supply chain maturity construct, whilst aiming to stay as true as possible to the usage of the term by Bowersox et al. (2000). This leads to the following additional research question:

RQ3a: What are the underlying dimensions of supply chain maturity in an evolving service supply chain context?

The outcomes of the previous two essays inform and develop the knowledge-based aspects of maturity. Regarding the inclusion of supply chain practice aspects in the maturity construct, the Supply Chain Council (2004) SCOR model proves invaluable. The practices identified in the earlier review of academic and practitioner literature under each of the Plan, Source, Deliver, Make, NPD and Returns elements of the SCOR model are incorporated into the supply chain maturity construct. Nevertheless, it is not assumed that all of these SCOR practices are necessarily appropriate to all situations. In fact, essay 3 does not attempt to develop a 'one size fits all' supply chain maturity construct, but rather puts the onus on validating the concept based upon 'appropriate supply chain practices' according to context specific supply chain operational configurations (Bessant et al., 2003). Thus the following proposition emerges:

Proposition 3a: Supply chain maturity can be defined in terms of knowledge sharing across practices that are 'appropriate' to specific operational supply chain configurations.

Both supply chain and knowledge management literatures suggest the potential impact upon performance from combined collaborative knowledge sharing and appropriate practice implementation. Thus the following additional proposition emerges from the literatures:

Proposition 3b: Supply chain maturity will have a significant impact upon performance in an evolving service context.

Yet, as with supply chain competence, the supply chain and knowledge management literatures do not give universal agreement regarding the direction of this impact upon performance. Whilst some literature (Bowersox et al., 2000) only considers a beneficial impact upon performance from the combination of up-to-date supply chain practices, and high levels of knowledge sharing, others warn of potential negative impact. Some supply chain literature indicates that not all supply chain practices are necessarily appropriate (Davenport, 1998). In addition, some knowledge and operations management literature warns that knowledge sharing and development activities in certain areas do not necessarily lead to performance improvement (Upton, 1995; Vokurka & O'Leary-Kelly, 2000). In fact, certain performance diminishing phenomena could lead to insignificant or negative impact of supply chain maturity upon performance depending upon the contingencies present in differing supply chain configurations (Leonard-Barton, 1992).

These research questions, proposition and issues are further developed and empirically analysed in Chapter 7- Essay 3: "Investigating Supply Chain Maturity in an Evolving Service Context: Healthcare".

3.5 SUMMARY

This chapter considers how this doctoral study can best make a contribution to those areas in the supply chain literature identified in Chapter 2. The literature-derived motivation for exploring "what has to occur to advance along the [evolutionary] continuum" of supply chain theory and practice is discussed. In striving to address this issue two distinct conceptual and contextual gaps in knowledge need to be investigated. A combination of these gaps, in light of relevant literature, leads to the articulation of the broad research question for this study:

"What is the impact of knowledge dimensions in
manufacturing and service supply chains?"

Synthesis of the literature suggests three particularly pertinent knowledge dimensions: supply chain knowledge transfers, supply chain competence and supply chain maturity. The scope is outlined for this study to investigate each of these dimensions within manufacturing and/ or evolving service supply chain contexts.

The knowledge management literature is identified as potentially adding conceptual depth and new insights to the consideration of managing knowledge in supply chains. In order to apply the 'knowledge lens' to supply chain management, several fundamental theory building and research design issues are considered regarding the unifying of knowledge management and supply chain perspectives. To address criteria for such importation of theory from other fields, a unifying framework is formulated for supply chain knowledge management. Several knowledge management theories and constructs are considered within the supply chain context. This analysis concludes that it is relevant and appropriate to adopt a knowledge-based perspective in this doctoral study of the evolving supply chain. Furthermore, steps are taken to ensure the specific knowledge dimensions are consistently defined and applied across the two literature streams. Coherent working definitions for each of the above knowledge dimensions are expressed.

An overall conceptual research model is specified, and based upon the logical progression from knowledge creation/ transfer, through acquisition/ improvement, and finally to the evolution of supply chain knowledge. Corresponding to this logical knowledge-based progression the research model outlines three sequential essays. The three essays are designed to assess, in turn, the impact of supply chain knowledge transfer, supply chain competence and supply chain maturity upon performance.

Through sub-dividing the overall research model, the three sequential essays are further framed by applying the knowledge dimension concepts in relevant manufacturing and/ or service contexts. Focussed essay-specific research frameworks are expressed, whereby each essay considers one primary research question and related secondary questions. The first essay is framed to investigate the impact of knowledge transfer in manufacturing supply chains. The second essay is framed to replicate and extend the Narasimhan et al. (2001) supply chain purchasing competence construct and to compare its applicability, relevance and impact across manufacturing and service supply chain contexts. The third essay is set-up to develop robust supply chain maturity constructs relating to collaborative knowledge sharing across 'appropriate' supply chain practices, and to investigate their impact upon performance in the evolving service context of healthcare.

Literature synthesis results in broad propositions that warrant further development and investigation in subsequent essay chapters:

Chapter 5- Essay 1: "Investigating Explicit Knowledge Transfer in Manufacturing Supply Chains"

Chapter 6- Essay 2: "Comparing Supply Chain Purchasing Competence in Manufacturing and Service Contexts"

Chapter 7- Essay 3: "Investigating Supply Chain Maturity in an Evolving Service Context: Healthcare"

Before these chapters, Chapter 4 builds upon the research framework, considering appropriate research methodologies to enable the above investigations.

CHAPTER 4 – METHODOLOGY

Steps 1 and 2 of Bryman's (1988) seven-step research process have been covered in previous chapters. This chapter moves on to consider steps 3, 4, 5 and 6:

3. Decide upon an approach, which is in keeping with the philosophical position of the research,
4. Formulate the plan or research design,
5. Collect the qualitative or quantitative data as appropriate to the philosophical position,
6. Analyse and interpret the data with appropriate methods.

Section 4.1 addresses steps 3 and 4 in outlining the philosophical position and formulating the research design. The chosen approach of survey research, general implementation issues, and the need for rigorous survey methods in operations management research are covered.

Section 4.2 addresses step 5- the specific data collection methods of mail, telephone and Internet surveys. These were chosen and implemented specifically to address the research questions and the three essays framed in Chapter 3.

Section 4.3 addresses step 6 with an overview of possible appropriate data analysis methods that will be further developed in each essay in Chapters 5, 6 and 7.

Bryman's (1988) concluding steps 6 and 7 of interpreting the data, validating findings and presenting them are covered in the development of the individual essays in Chapters 5, 6 and 7.

4.1 RESEARCH DESIGN

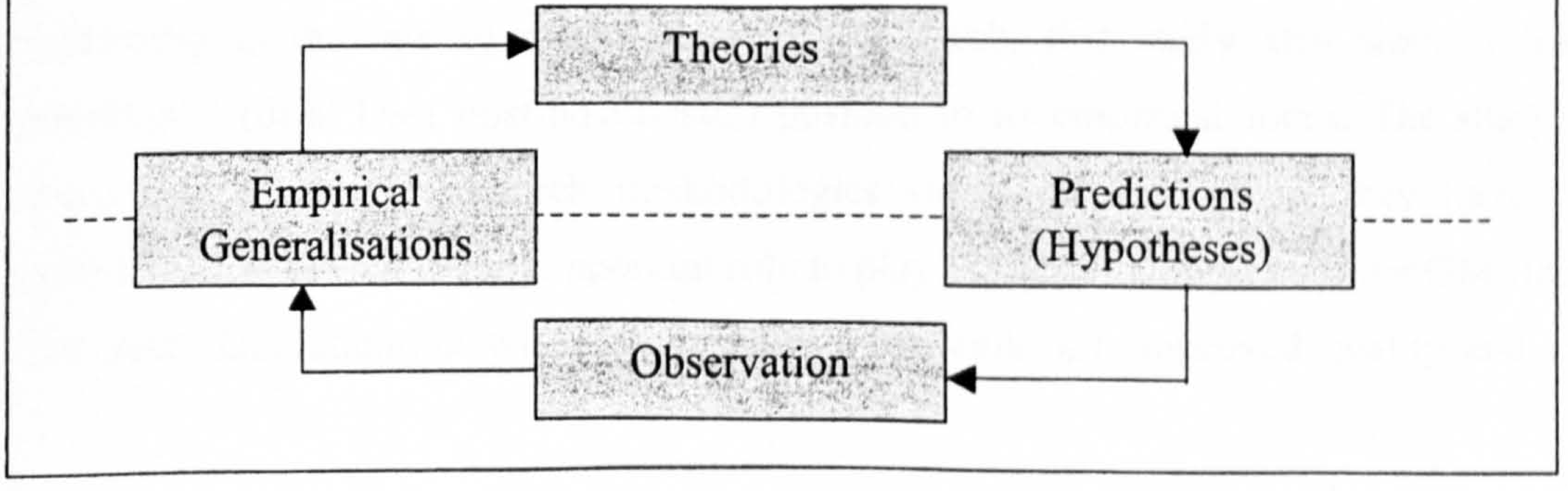
> "Decisions have to be made about what sort of observations are needed to solve the research problem... The researcher must then select an appropriate strategy for making the observations- experiment, survey, field research, or use of available data." (Singleton & Straits, 1999, p. 93)

The choice of an appropriate strategy should be made with due regard for philosophical and epistemological considerations in research (Croom, 2002). Various writers on research methodology start by setting out a dichotomous view of the researcher's choice of philosophical position. Bryman (1988), for example, discusses the two general approaches to organisational research as being concerned with either quantitative or qualitative methods, whilst both Easterby-Smith et al. (1991) and Gill and Johnson (1991) characterise the debate in terms of two main paradigms: positivism and phenomenology. Meredith et al. (1989) view the epistemological choice as being between a rational and existential paradigm, whilst Hirschman and Holbrook (1992) adopt a similar view, contending that research paradigms exist on a continuum between material determinism (empiricism) and mental determinism (rationalism).

In their discipline note, Pannirselvam et al. (1999), found that operations management (OM) research had remained very much positivistic (or at least post-positivistic) in nature- with surveys and simulation being the predominant methods used in journal and conference publications.

This doctoral study aims to contribute to the OM and supply chain literature by conducting rigorous and scientific research. As such, the scientific process is crucial in this research. Singleton and Straits (1999, p.27) quote Albert Einstein as saying that "science must start with facts and end with facts, no matter what theoretical structures it builds in between." In other words, they say at some point scientists are observers recording facts; next they try to describe and explain what they see; then they make predictions on the basis of their theories, which they check against their observations (i.e. the facts) again. The cycle is that theories generate predictions, predictions are checked against observations, the observations produce generalisations, and the generalisations support, contradict or suggest modifications to the theory. This process is shown in Figure 4.1.

Figure 4.1 The Scientific Process



Empirical relevance and generalisation- and thus empirically oriented research work is key to this scientific knowledge process (Babbie, 1990: Barwise, 1995).

Forza (2002) considers the increasing use of empirical data in the OM field to supplement mathematics, modelling, and simulation to develop and test theories. He states that many authors have called for this empirical research, since OM became a functional field of study (such as marketing, management information systems, etc.) within the management discipline.

The rationale in this increased empirical work was to reduce the gap between management theory and practice, to increase the usefulness of OM research to practitioners, and to increase the scientific recognition of the OM field. Recognition of the value of empirical research in OM has led to an increase in the number and percentage of studies based upon empirical research.

Flynn et al. (1990) provide an overview of general methodology that should be followed for conducting empirical research in the OM field:

1. Establishing the theoretical foundation for the research,
2. Selecting an appropriate research design and data collection method,
3. Properly implementing the study,
4. Finally, using correct data analysis techniques for interpretation.

In keeping with its positivistic tendencies, existing empirical work in the OM field has established survey research methodologies as being valuable and commonly used (Amoako-Gyampah & Meredith, 1989; Meredith, 1998; Scudder & Hill, 1998; Pannirselvam et al., 1999; Rungtusanatham et al., 2001). Rungtusanatham (1998) says that in recent years "remarkable progress has been demonstrated... by the quality and sophistication of the research endeavours" based upon survey research.

Following in the line of most recent OM research, this study also aims to take a positivistic (or at least post-positivistic) position in its empirical focus. The study will make use of survey research methodologies since, on the whole, they have been established as having a very important role to play in the development of the OM field of literature. Due attention will also be paid to the calls for improved quality and more appropriate use of survey research in OM (Malhotra & Grover 1998; Rungtusanathan et al., 2001).

4.1.1 Selecting an Appropriate Data Collection Methodology

The main data collection methodologies available to the supply chain and operations management researcher include case studies (e.g. Voss et al., 2002), surveys (e.g. Frohlich, 2002) and simulation modelling (e.g. Bertrand & Fransoo, 2002). Other potentially useful methodologies include the use of experiments (e.g. Cook & Campbell, 1979) and action research (e.g. Coughlan & Coghlan, 2002), though to the author's knowledge these have had limited application within the supply chain context due to implementation difficulties.

McGrath (1982) describes how each of these major forms of research methodology has inherent strengths and weaknesses, and how the choice of method limits the conclusions that can be drawn. McGrath (1982) highlights the unavoidable "dilemmatic" trade-offs involved with selecting a specific research design as a "three-horned dilemma" relating to: 1. Generalisability over populations; 2. Precision of variable control; and 3. Realism of observational context. It is always desirable, ceteris paribus, to maximise these goals, but no single research methodology can fully achieve more than one. Survey methodology maximises the ability to generalise over populations- but at the expense of precision and realism. Simulation modelling maximises the ability for precision, but sacrifices generalisability and realism. Case and action research methodologies both ensure high levels of realism, however compromise on precision and generalisability.

Recognising McGrath's (1982) overall strengths and limitations of each broad research option, Remenyi et al. (1998, p. 66) describe four main "factors to be considered when choosing an appropriate research methodology". Consideration of each of these factors resulted in the survey methodology being selected as the data collection methodology for this thesis. The contribution of each of the Remenyi et al. (1998, p. 66) factors to this decision are considered below:

1. "The literature review should reveal not only a suitable problem to be researched but also a suitable methodology which has been applied to this type of research question in previous research projects. The topic to be researched and the specific research question

is one of the primary drivers in the choice of methodology. As a general rule, precedent should be followed."

The literature review in Chapter 2 of this thesis draws upon operations management, logistics and supply chain management research based upon case, survey and simulation-based methodologies. As such, any of these methodologies (with inherent strengths and limitations) could potentially have been appropriate for this doctoral study. Nevertheless, the review in Chapter 2 also indicates that whilst the supply chain literature is rich in simulation modelling and case-based methodologies (e.g. Armistead & Mapes, 1993; Lee et al., 1997a), a need has been identified for more empirically validated and generalisable models explaining the scope, form, costs and benefits of supply chain management (Croom et al., 2000).

Furthermore, certain key papers identified the survey-based methodology as being the most suitable for this thesis. For example, the 'arcs of integration' research of Frohlich and Westbrook (2001) investigated the impact of data and information sharing between supply chain partners using survey data. A fundamental basis for the development of the research questions in this thesis was the Frohlich and Westbrook (2001) conclusion that the degree and extent of supply chain integration is liable to evolve beyond data and information levels towards the sharing of opinions, expertise and knowledge. Thus the research questions developed from such literature lent themselves to investigation through survey data collection.

Similarly, the development of research questions relating to supply chain competence was based upon the survey-based research of Narasimhan et al. (2001). It was particularly appropriate to adopt a survey data collection methodology for this part of the thesis, since the research questions addressed by Essay 2 were aimed at replicating and extending the Narasimhan et al. (2001) 'competence' framework. Replication necessitates the implementation of similar methodologies, and so, for this part of the thesis at least, data collection was restricted to survey methods.

2. "The research culture in the university, business school or institute where the work will be conducted is an important determining factor, as is the skill and interest of the researcher's supervisor."

Within London Business School all of the above research methodologies are applied with high academic success. Case study and survey-based methodologies are particular strengths within the Operations and Technology Management Department, and with the specific members of faculty associated with this doctoral research- Professors Chris Voss and Mark Frohlich. As acting supervisor, Professor Mark Frohlich's primary areas of skill and interest lie in the application and development of survey-based empirical data collection methodologies.

3. "[Researchers] need to be able to satisfy their own ideological or ontological and epistemological preferences."

The previous discussions in Section 1.2 and above in Section 4.1 indicate how the author's personal background, ideological motivations and epistemological leanings towards quantitative and positivistic research fit into the broader operations field (as represented by key academic journals such as the Journal of Operations Management, Decision Sciences, Production and Operations Management, International Journal of Operations and Production Management.) Therefore, whilst case-based research could have been an appropriate option for this thesis given the strengths within the LBS OTM department, the personal skills and preferences of the author were deemed to constitute a better fit with survey data collection methodologies.

4. Remenyi et al. (1998, p. 66) conclude that the choice of methodology can be influenced by opportunities available and issues such as of time and money.

Whilst issues such as time and money are always important, these were absolutely not of prime consideration in the selection of methodology for this thesis. Nevertheless, the occurrence of particular opportunities was important in the decision-making process. Early in the PhD programme, whilst still at the stage of considering which data collection methodology to select, I was fortunate to be invited by the LBS OTM faculty to administer the UK launch of the International Manufacturing Strategy Survey (IMSS). This was a tremendous opportunity to build-up academic skills in the survey data collection methodology. And since the opportunity only comes around once every four years the invitation was readily accepted. Therefore, in addition to the above criteria, the choice of a mail survey data collection methodology for the first essay was at least partially opportunistic. And having successfully implemented the IMSS mail survey and obtained interesting results from subsequent data analysis, it was considered appropriate to extend the skills gained in mail survey data collection skills into other areas of telephone and web-based survey implementations. Finally, despite the high temptation to cross-validate the survey based research findings with multi-method 'triangulation' through case studies, the decision was taken instead to concentrate limited doctoral resources towards developing web-based survey methods with the aim of making focussed methodological contributions (see Section 8.2).

Further to the above decision-making processes and criteria for selecting survey data collection methodologies, due consideration was also given to the inherent limitations of such research methodologies. As McGrath (1982) clearly indicates all research methods have their broad strengths and limitations in terms of generalisability, precision and realism. Singleton and Straits (1999, p. 245) provide more specific uses and limitations of surveys. In terms of advantages, they state that:

> "Amongst all approaches to social research, surveys offer the most effective means of social description; they can provide extraordinarily detailed and precise information about large heterogeneous populations. By using probability sampling, one can be certain, within known limits of error, whether the responses to a sample survey accurately describe the larger target population. Further, the topics covered and the questions that may be included in surveys are wide ranging."

Nevertheless, despite being a very efficient data gathering technique, there are clearly several specific limitations to survey research. One major disadvantage of surveys relates to their use in explanatory research. As Singleton and Straits (1999, p. 246) elaborate:

> "Beyond association between variables, the criteria for inferring cause-and effect relationships cannot be established as easily in surveys as in experiments. For example, the criterion of directionality- that a cause must influence its effect- is predetermined in experiments... But in most surveys this is often a matter of interpretation, since variables are measured at a single point in time."

Another important limitation of survey-based data collection relating to causal inferences concerns the "criterion of eliminating plausible rival explanations". Whilst extraneous variables can be held constant with methodologies such as experimentation, surveys must first anticipate and measure relevant extraneous variables and then exercise statistical control over them in data analysis. Causal inferences from survey research are therefore generally made with less confidence than inferences from, say, experimental research.

An additional limitation is that, whilst surveys are reasonably flexible with respect to topics of research, they also tend to be highly standardised and less adaptable than other research approaches to changing the course of research after the study has begun. That is, once the questionnaire is in the field, it is too late to make changes.

A serious weakness that survey research shares with other methods is that it is susceptible to "reactivity" such as the tendency of respondents to give socially desirable answers to sensitive questions. This introduces systematic measurement error. Furthermore, survey research relies heavily upon reports of behaviour rather than observations of behaviour. As a consequence, measurement error may be introduced by respondents' lack of truthfulness, misunderstanding of questions, inability to recall past events accurately and instability of opinions and attitudes.

Further limitations to survey data collection are represented by the inherent trade-offs between time and cost constraints and minimisation of four types of survey error: sampling error, measurement error, statistical conclusion error and internal validity error (Forza, 2002). Resource constraints can undoubtedly hamper survey research, but more importantly, failure to minimise each of these four errors "can and will lead to erroneous conclusions and regression rather than progress in contribution to theory" (Malhotra & Grover, 1998).

Finally, survey administration involves a relatively brief encounter with any single targeted respondent Singleton and Straits (1999, p. 247). This does not provide a very good understanding of the context within which phenomena may be interpreted over an extended period of time. For such increased levels of contextual understanding, the best data collection approach is field-based research such as case studies. Remenyi et al. (1998, p. 57) state that:

> "As a general rule the nature of the evidence which may be collected by means of a questionnaire is regarded as relatively superficial, especially in comparison to the evidence that it is possible to collect from other techniques such as case studies or personal interviews."

Remenyi et al. (1998, p. 159) conclude: "It should be accepted that no survey is perfect."

Whilst the above limitations and errors inherent in survey research cannot be completely avoided, their effects can often be reduced. The following Sections 4.1.2, 4.1.3 and 4.1.4 go on to consider the role survey research can play in theory development, and general 'good practice' survey implementation strategies to minimise weaknesses associated with this methodology. Furthermore, limitations and guidelines for multivariate data analysis and interpretation are considered in Section 4.3.

4.1.2 Survey Research and Theory Development

There are two major types of survey research that can contribute to theory development (Kerlinger, 1986):

1. Exploratory: where the objective is to become more familiar with the topic. There is usually no model in exploratory research and the concepts of interest need to be better understood and measured. Another type of exploratory survey research is referred to as 'descriptive'. This type of study has been described as indispensable in the early stages of studying a phenomenon as it develops the units that comprise theories. (Dubin, 1978).
2. Explanatory: which is devoted to finding causal relationships among variables. It does so from theory-based expectations on how and why variables should be related. Hypotheses could be basic (i.e. relationships exist) or could be directional (i.e. positive or negative). Results are interpreted and in turn contribute to theory development.

Malhotra and Grover (1998) consider the role of these types of survey research in advancing scientific knowledge and developing theory, and find that such survey research has three characteristics that distinguishes it from other field-based methods such as case studies:

1. Survey research involves collection of information by asking people for information in some structured format- such as mail questionnaire, telephone interview, or Internet survey.

2. Survey research is usually a quantitative method that requires standardised information in order to define or describe variables, or to study relationships between variables.

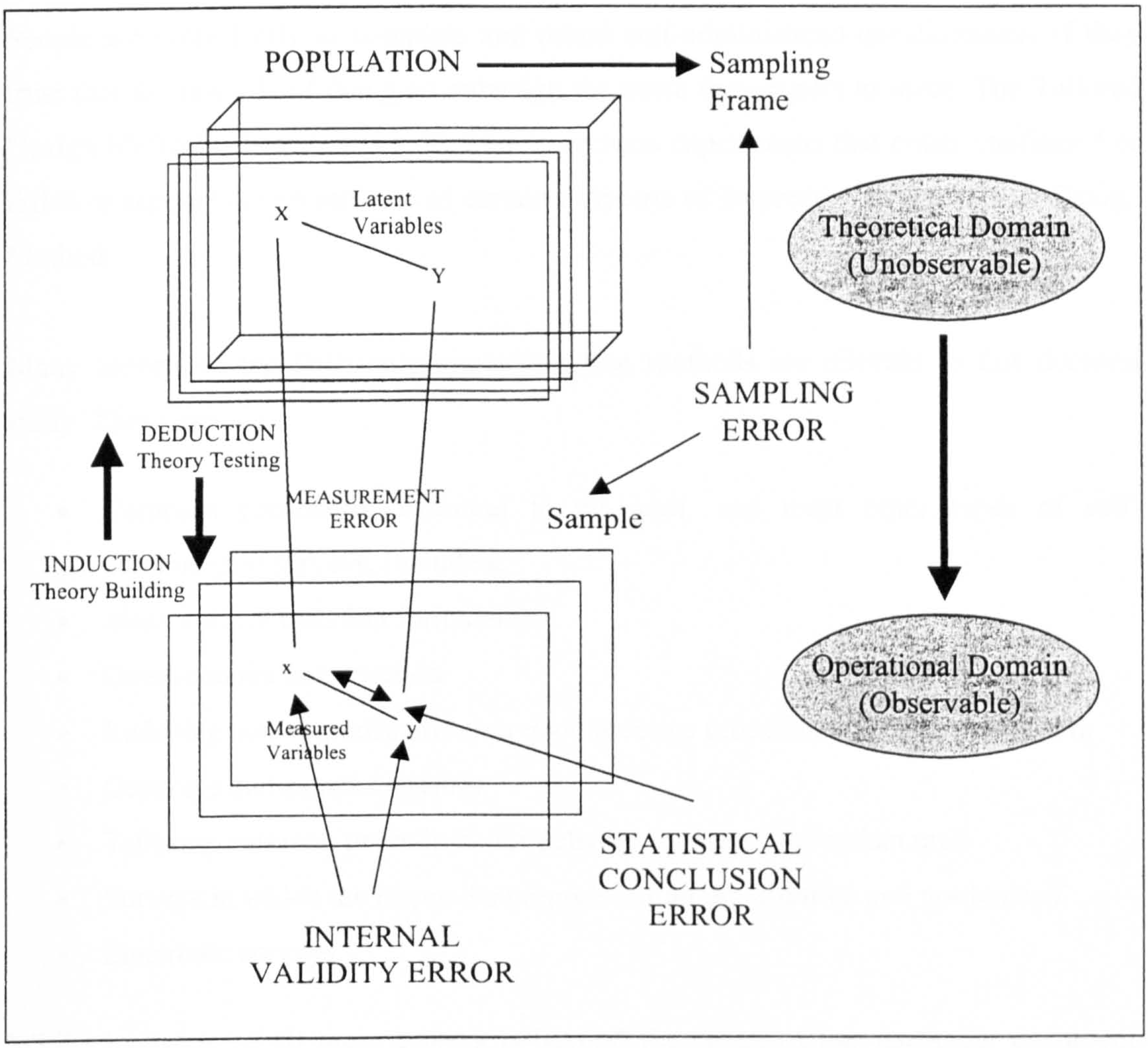
3. Information is gathered via a sample, which is a fraction of the population, with the need to be able to generalise findings from the sample to the population.

Kerlinger (1986) define theory as "a set of interrelated constructs (concepts), definitions and propositions that present a systematic view of phenomena by specifying relationships among variables, with the purpose of explaining and predicting the phenomena." Malhotra and Grover (1998) reason that this definition spans two domains: the theoretical domain and the operational domain. The relationship between these domains is shown in Figure 4.2 below.

Regarding the role of survey research in theory building Malhotra and Grover (1998) conclude that "a middle ground involving symbiotic interaction between deductive and inductive approaches, theory building and testing, and exploratory and explanatory research, is probably the best representation of the scientific research cycle".

As can be seen from Figure 4.2, the translation of latent constructs into measurable variables can introduce a number of errors. Survey research must work toward the reducing of these errors through careful adherence to norms or standards. Many errors result from poor survey implementation issues. The following section considers survey implementation methods with a view to ensuring quality data and high response rates.

Figure 4.2 The Link and Sources of Error Between the Theoretical and Operational Domain in Survey Research



4.1.3 General Survey Implementation

Dillman (1977) and Dillman (2000) investigate the best implementation methodologies to reduce overall survey error in different types of survey- including mail, telephone and Internet surveys. He designs the "Total Design Method", and later modifies it to the "Tailored Design Method".

In essence these methods set-out procedures for conducting successful self-administered surveys that produce both high quality information and high response rates. The most important concept underlying the Dillman (1977, 2000) survey methods has to do with applying social exchange ideas to understand why respondents do or do not respond to questionnaires.

People are more likely to complete and return self-administered questionnaires if they trust that the rewards of doing so outweigh the costs they expect to incur. The Tailored Design Method is based on results from numerous experiments that either confirmed or failed to support the importance of certain elements of its predecessor, the Total Design Method.

Many aspects of the Dillman's implementation methods are relevant to this doctoral study. These include:

- Common procedures essential to all mail, and most other types of self-administered surveys, including:
- Measurement question formulation
- Questionnaire construction
- Reducing non-response error via good practice procedures for implementation
- Coverage and sampling issues
- Tailoring common procedures for delivery by means other than mail
- Surveys in which the respondent reports for an organisation and not himself
- Electronic surveys

Whilst inclusion of all these aspects is beyond the scope of this particular document, certain generic survey issues are considered in the following sub-sections.

4.1.3.1 Survey Error

The Dillman (1977) and Dillman (2000) methods aim to reduce what he sees as being the four major sources of survey error and their consequences:

1. **Sampling error** is a result of attempting to survey only some, not all, of the units in the population,
2. **Coverage error** occurs when the list from which the sample is drawn does not include all the elements of the population, thus making it impossible to give all

elements of the population an equal or known chance of being included in the sample survey.

3. **Measurement error** occurs when a respondent's answer to a question is inaccurate, imprecise, or cannot be compared in any useful way to other respondent's answers. This results from poor question wording and questionnaire construction, and is a particular concern in self-administered surveys.
4. **Non-response error** occurs when a significant number of people in the survey sample do not respond to the questionnaire *and* have different characteristics from those who do respond, when these characteristics are important to the study.

As Dillman (2000, p. 10) states:

> "Surveys can fail to achieve their objectives for any or all of these reasons... efforts to conduct any survey must begin with an understanding of the threat to precision and accuracy that stems simultaneously from these four cornerstones of survey research... none can be ignored."

4.1.3.2 Respondent Motivation and Multiple Attempts

Looking at the theoretical foundations behind why and how people respond to self-administered surveys Dillman (2000) considers what constitutes wrong questions and misplaced emphases. He clarifies two key issues behind achieving quality survey implementation:

1. Responding to a self-administered questionnaire involves not only cognition, but also motivation (Jenkins & Dillman, 1995; Jenkins & Dillman, 1997), and
2. Multiple attempts are essential to achieving satisfactory response rates to self-administered surveys regardless of whether administered by e-mail, the web, or postal delivery (Scott, 1961; Heberlein & Baumgartner, 1978; Dillman, 1991)

The first issue recognises that people must understand clearly what is wanted of them if they are to respond. Yet, there is more to getting a response than the four-step cognition model described by Tourangeau and Rasinski (1988), which includes comprehension, retrieval, deciding and reporting. Dillman (2000) shows that people must be motivated to go through the process associated with understanding and answering each question and returning the questionnaire to the survey sponsor. This is especially important with self-administered surveys.

Regarding the motivation aspect of achieving good survey response, Dillman (2000, p. 15-20) suggests that the following list of reward, cost and trust factors should be considered:

- Show positive regard
- Say thank you
- Ask for advice
- Support group values
- Give tangible rewards
- Make the questionnaire interesting
- Give social validation
- Inform respondents that opportunities to respond are scarce
- Ways of reducing social costs
- Avoid subordinating language
- Avoid embarrassment
- Avoid inconvenience
- Make questionnaires appear short and easy
- Minimize requests to obtain personal information
- Keep requests similar to other requests to which a person has already responded.
- Ways of establishing trust
- Provide a token of appreciation in advance (includes stamps)
- Sponsorship by a legitimate authority
- Make the task appear important
- Invoke other exchange relationships

4.1.3.3 Effective Survey Communication

Considering the communication aspects of a paper-based survey, Dillman (2000, p.24) states that visual layout and design are crucial: "Questionnaires are written in two languages. One language consists of words. The other consists of graphical symbols." Therefore two aspects of a questionnaire must be developed and placed in concert with one another:

1. Information organisation: the prescribed order in which we want people to process the words and other symbols used to convey the questions and all needed instructions to respondents.
2. Navigational guides: the graphical symbols and layout used to visually direct people along a prescribed navigational path for completing the questionnaire.

Similar mechanisms are also important for telephone and Internet surveys.

Of particular importance are the survey questions themselves. With regard to written questions, Dillman (2000, p. 32) states that:

> "The goal of writing a survey question for self-administration is to develop a query that every potential respondent will interpret in the same way, be able to respond to accurately, and be willing to answer. However, in practice, producing good results is often difficult... It is the need to consider many competing things at once that makes it difficult to write questions for self-administered surveys."

He goes on to say that survey questions fail in their purpose for many reasons, ranging from use of the wrong words or an inappropriate structure to simply not being answerable.

Dillman (2000, p. 34-40) suggests that once a working draft of proposed survey questions and response choices has been prepared, the following eight inquiries should be posed for each question. Answers to these questions will help diagnose problems and guide towards structural and wording decisions that are appropriate for the study.

Question 1: Does the question require an answer?
Question 2: To what extent do survey recipients already have an accurate, ready-made answer for the question they are being asked to report?
Question 3: Can people accurately recall and report past behaviours?
Question 4: Is the respondent willing to reveal the requested information?
Question 5: Will the respondent feel motivated to answer each question?
Question 6: Is the respondent's understanding of response categories likely to be influenced by more than words?
Question 7: Is the survey information being collected by more than one mode?
Question 8: Is changing a question acceptable to the survey sponsor?

In addition, certain question structures are more appropriate under certain circumstances. There are fundamentally only three ways in which a survey question can be structured:

1. **Open-ended**: no answer choices are provided. These are frequently useful in self-administered surveys, but their usefulness depends upon the nature of the questions as well the way in which they are structured.

2. **Ordered response category closed ended**: are most useful when there is a well-defined concept for which an evaluative response is wanted, unencumbered by thoughts of alternative or competing ideas. The list of scalar concepts that might be used to evaluate a concept or idea is almost endless. (e.g. strongly agree to

strongly disagree- answer choices such as these are referred to as "vague quantifiers")

3. **Un-ordered response category closed ended:** Typically, closed-ended questions with unordered categories are more difficult for respondents to answer because of the amount of information that must be processed.

Each type can be useful in surveys, and each can pose particular challenges with regard to their effective communication. Shifting from one structure to another can be an effective tool for responding to the kinds of problems suggested above.

4.1.4 'Good' Survey Research in Operations Management

4.1.4.1 Ideal OM Survey Attributes

> "To effectively contribute to theory development in the production and operations management field, [survey] methodology must be carefully implemented. Poorly designed and executed survey research is of little or no value." (Malhotra & Grover, 1998)

In maturer fields like marketing, the issue of poorly implemented survey research has been catalogued:

> "Given the demonstrably poor quality of some of the measures that have been used in consumer behaviour research, researchers should be cautious about evaluating or comparing alternative theories based solely upon empirical evidence unless the appropriateness (validity) of some of the measures has been determined." (Cote & Buckley, 1988)

Malhotra and Grover (1998) state that these observations have major implications for theory building in the OM field. They provide a normative perspective on 'good survey research practices', drawing from work in other social science disciplines like psychology, marketing, organisational behaviour, and other related fields that are more mature in the use of surveys. They state that overlooking normative standards can be disastrous in that "no single finding in such a study can be trusted!" Their evaluation sets-out a list of ideal survey research attributes along with identifying questions- as summarised in Table 4.1.

Table 4.1 Ideal Attributes for OM Survey Research

Attribute	Identifying Question
Unit of Analysis	1. Is the unit of analysis clearly defined for the study?
	2. Does the instrumentation consistently reflect that unit of analysis?
	3. Is the respondent(s) chosen appropriate for the research question?
Triangulation	4. Is any form of triangulation used to cross-validate results?
Measurement Error	5. Are multi-item variables used?
	6. Is content validity assessed?
	7. Is field-based pretesting of measures performed?
	8. Is reliability (internal consistency) assessed?
	9. Is construct validity assessed?
	10. Is pilot data used for purifying measures or are existing validated measures adapted?
	11.Are confirmatory methods used?
Sampling Error	12. Is the sample frame defined and justified?
	13. Is random sampling used from the sample frame?
	14. Is the response rate over 20%?
	15. Is non-response bias estimated?
Internal Validity Error	16. Are attempts made to establish internal validity of the findings?
Statistical Conclusion Error	17. Is there sufficient statistical power to reduce statistical conclusion error?

According to Hunter et al. (1983) and Flynn et al. (1990), any research should be carried out in such systematic and programmatic manner.

4.1.4.2 Response Rates for OM Surveys

> "When a response rate is low a study is immediately open to legitimate concerns about non-response bias. Low response rates also waste precious research time and money in pursuing eventual non-participants." (Frohlich, 2002)

Survey response rate is formally defined as the number of completed questionnaires divided by the number of eligible sample members (Kviz, 1977). The main issue concerning response rates is that it has become "one of the primary yardsticks for judging successful survey research" in the OM field (Frohlich, 2002).

Whilst low response rates are a very real concern in survey research, there are various techniques that the researcher can employ, and Frohlich (2002) recommends exploiting "every trick in the book" in certain circumstances in order to achieve an acceptable response. These techniques are summarised in Table 4.2.

Table 4.2 Techniques for Improving Response Rates

Technique	Definition
Pre-Notice	Brief advance letter or phone call to generate early interest
Sponsorship	Endorsement of survey by third party and/ or use of their logo on the survey
Multiple Mailings	Multiple waves of mailings, usually 2-3 waves with cover letters and extra surveys and/ or increasingly firm reminder letters
Appeals	Direct/ sincere request for help in the cover letter
Results	Offer in the cover letter to provide a copy of the results
Steady Pressure	Periodic calling and/ or mailings until manager says yes or no
Leverage Design	Having a business partner/ contact like a major customer or the corporate office request survey completion
Subject interest	Channelling the survey to the most appropriate/ interested manager
Pre-paid postage	Including pre-paid postage return envelope
Formatting	Carefully spaced questions and survey laid out to look easy to do, put most interesting questions first
Pre-tested survey	A pilot to improve readability, question order, and remove ambiguous questions
Existing scales	Using, where possible, reliable prior scales and therefore having to ask fewer questions.

It is not so much the application of these techniques individually that result in improved survey response- but more the combined effect of employing as many techniques as is considered appropriate in a given survey implementation.

In different circumstances different survey methodologies are appropriate. The following section goes on to consider the actual data collection methodologies used for each of the proposed research frameworks in Chapter 3 and essays developed in Chapters 5, 6 and 7.

4.2 DATA COLLECTION

This section introduces the specific mail, telephone and Internet survey methodologies chosen to collect data for each of the respective essays developed in Chapters 5, 6 and 7. Further methodological issues relating to survey design and implementation, sampling procedures, measurement, operationalisation of variables and missing data are discussed within the context of each essay.

Survey administration, protocol information and questionnaire items not covered in this section or the relevant essay sections are included in Appendices 1 to 5.

4.2.1 Data Collection for Essay 1: Existing Mail Survey

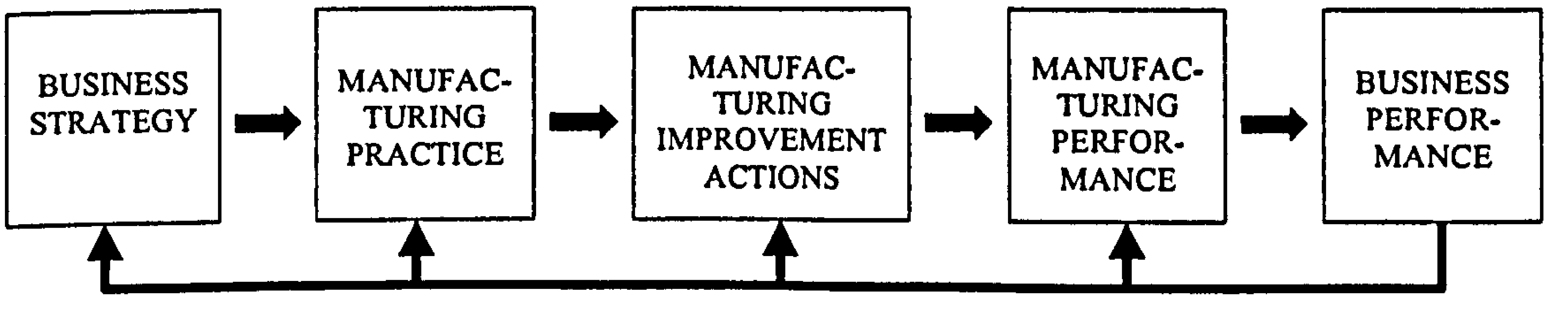
Given the exploratory nature of this first research essay, it was considered most appropriate to make use of an existing research network- the International Manufacturing Strategy Survey (IMSS). This was considered particularly appropriate since the main focus of the existing IMSS survey network is to test broad hypotheses relating to the effect of operational strategies, practices and procedures upon the operational and business performance of manufacturing-oriented companies. Several excellent publications have been based upon previous IMSS data collections (e.g. see Voss & Blackmon, 1998; Ettlie, 1998; Frohlich & Westbrook, 2001).

4.2.1.1 The 2001 IMSS Mail Survey

The International Manufacturing Strategy Survey (IMSS) evolved from other surveys in 1993, to provide the research community with information on how manufacturing firms face serious challenges under different national and industrial contexts. The survey is carried out every 2 to 3 years, with the previous survey being conducted in 1998. The IMSS has covered up to 23 countries, with the participation of 25 leading academic institutions and 703 firms. The survey is designed to explore and identify the strategies and practices utilised by manufacturing firms around the world.

The IMSS survey is posed to the Director of Operations/ Manufacturing of selected 'best practise' companies and is divided into several sections. The overall model for the IMSS research survey is shown in Figure 4.3.

Figure 4.3 Research Model for International Manufacturing Strategy Survey



4.2.1.2 Operationalisation of Variables

Prior to carrying out the data collection, question items in the existing IMSS survey instrument were reviewed for usefulness for this doctoral study, and the following sections were considered particularly appropriate for operationalisation of dependent, independent and control variables:

Section A: Strategies, objectives and costs
Section B: Current manufacturing and integration practices and initiatives
Section D: Manufacturing Performance

Existing survey items were carefully selected to capture the appropriate constructs for 'performance' and both the structural and procedural dimensions of 'knowledge transfer'- as per the previous definitions. The survey items and operationalisation of variables are discussed within the first essay in Chapter 5, Section 5.4.

4.2.1.3 Mail Questionnaire Administration

To improve reliability and scientific robustness of the global IMSS database, guidelines were issued aimed at uniformity in the way the survey was managed around the global network. The guidelines were generic enough to leave some degrees of freedom to the national research groups- allowing them to customise the methodology to suit the local specificity and needs. The process of survey management was articulated in 5 main steps relating to:

1. **Population Definition:** ISIC Division 38- Manufacture of Metal Products, Machinery and Equipment
2. **Sample Selection**
3. **Survey Planning and Management**
4. **Data Quality Control**
5. **UK Specific IMSS Methodology**

Appendix 1 further details the IMSS survey administration procedures and protocol.

4.2.1.4 Data Collected

The UK response sample is as shown in Table 4.3.

Table 4.3 Breakdown by Sector of UK IMSS Sample

ISIC sector (*)	No. of companies
381	20
382	9
383	9
384	4
385	4
Don't know	1
Total	**47**

Total non-respondents summed 57. The overall UK response rate was 45.19%. Of those responding, 10 had responded to the 1997 IMSS survey- providing some possibilities for longitudinal research. Data was collected following the IMSS guidelines, and using the latest existing version of a mail questionnaire instrument. Due to delays in data collection from other institutions, an early release of the IMSS data was used for exploratory analysis. The above UK data was added to that of the participating countries shown in Table 4.4.

Table 4.4 IMSS Survey Responses Per Participating Country

Country	Responses
Argentina	14
UK	47
Hungary	58
Norway	51
Germany	32
Ireland	32
Italy	60
Denmark	38
Australia	33
Spain	20
Total	**385**

To control for regional variations, the data from Australia and Argentina was removed for the analysis in Essay 1 (Chapter 5). The total sample used for Essay 1 thus consisted of 338 manufacturers and the response rate was over 20 percent.

4.2.2 Data Collection for Essay 2: Telephone Survey

4.2.2.1 The "European Spend Agenda" Telephone Survey

As previously discussed in Section 3.4.2, particularly good opportunities exist for comparisons between the upstream, supplier side of manufacturing and service supply chain contexts. In the light of this, a leading role was taken in the creation and annual implementation of a longitudinal telephone survey of large corporate purchasing. The 'European Spend Agenda' survey was conceived with the aim of identifying core themes, targets, obstacles and opportunities facing the purchasing function within large modern manufacturing and service organisations. The project was sponsored by *'Ariba'*- a leading commercial purchasing software provider, and launched in the UK, France, Germany, Italy and Benelux. The telephone delivery of the survey was conducted through a reputable commercial market research firm- 'Vanson Bourne'.

In line with the research framework for Essay 2 formulated in Chapter 3, the telephone survey instrument was specifically designed and implemented to capture appropriate and quality data corresponding to the required dimensions of supply chain 'purchasing competence' and performance in manufacturing and service supply chain contexts.

4.2.2.2 Operationalisation of Variables

Survey items were created for the 'purchasing competence' independent variable, in strict accordance with the existing work of Narasimhan et al. (2001). The resulting survey questions covered each of the Narasimhan et al. (2001) purchasing competence dimensions- and additionally, the dimension 'IT Competence'.

Survey items were also created for the purchasing performance dependent variables following the work of Chao et al. (1993). A combination of the most important Chao et al. (1993) objective and subjective measures were included as survey items.

The full survey instrument, as delivered by a trained telephone researcher, is reproduced in Appendix 2.

4.2.2.3 Telephone Survey Administration

Best practice guidelines were formulated and followed to ensure uniformity in the way the survey was managed and implemented by the commercial market research firm across manufacturing and service companies and the different countries involved. Details relating to population definition, sample selection, survey planning and management and data quality control for the telephone survey design and implementation are outlined in Essay 2 Section 6.4 and in Appendix 3.

4.2.2.4 Data Collected

Table 4.5 shows the individual country sampling to achieve a total final sample size of 200 manufacturing and financial services responses. The table also indicates the standard method for calculating response rates in such telephone surveys.

Table 4.5 Overall Sample Responses per Country

Country	A. Total Sample supplied	B. Interviews completed	C. Refusals	D. Callbacks	E. Rejected (not qualifying)	F. Unused sample	G. Response rate (B/(A-E-F)
Germany	458	50	83	33	0	292	30%
France	407	50	84	115	19	139	20%
Italy	619	25	46	89	14	445	16%
Benelux	287	25	50	69	10	133	17%
UK	409	50	48	60	5	246	32%
Overall	**2180**	**200**	**311**	**366**	**48**	**1255**	**23%**

Further analysis of responses and aspects relating to the collection of this telephone survey data are discussed in Essay 2, Section 6.4.

4.2.3 Data Collection for Essay 3: Internet Survey

4.2.3.1 The Supply Chain Operational Performance Evaluator (SCOPE) Online Survey

For the last data collection, an Internet survey approach was selected. One reason for choosing this approach was to increase motivation of targeted respondents to take part in the survey and thus maintain high response rates. In particular, in order to stimulate practitioner interest the online survey was programmed to provide real-time feedback of the participant's scores as they progress through the survey. The online feedback charts compare their scores with the 'best-in-sector' and sector mean. Furthermore, in line with the suggestions of Frohlich and Done (2004) it was felt that such an approach would lay a foundation for interesting areas of exploration beyond the current doctoral research. For example, the author aims to use online survey methods to take the first tentative steps towards expanding the unit of analysis to the whole supply chain. Whilst this is clearly beyond the scope of this research study, the current early form of the SCOPE online survey is appropriate for investigating the underlying dimensions of supply chain maturity, as previously outlined. The Healthcare sector is identified as an ideal sector to commence data collection and analysis with this interactive survey instrument.

To fully detail the contents of the SCOPE online survey is beyond the space limitations of this dissertation document- nevertheless, it can be accessed via Internet Explorer at the following URL address: http://scope.london.edu/healthcare

To enter the real-time, interactive survey please enter the following when prompted for your email address: **[yourname]@test.com**

Select "New User" and enter the following password (twice): **test101**

4.2.3.2 Operationalisation of Variables

As previously discussed in Chapter 3, the 'maturity' construct is composed of both knowledge management dimensions and supply chain practice dimensions. It is operationalised by asking questions regarding the extent to which the company collaborates and shares knowledge with supply chain partners across each of the Supply Chain Council (2004) SCOR model areas of Plan, Source, Deliver, Make, New Product Development and Returns. These questions were formulated following a comprehensive review of the practitioner and academic literatures. Similarly, a series of operational performance measures were adopted from the literature and included in the online survey instrument.

Whilst a full representation of the interactive and adaptive online survey instrument is not possible within the space constraints of this document, the embedded survey items used to collect data for analysis are listed in Appendix 4.

4.2.3.3 Online Survey Administration

The survey was designed, programmed, developed and pre-tested in several phases over 12 months for both functionality and content suitability. In addition a pilot test was conducted to ensure practitioner usability and appropriateness for generating quality academic empirical data. Preliminary analyses were conducted to confirm that the data generated was suitable for creating the proposed valid and reliable parsimonious supply chain maturity scales. The pilot study also confirmed a high interest level amongst practitioners to take part in the survey. The pilot test identified a few minor wording improvements and two insignificant survey items. These were dropped from subsequent releases in the interests of survey brevity.

Details relating to population definition, sample selection, survey planning and management and data quality control for the online survey administration are outlined in Essay 3 section 7.4 and in Appendix 5.

4.2.3.4 Data Collected

Table 4.6 shows the individual sub-sector sampling and also indicates the standard method for calculating response rates.

Table 4.6 Analysis of Healthcare Product Supplier Samples and Response Rates

Sub-Sector	A. Total Supply Base Considered	B. Rejected (non-product suppliers)	C. Out-of-date contacts	D. Total Companies Contacted (A-B-C)	E. Total Surveys Completed	F. Response Rate (E/D)
Diagnostic & Medical	135	18	15	102	30	29.4%
Food and Nutrition	109	21	27	61	15	24.6%
Facilities/ Utilities	195	71	41	83	12	14.5%
Pharmaceuticals	187	37	55	95	13	13.7%
Office Services	61	33	4	24	9	37.5%
Rehabilitation Services	174	125	30	19	6	31.6%
Textiles & Domestics	68	21	17	30	11	36.7%
IT	193	114	51	28	10	35.7%
Medical & Surgical	209	59	48	102	33	32.4%
Other	280	155	73	52	15	28.8%
Overall	**1611**	**654**	**361**	**596**	**154**	**25.8%**

A total of 596 Supply Chain Managers and Directors from all relevant healthcare product supplier categories were invited to access the online survey. From these, 154 full responses were obtained, constituting a good overall response rate of 25.8%. Whilst response rates did vary across the supplier categories this was within acceptable limits, and each product category was adequately represented in the final respondent sample. This data collection is discussed further in Essay 3, Section 7.4.

4.3 DATA ANALYSIS

From the literature, it is clear that empirical survey data is best analysed by multivariate techniques. As Gatty (1966) states:

> "For the purposes of... any... applied field, most of our tools are, or should be, multivariate. One is pushed to a conclusion that unless a ... problem is treated as a multivariate problem it is treated superficially."

Hardyck and Petrinovich (1976) go further:

> "Multivariate analysis methods will predominate in the future and will result in drastic changes in the manner in which research workers think about problems and how they design their research. These methods make it possible to ask specific and precise questions of considerable complexity in natural settings. This makes it possible to conduct theoretically significant research and to evaluate the effects of naturally occurring parametric variations in the context in which they normally occur. In this way, the natural correlations among the manifold influences can be studied statistically without causing a typical isolation of either individuals or variables."

Hair et al. (1998, p. 4) state:

> "It is only through multivariate techniques that multiple relationships... can be adequately examined to obtain a more complete, realistic understanding..."

Whilst the actual data analysis is undertaken within each of the three essays, the following section overviews particularly relevant multivariate analysis techniques.

4.3.1 Multivariate Analysis

Hair et al. (1998, p. 6) broadly define multivariate analysis as all statistical methods that simultaneously analyse multiple measurements on each individual or object under investigation. To be considered truly multivariate, and not just multivariable, all the variables must be random and interrelated in such ways that their different effects cannot meaningfully be interpreted separately. The purpose of multivariate analysis is to measure, explain and predict the degree of relationship among variates. Thus the multivariate character lies in the multiple variates (multiple combinations of variables), and not only in the number of variables or observations.

4.3.1.1 Types of Multivariate Techniques

The following multivariate analysis techniques (Hair et al., 1998; Cohen et al., 2003) prove to be particularly useful in the analysis of the data collected from the above three surveys.

Principle Components and Common Factor Analysis

Factor analysis (including principle component and common factor analysis) is a statistical approach that can be used to analyse interrelationships among a large number of variables and to explain these variables in terms of their underlying dimensions- or factors. The objective is to find a way of condensing the information contained in a number of original variables into a smaller set of variates (factors) with a minimum loss of information. By providing an empirical estimate of the structure of the variables considered, factor analysis becomes an objective basis for creating summated scales.

Multiple Regression

Multiple regression is the appropriate method of analysis when the research problem involves a single metric dependent variable presumed to be related to two or more metric independent variables. The objective of multiple regression analysis is to predict the changes in the dependent variable in response to changes in the independent variables. This objective is most often achieved through the statistical rule of least squares.

Whenever the researcher is interested in predicting the amount or magnitude of the dependent variable, multiple regression is useful. For example, monthly expenditures on dining out (dependent variable) might be predicted from information on a family's income, its size, and the age of the head of household (independent variables).

Structural Equation Modelling

Structural equation modelling, often referred to simply as LISREL (the name of one of the more popular software packages), is a technique that allows separate relationships for each of a set of dependent variables. In its simplest sense, structural equation modelling provides the appropriate and most efficient estimation technique for a series of separate multiple regression equations estimated simultaneously. It is characterized by two basic components:

1) The structural model
2) The measurement model.

The structural model is the "path" model, which relates independent to dependent variables. In such situations, theory, prior experience, or other guidelines allow the researcher to distinguish which independent variables predict each dependent variable. Models discussed previously that accommodate multiple dependent variables-multivariate analysis of variance and canonical correlation-are not applicable in this situation because they allow only a single relationship between dependent and independent variables.

The measurement model allows the researcher to use several variables (indicators) for a single independent or dependent variable. For example, the dependent variable might be a concept represented by a summated scale, such as self-esteem. In the measurement model the researcher can assess the contribution of each scale item as well as incorporate how well the scale measures the concept (reliability) into the estimation of the relationships between dependent and independent variables. This procedure is similar to performing a factor analysis of the scale items and using the factor scores in the regression.

Canonical and Set Correlation

Canonical correlation analysis can be viewed as a logical extension of multiple regression analysis. Multiple regression analysis involves a single metric dependent variable and several metric independent variables. With canonical analysis, the objective is to correlate simultaneously several metric dependent variables and several metric independent variables. Whereas multiple regression involves a single dependent variable, canonical correlation involves multiple dependent variables. The underlying principle is to develop a linear combination of each set of variables (independent and dependent) to maximise the correlation between the two sets. Stated differently, the procedure involves obtaining a set of weights for the dependent and independent variables that provide the maximum simple correlation between the set of dependent variables and the set of independent variables.

The technique of set correlation analysis provides a further extension to canonical correlation and addresses the two weaknesses of the canonical technique. Firstly, set correlation provides a single measure of strength of the overall relationship between dependent and independent variables; and secondly, set correlation analysis offers greater scope in terms of understanding the nature of these relationships. In these respects, the technique of set correlation analysis is a sophisticated methodology that provides a single framework of measures of association, parameter estimation, hypothesis testing, and statistical power analysis that encompasses most of the standard data-analytic methods (Cohen et al., 2003, p. 609).

4.3.2 Guidelines for Multivariate Analyses and Interpretation

Hair et al. (1998, p. 22) outline the usefulness of multivariate methods, yet are also careful to caution their use without the requisite conceptual foundation to support the selected technique. They reason that analysis and interpretation of any multivariate problem can be helped by following a set of general guidelines, and set out a "philosophy of multivariate analysis" that includes:

- <u>Establish Practical significance as well as Statistical Significance</u>: Practical significance asks the question "So what?" For any managerial application, the results must have a demonstrable effect that justifies action. In academic settings, research is becoming more focused on not only the statistically significant results, but also their substantive and theoretical implications, which are many times drawn from their practical significance."
- <u>Sample size affects all results</u>: For smaller samples, the sophistication and complexity of the multivariate technique may easily result in either a) too little statistical power for the test to realistically identify significant results, or b) too easily an "overfitting" of the data such that the results are artificially good because they fit the sample very well, yet have no generalisability.
- <u>Know your data:</u> Multivariate analysis require a rigorous examination of data because of the influence of outliers, violations of assumptions, and missing data can be compounded across several variables to have quite substantial effects. The

multivariate researcher must take the time to use diagnostic techniques for a greater understanding of the data and the basic relationships that exist.

- Strive for Model Parsimony: "Multivariate techniques are designed to accommodate multiple variables in the analysis. This feature, however, should not substitute for conceptual model development before the multivariate techniques are applied. Although it is always more important to avoid omitting a critical predictor variable, termed specification error, for several reasons the researcher must also avoid inserting variables indiscriminately and letting the multivariate technique "sort out" the relevant variables." Firstly, irrelevant variables increase the technique's ability to fit the sample data- but at the expense of overfitting the data and making them less generalisable to the population. Secondly, irrelevant variables do not typically bias the estimates of the relevant variables, but they can mask the true effects because of multicollinearity. As multicollinearity rises, the ability to define any variable's effect is diminished. Thus including variables that are conceptually irrelevant can have harmful effects even if they do not directly bias the model results.
- Look for errors: Errors (e.g. the residuals in regression analysis, outliers in cluster analysis) should not be looked upon as a measure of failure or merely something to eliminate, but as a starting point for diagnosing the validity of the obtained results and an indication of the remaining unexplained relationships.
- Validate your results: One of several methods: a) splitting the sample and using one sub-sample to estimate the model and the second sub sample to estimate the predictive accuracy, b) employing a "bootstrapping" technique, c) gathering a separate sample to ensure that the results are appropriate for other samples. The researcher must strive not only to estimate a significant model but to ensure that it is representative of the population as a whole.

4.3.3 Examining the Data

Careful examination of the raw survey data prior to conducting multivariate analysis needs to be carried out with the aim of creating a data set that would lead to better prediction and more accurate assessment of dimensionality. In particular, the issue of missing data needs to be addressed.

"Missing data are a fact of life in multivariate analysis; in fact, rarely does the researcher avoid some form of missing data problem. For this reason, the researcher's challenge is to address the issues raised by missing data that affect the generalisability of results. To do so, the researcher's primary concern is to determine the reasons underlying the missing data, with the extent of missing data being a secondary issue in most instances. This need to focus on the reasons for missing data comes from the fact that the researcher must understand the processes leading to the missing data in order to select the appropriate course of action." (Hair et al., 1998, p. 46)

Tsikriktsis (2002) says that researchers should not fall into the trap of listwise deletion that provides a "quick and easy fix". Listwise deletion reduces statistical power and accuracy more than many other techniques. Instead, he suggests researchers should consider the recommendations in Table 4.7.

Table 4.7 Techniques to Deal With Relevant Patterns of Missing Data

Amount of missing data	*Pattern* Missing completely at random	Missing at random	Non-missing at random
Less that 10%	1) Pairwise 2) Regression or hot-deck	1) Hot-deck 2) ML 3) Regression	1) ML 2) Hot-deck or regression
More than 10%	1) Pairwise 2) Regression or hot-deck	1) Hot-deck 2) ML	1) ML

Notes: a) The preferred order of the missing data techniques is denoted by the number in front of each technique. b) The above table is based on original work by Roth (1994).

4.4 SUMMARY

This chapter outlines the methodological approaches taken in order to investigate the research model proposed in Chapter 3. A research strategy was formulated consistent with appropriate philosophical and epistemological research considerations set out by seminal operations management, business and social research guidelines. The research design of this study fits with the largely positivistic nature of existing OM research and is based upon the collection and analysis of quantitative empirical data. In attempting to contribute to the rigorous OM literature the research design takes account of the scientific process of theory driven hypotheses being checked against observed facts to produce generalisations that support, contradict or modify the original theory.

Survey research methodologies have proved to be particularly valuable in this respect in the OM field, and as such, were chosen as the basis for this doctoral investigation. The role of exploratory and explanatory survey research in theory development were considered, and due regard given to the important issue of linking theoretical and operational domains. Also specific survey implementation procedures were addressed with a view to i) reducing overall survey error, ii) attaining high response rates and iii) effectively communicating the intended survey items. The research design also accounted for "good" survey research attributes and techniques for achieving adequate response rates in OM research. This highlighted the need for different survey methodologies tailored to meet different research goals.

Thus three separate survey data collections were conducted corresponding to each of the three research questions and essays framed in Chapter 3 and developed in Chapters 5, 6 and 7. Issues such as variable operationalisation and survey administration were treated totally distinctly for each survey, the major characteristics of which were as follows:

1. Mail Survey for Essay 1: An exploratory survey exercise capitalised upon the established International Manufacturing Strategy Survey (IMSS) network. A total of 385 manufacturing companies corresponding to ISIC division 38 were surveyed across 10 countries. The overall response rate was over 20% whilst the specific UK survey administration resulted in a 45% response rate.

2. Telephone Survey for Essay 2: A purpose-designed survey to capture specific competence and performance measures across manufacturing and service contexts. A total of 200 high-turnover European companies, divided equally between manufacturing and financial service sectors were surveyed. With the support of a commercial market research firm best practice was followed, resulting in a good response rate of 23%.

3. Internet Survey for Essay 3: An innovative web-based survey developed as part of this doctoral investigation with the intent of advancing supply chain research methodologies. The aim was to design a survey instrument to collect data for Essay 3 (in addition to laying the foundation for interesting areas of investigation beyond the current doctoral investigation.) The adaptive survey instrument allowed for differing supply chain operational configurations and appropriate

practices. A total of 154 product suppliers to the UK Healthcare service sector were surveyed across the various supply classifications and an overall good response rate of 26% was achieved.

With regard to examining, analysing and interpreting the data collected, various guidelines and multivariate techniques were considered. The following multivariate techniques were judged to be of particular relevance and usefulness for the purposes of this doctoral investigation:

a. Principle components and common factor analysis
b. Multiple regression
c. Structural equation modelling
d. Canonical and set correlation analysis.

The following Chapters 5, 6 and 7 use the methods described in this chapter to investigate the research questions and to develop the essays framed in Chapter 3. Overall conclusions are presented in Chapter 8.

CHAPTER 5 – ESSAY 1:

INVESTIGATING EXPLICIT KNOWLEDGE TRANSFER IN MANUFACTURING SUPPLY CHAINS

5.1 INTRODUCTION

Growing evidence suggests that companies must efficiently and effectively create, capture, and share knowledge in order to solve problems and exploit opportunities (Brown & Duguid, 1991; Drucker, 1991; Kogut & Zander, 1992; Davenport et al., 1996). Unfortunately, most organizations find that successful knowledge management is an uphill struggle and its benefits elusive (Heibeler, 1996; Payne, 1996). Consequently, this field has become one of the most hotly debated yet least understood topics in business today (Hult, 2003).

While theoretical work such as Nonaka (1994) has started unravelling the riddles of internally generated knowledge, our understanding about externally created knowledge is still relatively weak. There is an especially notable gap in the knowledge management literature from an integrated upstream and downstream supply chain perspective (Hult et al., 1999). Despite the apparent synergies between the areas, to date limited work has been carried out that applies relevant supply chain concepts to the field of knowledge management, and vice versa for that which applies a knowledge perspective to the field of supply chain management. Just as Bowersox et al. (2000) predicted, knowledge based learning is becoming a key to revolutionizing 21st century supply chains, and yet many questions still remain unanswered about the topic.

Investigation of external knowledge is especially important for two reasons. First, there is a need to develop a finer-grained understanding of the transfer processes involved in coordinating and sharing inter-organizational knowledge between external partners in the supply chain (Hult et al., 2000). Notably, a better understanding of the coordination of knowledge between suppliers and customers will extend previous work like Cohen and Levinthal (1990), Mowery et al. (1996), Ingram and Baum (1997), and Ahuja (2000) that considered the acquisition of 'generic' knowledge from somewhere in an organization's surrounding environment.

Second, the supplier - manufacturer - customer triad needs to be considered in unison, and the possible directional implications of knowledge transfer merit greater investigation. The limited existing work in this area has generally focused on knowledge transfer from either the supply side or the customer side of a manufacturer (Schonberger, 1990; Slater & Narver, 1995; Hult et al., 2000; Ulwick, 2002) but rarely takes a more integrated supply chain perspective of simultaneous upstream and downstream flows. Hence, there remains the need to compare each of these directions of knowledge transfer in one single piece of work. Frohlich and Westbrook (2001) raised the question "is it more important to link with suppliers, customers or both?" and this question has not yet been addressed from a knowledge perspective. While both Huber (1991) and Gupta and Govindarajan (2000) reference knowledge "richness", no research has so far isolated the comparative richness of external knowledge emanating from upstream versus downstream in the supply chain.

This essay aims to make distinct theoretical contributions and identify managerial implications by linking the knowledge management and supply chain management streams. The knowledge management literature recognises two forms of knowledge: explicit, codified knowledge and tacit 'know-how' (Polyani, 1966; Brown & Duguid, 1991; Romer, 1995). Both explicit and tacit forms of knowledge are important and constitute the information, opinions and expertise present within organisations (Nonaka, 1994). Recent studies have investigated both explicit and tacit components of knowledge within organisations (e.g. Edmondson et al., 2003). Yet, this investigation focuses upon explicit knowledge since it plays an increasing role for modern organizations and is more precisely formulated and articulated thus enabling accurate empirical analysis (Zack, 1999). Within a supply chain context explicit knowledge incorporates, and goes beyond, the provision of operating data and information to suppliers and customers to include both 'declarative' and 'procedural' knowledge components (Kogut & Zander, 1992). Declarative explicit knowledge transfers between organisations include shared inventory and delivery information. Procedural explicit knowledge transfers include joint activities such as planning and forecasting, and shared methods such as Kanban. Using manufacturers positioned between suppliers and customers as the unit of analysis, we developed a model that investigated the impact upon performance of upstream and downstream explicit knowledge.

The next section of this chapter reviews the literature on knowledge and supply chain management and develops specific hypotheses concerning their relationships. Subsequent sections describe the data and hypotheses tests, discuss the results, draw conclusions, and consider the managerial implications. The last section outlines suggestions for further research.

5.2 EXPLICIT KNOWLEDGE IN THE SUPPLY CHAIN

Building upon earlier works such as MacKay (1969), Churchman (1971), Bruner (1973), Bobrow and Collins (1975), Matchlup (1980), and Dretske (1981), Zack (1999) offers a refined explanation and definition of explicit knowledge. He defines this form of knowledge as being distinct from data and information in that it "can be viewed both as a thing to be stored and manipulated and as a process of simultaneously knowing and acting - that is, applying expertise."

When combined with the work of Kogut and Zander (1992) and Albino et al. (1999), Zack's (1999) definition suggests two dimensions to explicit knowledge in the supply chain. The first dimension involves the 'declarative' or 'structural' elements of storing and sharing knowledge related to issues such as inventory levels, production plans and delivery frequencies. The second explicit knowledge dimension involves the 'procedural' elements of coordinating, planning, and forecasting between partners in the supply chain, as well as shared methods such as Kanban. Similarly, Handfield and Nichols (1999), Hill (2000), and Chase et al. (2001) note in their definitions of supply chain management that knowledge storing/sharing systems, procedural activities and application of combined expertise are integral to supply chain partnerships. In short, explicit knowledge is generated and transferred in supply chains and this knowledge needs to be effectively managed.

While there is evidence in the literature that organizational knowledge is an important determinant of competitiveness (Brown & Duguid, 1991; Kogut & Zander, 1992; Davenport et al., 1996; Quinn et al., 1996) not all knowledge creation, capture, and distribution are equal. Some studies have demonstrated the value of looking beyond the boundaries of the organization in order to capture beneficial knowledge (Cohen & Levinthal, 1990; Hagedoorn & Schekenraad, 1994; Mowery et al., 1996; Hansen, 1999; Ahuja, 2000).

Others highlight the dangers of only searching inwards for beneficial knowledge. Brown and Duguid (1991) reported on the emergence of unified internal working, learning, and innovating practices that become a performance limiting phenomena. Ingram and Baum (1997) demonstrated that a firm can develop knowledge internally that is beneficial to its capacity to compete in a changing environment - but in the long run this can lead to 'competency traps' that diminish performance. Levinthal and March (1993) warned that an organization that does not look externally for new knowledge is in danger of becoming 'myopic'. Similarly, over exploiting internal knowledge can be self-destructive in the long run and lead to corporate 'inertia' (Miller & Chen, 1994).

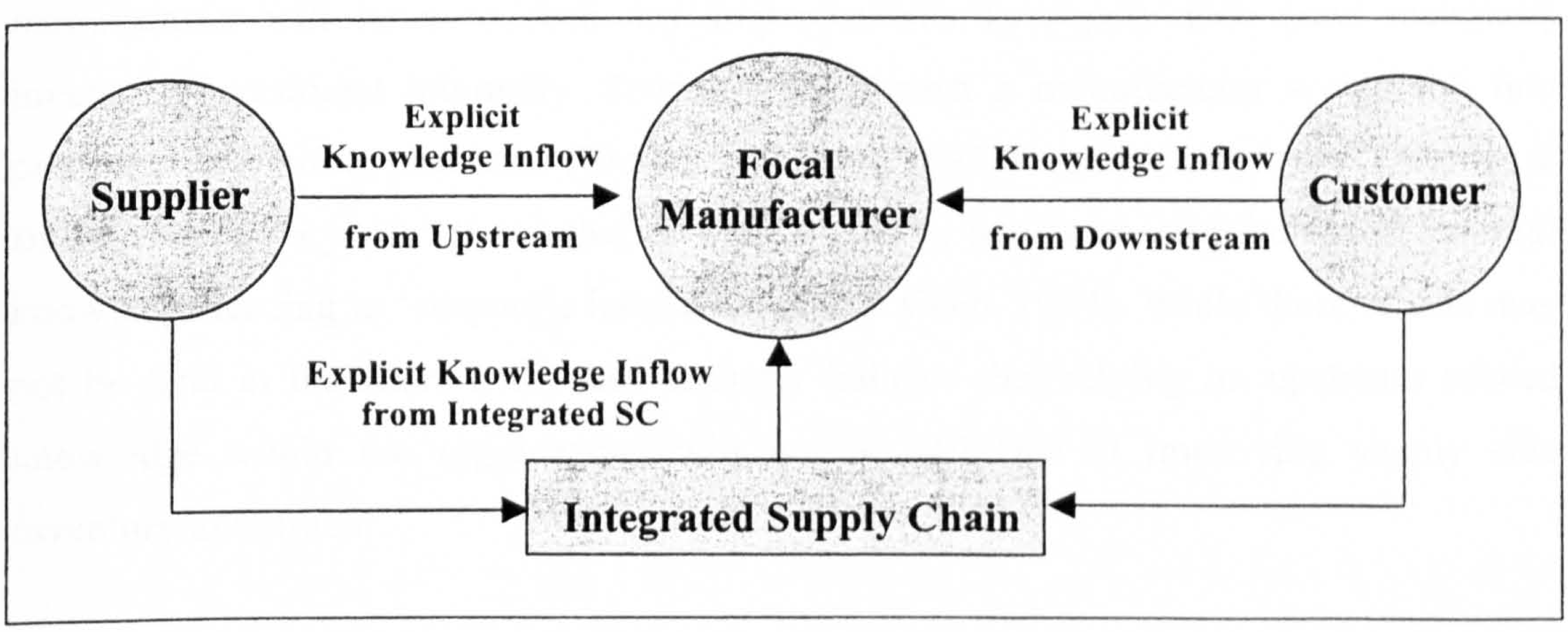
At the same time, the supply chain literature notes the benefits of sharing information with and coordinating activities between supply chain partners in order to overcome problems (Davis, 1993; Fisher et al., 1994; Fisher, 1997; Lee et al., 1997a; Magretta, 1998). The importance of suppliers and customers as potential sources of beneficial knowledge becomes even more apparent when considering that these are usually the most aligned towards the mutual objectives of a manufacturer of all external organizations. Hence there is more chance of success in terms of knowledge adoption from these sources than from any others (Cohen & Levinthal, 1990; Almeida, 1996; Dussuage et al., 2000).

In summary, the knowledge management and supply chain literature parallel each other in the proposition that external explicit, codified knowledge shared and coordinated between supply chain partners significantly benefits internal organizational efficiency. This proposition warrants further analysis of the links between external explicit knowledge in the supply chain and improved organizational efficiency. The next section therefore moves on to develop finer-tuned hypotheses regarding explicit knowledge sharing and coordination activities with specific upstream, downstream, and integrated supply chain sources.

5.3 CONCEPTUAL MODEL AND HYPOTHESES DEVELOPMENT

The evolving supply chain literature, and some knowledge based research, has taken the general 'external' viewpoint further. While showing that externally focused efforts can have dramatic effect upon organizational efficiency and performance, it also demonstrates the need for refining research on explicit knowledge flows in specific parts and directions in the supply chain. In this regard, we used the conceptual framework in Figure 5.1 in order to develop more refined hypotheses. The framework is that of a manufacturing company in a three-member supply chain. Potentially valuable external explicit knowledge can be acquired by the focal manufacturer from either upstream suppliers or downstream customers. That is, there is potential positive explicit knowledge inflow from upstream and downstream. As discussed above, while there are other external sources of potentially beneficial explicit knowledge, these are likely to be the major ones since arguably the strongest external relationships that a typical manufacturing company has are with customers and suppliers - especially when it comes to sharing explicit knowledge.

Figure 5.1 Essay 1 Theoretical Framework



In addition, the supply chain management literature provides strong support for the value of integrating information sharing and processing activities across the different supply chain members (e.g. Stevens, 1989; Narasimhan & Jayaram, 1998; Frohlich & Westbrook, 2001). This suggests that if a manufacturer is in a position to do so, it can also benefit from explicit knowledge emanating from an 'integrated supply chain' (Reck & Long, 1988; Clinton & Closs, 1997; Bowersox et al., 2000).

By combining activities with external organizations in a supply chain in each of the structural and procedural dimensions of knowledge discussed above, explicit knowledge transfer will be achieved. More specifically, according to Cohen and Levinthal (1990) as long as the formal codified organizational routines are in place to ensure an adequate absorptive capacity, as well as sufficient motivational disposition and transmission channels (Gupta & Govindarajan, 2000), then explicit knowledge inflow into the focal manufacturer will take place.

5.3.1 Explicit Knowledge Inflow from Upstream in the Supply Chain

Hult et al. (2000) found a positive effect of organizational learning antecedents upon internal purchasing information processing and cycle time performance. This corresponds favourably to the supply side of our conceptualisation, even though theirs was primarily an internal study. While the internal/external distinction is important, if there are high efforts to share and coordinate explicit knowledge with external suppliers then it should also improve performance.

Conversely, if there is little or no explicit knowledge inflow from upstream, then a manufacturer will have to seek any improvements in supply side (raw materials) inventory investment internally. Sooner or later such a manufacturer would run into performance limiting problems (Brown & Duguid, 1991), 'competency traps' (Ingram & Baum, 1997), 'myopia' (Levinthal & March, 1993), and over exploitation of internal knowledge leading to 'corporate inertia' (Miller & Chen, 1994). While these effects may not be fatal in the short term, they strongly indicate that relying on upstream related knowledge within the organization will not be effective at improving supply side inventory investment.

The supply chain literature supports this argument. Bowersox et al. (2000) discuss the need for collaborative arrangements with suppliers that surpass mere information sharing and move towards common vision and cross-organizational actions and behaviour. Handfield (1993) provides empirical evidence of greater information sharing and interaction with suppliers leading to improved upstream procedures. Narasimhan and Jayaram (1998) also provide empirical evidence for strategic sourcing interaction with suppliers as positively influencing manufacturing goal achievement. Finally, Krause

(1999) demonstrates the importance of liaising and combining expertise in the development of suppliers to achieve the buying firm's supply needs.

The supply chain management literature as a whole treats low inventory investment as being synonymous with higher levels of organizational efficiency. In keeping with this perspective, low inventory investment is used in this paper as the desired outcome of explicit knowledge inflows. Accordingly, based upon the existing knowledge and supply chain literature, we hypothesize the following:

H1: Explicit knowledge inflow from upstream in the supply chain will lead to a reduction in inventory investment.

5.3.2 Explicit Knowledge Inflow from Downstream in the Supply Chain

Hult et al. (1999) showed that facets of organizational learning have a positive influence on customer orientation and relationship commitment. In itself, this provides no firm evidence to expect improved organizational efficiency, yet it does lend knowledge-based support to Schonberger (1990), who suggested that more effective firms have long-linked partnerships with their external customers. From a marketing knowledge perspective, Slater and Narver (1995) suggest that performance can be enhanced when a 'market orientation' (i.e. customer focus) is combined with organizational learning. Thus, while the existing knowledge-based literature relating specifically to the customer side of the supply chain is limited, it does provide important theoretical evidence for downstream knowledge inflow potentially serving to improve organizational efficiency.

If the reverse were true, and there were little or no knowledge inflow from downstream, then a manufacturing company would have to seek any improvements in customer side (finished goods) inventory investment from within. As with the earlier argument in favour of upstream knowledge inflow, sooner or later, such a manufacturer would run into the same problems of performance limitations (Brown & Duguid, 1991), 'competency traps' (Ingram & Baum, 1997), 'myopia' (Levinthal & March, 1993), and 'corporate inertia' (Miller & Chen, 1994). Therefore, with little or no knowledge inflow from downstream customers, it is likely there would be a corresponding undesirable increase in customer related inventory investment.

This argument is supported by the supply chain literature that considers downstream issues. Bowersox et al. (2000) point to downstream initiatives for establishing efficient, effective and relevant downstream inventory solutions by gaining an understanding of what drives customer purchase behaviour. They declare that "success hinges on establishing intimate relationships with key customers" and also upon sharing information with customers rather than anticipatory inventory planning. Evidence suggests that the stronger the downstream manufacturer/ customer integration is in a supply chain the greater the benefits (Narasimhan & Jayaram, 1998; Johnson & Scudder, 1999). Downstream explicit knowledge integration with customers is therefore often crucial to a manufacturer's own supply chain performance (Bowersox et al., 2000; Stock et al., 2000). Blackburn (1991), Daugherty et al. (1999), and Waller et al. (1999) linked distribution programs like automatic response and JIT II to improved performance. Conversely, there are inherent hazards of not fully coordinating with downstream partners in the supply chain (Lee & Billington, 1992; Armistead & Mapes, 1993). Therefore, based upon the existing knowledge and supply chain literature, we hypothesize the following:

H2: Explicit knowledge inflow from downstream in the supply chain will lead to a reduction in inventory investment.

5.3.3 Explicit Knowledge Inflow from an Integrated Supply Chain

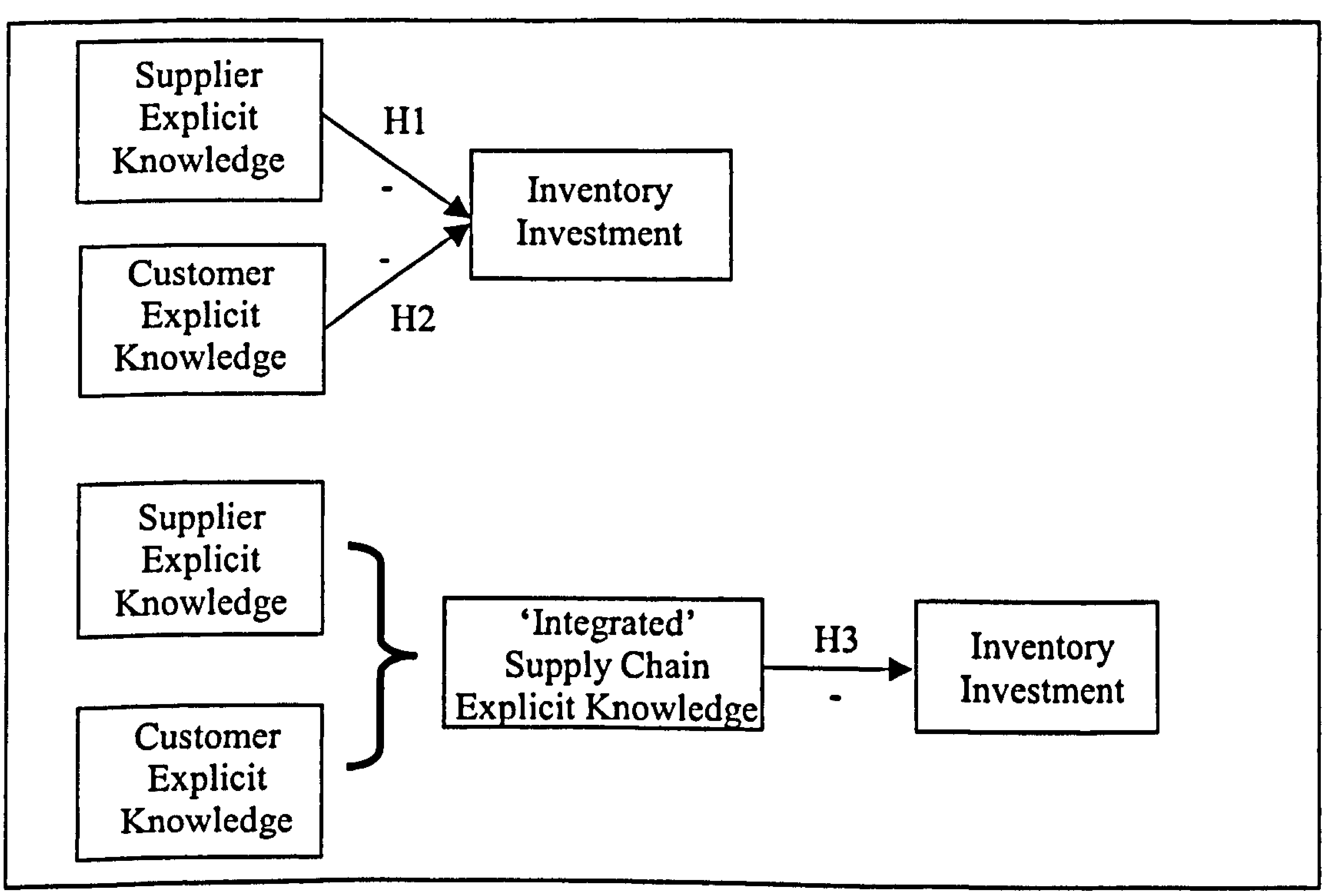
Zack (1999) reasoned that the "integration of [explicit] knowledge across different contexts opens an organization to new insights... increasing the scope and value of that knowledge. By being able to combine experiences... the scope of experience is broadened, as is the ability to learn from those experiences." Adding to this, Hult et al. (2000) took a rare organizational learning view of the entire customer to supplier supply chain, and found that learning facets have a positive correlation with general supply chain relationships. No conclusions are drawn for specific performance improvements from these works. Nevertheless, it would seem reasonable to infer that if the integration of explicit knowledge and improvement of relations across the supply chain allows for more, and better, organizational learning across the supply chain, then the ability for combined problem solving and opportunity exploitation will increase. Hence, explicit knowledge inflow from an integrated supply chain is likely to result in improved abilities to deal with functional problems such as excessive inventory investment.

The supply chain management literature provides strong empirical support for this argument. There has been growing consensus of the value in performance terms of coordinating and sharing supply chain information, and aligning organizational goals in order to improve overall supply chain efficiency. Frohlich and Westbrook (2001) showed that an integrated supply chain approach leads to performance improvements, reasoning that the "better coordination in the supply chain reduces uncertainty throughout the manufacturing networks", and that "tighter coordination helps eliminate any non-value-adding activities from internal and external production processes." Stock et al. (2000) looked at optimising the coordination of knowledge across an entire integrated supply chain, and reasoned that the level of organizational performance is dependent upon integrated information sharing from supplier to customer. One of the more important of the 'mega-trends' that will revolutionize supply chain logistics is the move from information hoarding to information sharing and "the open deployment of information across the supply chain is the catalyst that enables effective integration" (Bowersox et al., 2000). Therefore, based upon the existing knowledge management and supply chain literature, we hypothesize the following:

H3: Explicit knowledge inflow from an integrated supply chain will lead to a reduction in inventory investment.

The above three hypotheses are summarized in Figure 5.2.

Figure 5.2 Essay 1 Hypotheses



5.4 METHODS

The hypotheses were tested using data from the 2001 International Manufacturing Strategy Survey (IMSS). The IMSS survey was designed to explore and identify the philosophies, strategies and practices in manufacturing firms around the world. Respondents were typically Manufacturing VPs and therefore had ready access to all of the upstream and downstream knowledge and performance measures used in this paper. In order to control for regional variations, this study analysed eight European countries including Denmark, Germany, Hungary, Ireland, Italy, Norway, Spain and the United Kingdom. The IMSS sampling frame included between 20 and 60 manufacturers from each of the eight countries. In non-English speaking nations, full-time OM professors familiar with manufacturing strategy translated the surveys. The total sample used for this analysis was 338 manufacturers and the response rate was approximately 20 percent.

The IMSS sampled from single plants or business units within manufacturing companies belonging to the population as defined by ISIC Division 38: Manufacture of Fabricated Metal Products, Machinery and Equipment. A balanced number of surveys were gathered in each of the sub-industry sectors as seen in Table 5.1. The average company size was 1079 employees and the mean market share was 41 percent.

Table 5.1 ISIC Division 38 Sub-Divisions Represented in the 2001 IMSS Data

International Standard Industrial Classification of Economic Activities (ISIC- 1968)	
Major Division 3.	Manufacturing
Division 38.	Manufacture of Fabricated Metal Products, Machinery and Equipment

ISIC	Count	Percent	Definition
381	93	27.5	Manufacture of metal products, except machinery and equipment
382	89	26.3	Manufacture of machinery, except electrical
383	76	22.5	Manufacture of electrical equipment apparatus, appliances and supplies
384	32	9.5	Manufacture of transportation equipment
385	23	6.8	Manufacture of professional and scientific and measuring and controlling equipment not elsewhere classified, and of photographic and optical goods.
-	25	7.4	Missing / not identified

5.4.1 Operationalisation of Variables

The dependent variable - inventory investment - was constructed using object measures. As previously discussed, the supply chain management literature treats low levels of inventory investment as synonymous with high levels of organizational efficiency. For example, Lee et al. (1997b) argued that excessive inventory investment was a signal of "tremendous" organizational inefficiency. Therefore, in order to best capture the magnitude of a manufacturer's inventory investment reflecting the upstream and downstream nature of the supply chain, a multi-item scale was constructed from three objective measures: days of raw materials; days of work-in-process; and days of finished goods inventory. The data were checked for normality and outliers before creating the final scale. Confirmatory factor analysis was used to check the scale's uni-dimensionality and the Kaiser-Meyer-Olkin measure of sampling accuracy was 0.66. The Cronbach alpha for this scale was 0.72, and the mean inventory investment was a total of 74.86 days.

The independent variables, supplier's explicit knowledge (SEK) and customer's explicit knowledge (CEK), were based upon identical multi-item scales shown in the Figure 5.3. Both scales were grounded in the literature and gauged a manufacturer's effort to integrate explicit knowledge with its suppliers and customers in terms of inventory levels, production plans and demand forecasts, delivery frequencies, and Kanban signals. Each item was measured on 1-5 Likert scales (1 = none 5 = high).

The most appropriate approach for scale purification when theory drives a study is confirmatory factor analyses (CFA) (Kim & Mueller, 1978). Items were selectively deleted through repeated CFA runs (LISREL 8) and each time we identified a measure for deletion based upon standardized residuals, observed improvements in comparative goodness of fit index (CFI), normed fit index (NFI), magnitude of modification indices, chi-square with corresponding degrees of freedom, and overall interpretability. Three weak/ redundant measures were eventually dropped to form the parsimonious and reliable four-item scales for SEK and CEK shown in Figure 5.3 and Table 5.2. The individual measures for these supplier and customer scales were summed together, and the Cronbach alpha for SEK was 0.68 and for CEK was 0.76.

Figure 5.3 Two-Factor Oblique Measurement Model of Supply Chain Knowledge

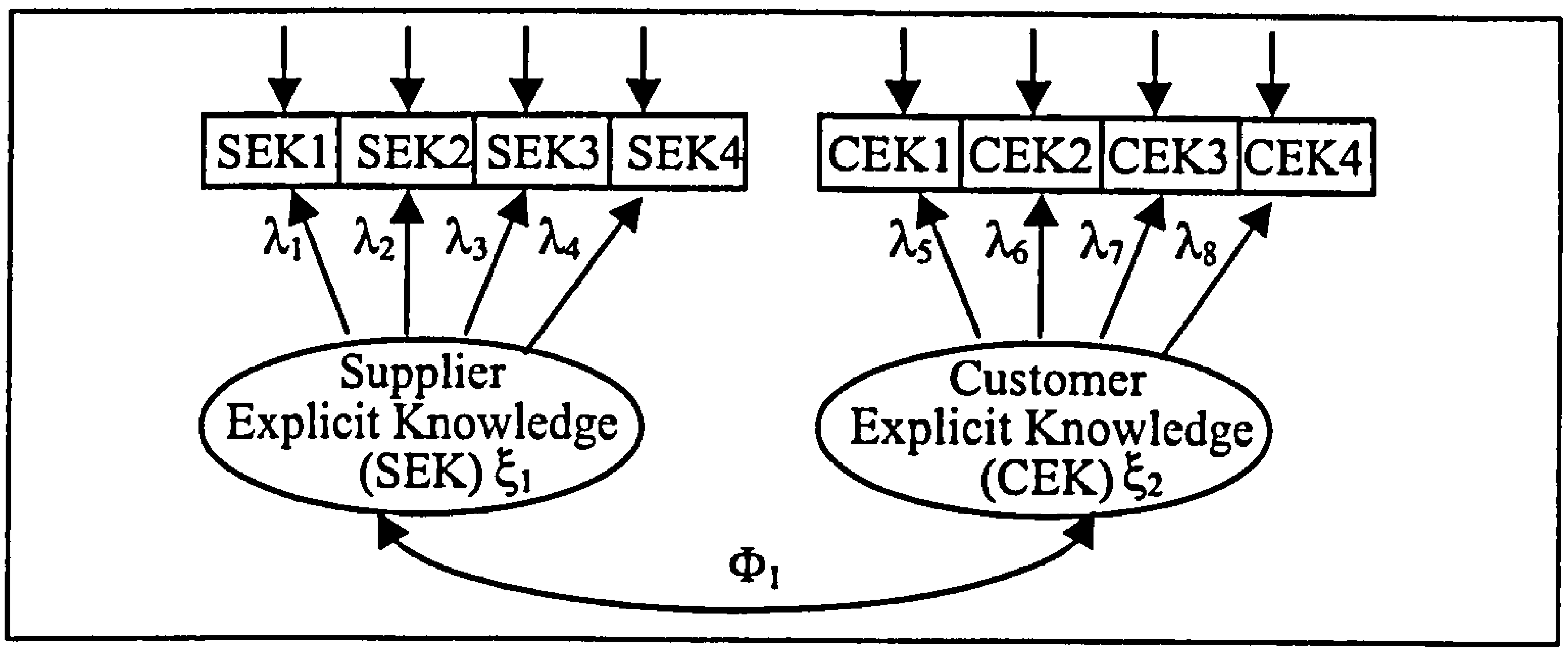


Table 5.2 Confirmatory Factor Analysis Statistics for Supply Chain Knowledge Items

ξ_1 **Supplier Explicit Knowledge (SEK):** What is your level of adoption with suppliers?

	None				High	Loading	*t*-score
SEK1: Share inventory level knowledge	1	2	3	4	5	$\lambda_1 = .75$	13.52[a]
SEK2: Share production planning and demand forecast knowledge	1	2	3	4	5	$\lambda_2 = .70$	12.61[a]
SEK 3: Delivery frequency knowledge	1	2	3	4	5	$\lambda_3 = .61$	10.99[a]
SEK 4: Kanban pull signals	1	2	3	4	5	$\lambda_4 = .77$	9.18[a]

ξ_2 **Customer Explicit Knowledge (CEK):** What is your level of adoption with customers?

	None				High	Loading	*t*-score
CEK1: Share inventory level knowledge	1	2	3	4	5	$\lambda_5 = .77$	13.95[a]
CEK2: Share production planning and demand forecast knowledge	1	2	3	4	5	$\lambda_6 = .73$	12.24[a]
CEK3: Delivery frequency knowledge	1	2	3	4	5	$\lambda_7 = .61$	10.87[a]
CEK4: Kanban pull signals	1	2	3	4	5	$\lambda_8 = .68$	11.84[a]

Goodness of Fit Statistic	2-Factor Model (df = 6)
χ^2	2.59 ($p < 0.86$)[b]
χ^2/df	0.43 (≤ 2.00)[b]
GFI	1.00 (> 0.90)[b]
AGFI	0.99 (> 0.90)[b]
RMSR	0.01 (< 0.10)[b]
NNFI	1.01 (~ 1.00)[b]
NFI	1.00 (> 0.90)[b]
Hotelling's Critical N	2186 (> 200)[b]

Covariance between supplier and customer explicit knowledge
$\Phi_1 = .68$
t-score = 14.65[a]

[a] t-scores significant at $p < 0.001$.
[b] Critical values for concluding "good" fit of model to data (Bollen, 1989; Hoyle, 1995; Marcoulides & Schumacker, 1996).

Since a single respondent rated supplier and customer explicit knowledge and performance, this may have led to common method bias. We checked for this using Harmon's one factor test (Podsakoff & Organ, 1986). Seven factors with eigenvalues greater than one were extracted from all the measures in this study and in total accounted for 68% of the variance. The first factor accounted for 15% of the variance. Since a single factor did not emerge, and one factor did not account for most of the variance, this suggested that the results were not due to common-method bias.

The reliability and validity of each scale and objective measure were further analysed following the Flynn et al. (1995) example. Construct validity was established by testing whether the items in a scale all loaded on a common factor when within-scale factor analysis was run. All three independent and dependent scales passed this test, which supports each scale's uni-dimensionality. Divergent or discriminant validity was tested three ways. First, bivariate correlations were checked between each of the scales measures and other potentially confounding variables such as market share and a make to stock strategy (Table 5.3). There were no significant correlations ($p < 0.05$), which helped establish that the scales were not measuring other unintended constructs. Second, we compared the average interscale correlations in Table 5.3 to the Cronbach alphas. Acceptable divergent validity is shown when the alphas are greater that the average interscale correlations. Finally, the average correlations between scale and nonscale items were lower than between scale and scale items which helped support discriminant validity.

Table 5.3 Measurement Analysis: Explicit Knowledge and Performance Scales

	Correlations[a] Between Measures and Other Implementation-related Variables				Average Item Total Corr.	
Measure	Cronbach's Alpha	Average Interscale Correlate	Market Share[b]	Make to Stock[c]	Non-scale Items	Scale Items
1. Supplier Explicit Knowledge	.68	.13	-.07	.05	.15	.50
2. Customer Explicit Knowledge	.76	.10	-.01	.04	.13	.57
3. Inventory Investment	.72	.35	.09	.09	.26	.63

[a] No correlations significant at $p < 0.05$; [b] Market share = actual market share percentage; [c] Make to stock percent = proportion of customer orders produced to stock.

Based upon the literature and industry observations we included a set of control variables in the regression model. These control variables represented a baseline against which to assess the effect of adding the relevant explanatory variables to test the hypotheses of this study.

5.5 RESULTS

Table 5.4 shows the baseline regression model, containing only the control variables, as well as the three subsequent hypotheses tests. To varying degrees, all three hypotheses were supported.

Table 5.4 Hypothesis Test Results

Variable	Baseline Model	Model 1 (H1)	Model 2 (H2)	Model 3 (H3)
Company Control				
Total Employees	-0.079	*-0.065*	*-0.066*	*-0.063*
	(0.003)	(0.003)	(0.003)	(0.003)
Competition Controls				
Product Focus	0.127	0.146*	0.146*	0.168*
	(4.025)	(4.066)	(4.135)	(4.160)
Customer Focus	0.149*	0.164**	0.118	0.137
	(4.029)	(4.042)	(4.299)	(4.182)
Fluctuating Controls				
Outsourcing	0.283***	0.274***	0.271**	0.271**
	(3.540)	(3.585)	(3.869)	(3.840)
Temporary Workers	-0.272***	-0.269***	-0.274**	-0.272***
	(3.178)	(3.176)	(3.339)	(3.309)
Operational Controls				
Select Supplier on Price	-0.108	-0.103	-0.128	-0.126
	(3.981)	(3.998)	(4.213)	(4.182)
Push vs. Pull	-0.011	0.060	0.041	0.073
Production	(3.530)	(3.928)	(3.858)	(3.956)
Dedicated Lines	-0.134*	-0.129	-0.111	-0.113
	(0.127)	(0.128)	(0.135)	(0.134)
Supplier Explicit Knowledge (SEK)		-0.154*		
		(1.515)		
Customer Explicit Knowledge (CEK)			-0.184**	
			(1.307)	
Integrated Explicit Knowledge (IEK)				-0.223**
				(0.066)
R^2	.223	.243	.250	.261
Adjusted R^2	.175	.188	.190	.202
F Statistic	4.624***	4.484***	4.155***	4.403***
Statistical Power ($\alpha = .01$)		99%	99%	99+%

Table gives Standardized Beta Coefficients. Standard Errors in Parenthesis
*p<0.10, **p<0.05, ***p<0.001 for two tailed test, n =338

Hypothesis 1- that explicit knowledge inflow from upstream in the supply chain will lead to reduced inventory investment, was weakly supported. While the relationship of explicit supplier knowledge (SEK) was in the expected negative direction, it was significant at only the $p < 0.10$ level. The resultant increase in adjusted R^2 showed slightly greater explanatory power in comparison to the baseline model and the F statistic remained highly significant ($p < 0.001$). The Durbin-Watson Test indicated no autocorrelation, and the statistical power of 99 percent was well above the 80 percent suggested threshold (Cohen, 1988).

Hypothesis 2- that explicit knowledge inflow from downstream in the supply chain will lead to reduced inventory investment, was strongly supported. The expected relationship between high customer explicit knowledge (CEK) and low inventory investment stayed in the expected negative direction while Model 2's adjusted R^2 increased. Similarly, the F statistic remained highly significant ($p < 0.001$), and the Durbin-Watson Test indicated no autocorrelation and the statistical power was 99 percent.

The interaction between SEK and CEK was used to test Hypothesis 3- that explicit knowledge inflow from an integrated supply chain will lead to a reduction in inventory investment. This hypothesis was strongly supported. Again, the interaction *'integrated explicit knowledge'* (IEK) variable had the expected negative relationship with performance and the adjusted R^2 increased over the baseline model. The Durbin-Watson Test indicated no autocorrelation and the statistical power was greater than 99 percent.

The statistical support for all three hypotheses supports and extends previous theory. Equally interesting, however, is that the results suggest other important trends. When comparing the hierarchical effects of adding in turn the SEK, CEK and IEK variables to the control model, the adjusted R^2 values increase and the magnitude and significance of the standardized beta coefficients increase. This indicates that IEK is more influential than either SEK or CEK on their own and suggests that integrating knowledge from both customer and supplier is the best approach. Also, CEK has a more influential and important effect upon reducing inventory investment than SEK. This suggests that the direction from which knowledge inflows come in the supply chain is also important.

5.6 DISCUSSION

This research was conducted with three overall objectives. First, the study sought to empirically replicate the general notion that explicit knowledge inflows from outside the organization have a beneficial effect upon performance. Second, the study aimed to add to existing literature through a finer-grained analysis of this external explicit knowledge. A specific objective of the study was to find out whether such explicit knowledge inflows from suppliers and customers in the external supply chain contributed to improved performance. Finally, consideration was given as to whether the existing literature could be expanded by ascertaining whether the richness of explicit knowledge depends upon whether it comes from the upstream or downstream direction, or from an integrated supply chain. In accordance with knowledge management literature, explicit knowledge flows between supply chain partners have been characterised in terms of i) shared 'declarative' knowledge elements related to inventory levels, production plans and delivery frequencies, and ii) shared 'procedural' knowledge elements of coordinating, planning, and forecasting between supply chain partners and shared practices such as Kanban. This study is limited in that it did not seek to investigate tacit elements of knowledge. Nevertheless, through adopting relevant perspectives from the knowledge management literature and considering explicit knowledge flows in both declarative and procedural terms, it is felt that this study goes beyond a simple analysis relating to the exchange of operating data between supply chain partners.

The support for all the stated hypotheses adds empirical weight to the concepts in the knowledge-based and supply chain management literature outlined in previous sections of this essay. The empirical results lend support to the general notion that inflows of 'external' explicit knowledge are beneficial to performance. More specifically, it would appear that particular explicit knowledge inflows emanating from upstream and downstream supply chain partners are beneficial in terms of the objective performance measure of inventory investment. Thus the first two objectives of this research have been met.

Regarding the third objective of our research, the results of the hierarchical regression indicate two possible new insights to the existing literature. Firstly, when considered independently, explicit knowledge inflow from downstream appears to be more powerful in terms of reducing inventory investment than explicit knowledge inflow from upstream. Therefore, the direction from which a knowledge inflow emanates could be important. Secondly, the results indicate that, of all explicit knowledge inflows considered, that from an integrated supply chain apparently has the most powerful beneficial effects upon inventory management. Thus, integrating explicit knowledge from both supplier and customer would appear to result in the richest explicit knowledge.

What theoretical mechanisms are behind these phenomena? The existing knowledge management literature cannot fully explain either, since it makes little direct comparisons between the richness of knowledge inflows from different directions. Possible explanations can be found in the supply chain literature though. One possible explanation as to why knowledge inflow from the downstream customer side could be richer than that from upstream is provided by the 'bullwhip effect' concept (Lee et al., 1997b), whereby demand variance is amplified moving upstream in a supply chain setting similar to our conceptual model. Thus useful ordering information from the customer could become distorted as it passes upstream. As Lee et al. (1997b) state: "distorted information from one end of a supply chain to the other can lead to tremendous inefficiencies- excessive inventory investment". The empirical results indicate that explicit knowledge from upstream is less rich in helping to reduce inventory investment, which suggests that it may well be more distorted than knowledge from downstream. Hence the bullwhip effect may also be prevalent beyond the data/ informational level at which it has been researched to date. In fact, the measures that Lee et al. (1997b) propose to counter the undesirable bullwhip effect (i.e., avoiding multiple demand forecast updates, breaking order batches, stabilizing prices, eliminating gaming in shortage situations) all require declarative explicit knowledge sharing and procedural explicit knowledge coordination with supply chain partners - in particular those providing explicit knowledge inflows from downstream.

Similarly, the work by Frohlich and Westbrook (2001) provides possible reasons as to why integrated explicit knowledge from supplier and customer could be the richest. Their work compared different supply chain strategies and demonstrated that the greatest degree (or 'arc') of integration was strongly associated with higher performance levels. They explained that better coordination in the supply chain reduces uncertainty throughout manufacturing networks and eliminates excessive inventory investment. Extending this explanation to the knowledge perspective of this research could explain why the explicit knowledge inflow from an integrated supply chain appears to be the richer in helping reduce inventory investment.

5.7 THEORETICAL CONCLUSIONS AND MANAGERIAL IMPLICATIONS

Whilst there are clear limitations relating to the lack of sophistication of findings and limited precision of conclusions that can be drawn from such an exploratory survey-based study, this investigation has identified relevant perspectives from the knowledge management literature that could prove valuable in extending the supply chain literature from a focus upon the exchange of assets, data and information towards the integration and leverage of expertise and knowledge. In this regard, the investigation leads to three broad knowledge-based conclusions. First, the empirical results appear to support existing knowledge management and supply chain management theory in that inflows of declarative and procedural explicit knowledge from outside the organization apparently do have a beneficial effect upon performance. More specifically, declarative and procedural explicit knowledge inflows from all of the considered supplier, customer and integrated supply chain partnership sources appear to have a beneficial effect upon inventory investment reduction.

Second, the results suggest that there are directional implications as to which explicit knowledge inflows are most beneficial in reducing inventory investment. Explicit knowledge inflows emanating from downstream would appear to be more valuable in reducing inventory investment than those from upstream. This may be due to a 'bullwhip effect', or similar phenomena, resulting in distortion of upstream explicit knowledge.

Third, the richest inflow of declarative and procedural explicit knowledge seems to come from the integrated supply chain. The results suggest that this inflow, that integrates explicit knowledge from both suppliers and customers, is the most powerful in terms of reducing inventory investment. This is possibly due to a combination of reduced uncertainty, and elimination of non-value adding activities, as a result of better overall supply chain coordination.

These findings potentially have some important implications for theory and managerial practice. In terms of theory, it may no longer be enough to consider a generalised approach to external explicit knowledge. The results indicate that all explicit knowledge outside the organization is not equal. Future research could continue combining knowledge-based and supply chain perspectives in further investigations of these potential inequalities. In addition, the implications of integrating explicit knowledge across supply chains could be more far reaching than the integration of data and information considered in the supply chain literature to date. Thus, continued knowledge-based research into supply chains is suggested as possibly offering new conceptual depth. Yet such increased depth may also pose challenges, especially when considering its application to research into increasingly complex supply chain issues.

In terms of managerial implications the results from this study indicate that, in real operational terms, benefits may result from explicit knowledge obtained outside the company, and specifically by integrating with supply chain partners. This study supports recent managerial literature, indicating that those companies that work together with their external supply chain partners could be the most likely to make significant operational performance improvements. Whilst the results of this study suggest that external explicit knowledge inflows do improve operating characteristics of manufacturing companies, they go further in proposing that limited resources may be best focused in certain directions in order to maximize return on effort.

If resources and competitive context permit, ideally a manufacturer might share and coordinate explicit knowledge with both upstream and downstream supply chain partners. Working towards an integrated supply chain appears to be justified from a knowledge-based perspective. However, with limited resources, competitive implications, bargaining power losses and so forth, many practitioners may not be in a position to adopt this ideal option. Therefore, this refinement of existing knowledge provides some guidance as to where the most valuable explicit knowledge could potentially come from. The results indicate that for manufacturing companies looking to reduce investment in inventory, knowledge-acquiring activities with downstream customer partnerships are potentially more likely to yield benefits than similar activities with upstream supplier partnerships (ceteris paribus).

5.8 FUTURE RESEARCH

Our findings suggest that the following areas of knowledge-based supply chain research may provide good opportunities for further investigation, and it is hoped that other researchers will be attracted to these areas.

1. This study draws on data from fabricated metal products, machinery and equipment manufacturers. There may be particular characteristics to these companies that do not apply to other operational sectors and contexts. For example, would these conclusions hold true in service supply chains? Context specific studies will potentially yield different results. Nevertheless, in conducting comparisons between different supply chain contexts efforts will need to be made to ensure compatibility of empirical data.
2. The broad nature of the knowledge flow constructs in this study, whilst supporting and extending current supply chain and knowledge management literature, could perhaps be more precisely defined in terms of established knowledge related supply chain management constructs- such as 'purchasing competence' (Narasimhan et al., 2001). Making use of such constructs will potentially yield different insights.
3. This study makes no mention of the routes companies have taken towards supply chain integration or the relative levels of evolution or 'maturity'. Different experiences, methodologies and maturity levels are likely to have implications on the nature and extent of knowledge flows. Thus interesting opportunities exist to compare the fast adopters of supply chain knowledge and practices with the laggards. Perhaps the best area for study regarding this are the newer supply chain contexts- such as services, whereby there is liable to be a greater spread in maturity than in the relatively mature traditional manufacturing supply chain contexts.
4. While the 'bullwhip effect' supply chain literature provides a strong theory for directional implications of information flow, very little work has been done to provide empirical evidence from a knowledge-based perspective. Confirmatory research to verify the bullwhip effect at the knowledge level would be useful.
5. Our research has revolved around the explicit, codified forms of knowledge transfer. Consideration of the tacit knowledge mechanisms in supply chains is likely to be fruitful.
6. The role of the Internet in supply chain integration has been profound. Further research of 'virtual integration' and similar developments from a knowledge perspective is likely to add insights to the existing literature.

CHAPTER 6 – ESSAY 2:

COMPARING SUPPLY CHAIN PURCHASING COMPETENCE IN MANUFACTURING AND SERVICE CONTEXTS

6.1 INTRODUCTION

Over the last decade, the area of purchasing has been elevated to a strategic level and has become established as an important area of study (Cox, 1996; Carter & Narasimhan, 1996). A strong reason for this rise in importance has been the recognition that functional level competences can dramatically affect firm performance (Vickery et al., 1993; Jayaram et al., 1999). Narasimhan et al. (2001) defined supply chain competence in terms of functional competences in purchasing, manufacturing and marketing/ sales. In particular, they highlighted the importance of purchasing competence, defining and validating the construct in terms of five underlying dimensions: Empowerment, Employee Competence, Tactical Interaction Effectiveness, New Product Development Interaction Effectiveness, and Buyer-Seller Relationship Management. Practitioners have sought to hone these dimensions of purchasing competence in the drive to reduce costs and improve performance.

In addition, in recent years information technology (IT) has become an enabler of supply chain activities and has impacted upon the way purchasing is performed (e.g. Guimaraes et al., 2002; Frohlich, 2002a; Sanders & Premus, 2002). With increasingly sophisticated IT, new competences have been developed in practices such as e-auctions, real-time knowledge sharing, spend/ order tracking, streamlined invoice payment systems and the purchasing of ever more complex commodities. Whilst Stratman and Roth (2002) validated an IT Competence dimension for enterprise resource planning (ERP), apparently no such dimension has been studied within the purchasing context.

Thus this study empirically replicated the work of Narasimhan et al. (2001), followed-up on their suggestions for further research and investigated the merit of adding IT Competence as a sixth underlying dimension of purchasing competence. This cross-validation and extension of the Narasimhan et al. (2001) purchasing competence construct used data from a telephone survey of 200 major European manufacturing and service companies. The explicit inclusion of financial service companies (identified as being worthy of such study by Roth and Jackson (1995)) was considered relevant given the increasing importance of service-oriented companies to developed economies (Voss et al., 1997); their similar reliance on the supply of physical goods (Chartered Institute of Purchasing and Supply, CIPS, 2003); and their motivation to develop purchasing competence that results in delivery and cost improvements (Handfield, 1993).

A final objective of this paper was to empirically explore the links between the dimensions of purchasing competence and performance. Chao et al. (1993) identified the most important purchasing performance measures, yet we know little about the connections between these measures and the competence dimensions that are understood to drive them. In fact, whilst the relationship between competence and performance is generally assumed by the operations and supply chain management literatures to be positive, strategic management literature reports evidence of phenomena such as 'competency traps' that can actually result in diminished performance (Brown & Duguid, 1991; Ingram & Baum, 1997). This therefore represents a potentially insightful area for empirical investigation, and this study sought to identify those dimensions of purchasing competence that drive specific performance measures.

A further contribution of this paper lies in the analysis techniques selected to address each objective. Whilst standard confirmatory factor analysis (CFA) was used to cross-validate the Narasimhan et al. (2001) purchasing competence construct and to verify the inclusion of an IT dimension, two proven, yet relatively novel techniques within operations management research were applied. The structural equation technique of group invariance analysis (Joreskog, 1971) was used to test whether the purchasing competence construct applied equally across both manufacturing and service contexts. Finally, to simultaneously investigate the relationships between purchasing competence dimensions and multiple performance measures set correlation analysis was used (Cohen & Cohen, 1983)- a sophisticated technique that addresses several shortcomings of more common multiple regression/ correlation methods.

The next section synthesizes relevant literature and develops propositions and hypotheses regarding purchasing competence and purchasing performance in manufacturing and financial services companies. Subsequent sections describe the data collection and analysis methods, discuss the results, draw conclusions and consider the managerial and research implications.

6.2 PURCHASING COMPETENCE: ISSUES EMERGING FROM THE LITERATURE

6.2.1 Underlying Dimensions of Purchasing Competence and the Role of IT

Narasimhan et al. (2001) developed and validated a purchasing competence construct consisting of five underlying dimensions. These dimensions were, in turn, defined in terms of 15 purchasing practices. The formulation of each dimension came from a synthesis of the literature concerned with the human resource, internal interface, and external interface elements of purchasing. The human resources related literature (e.g. Anklesaria & Burt, 1987; Ellram & Pearson, 1993; Guinipero & Vogt, 1997) resulted in the inclusion of the 'Empowerment' and 'Employee Competence' dimensions. Literature relating to internal interfaces (e.g. Stuart, 1991; Guy & Dale, 1993; Mendez & Pearson, 1994) revealed the 'Interaction- NPD' and 'Interaction-Tactical' dimensions. And literature regarding the external interface (e.g. Stuart, 1993) suggested the inclusion of the 'Buyer-Seller Relationship Management' dimension. No literature was found suggesting that any of these dimensions could be ignored in today's international companies. All of the underlying dimensions and defining practices are still relevant to the purchasing function. Thus, maintaining the definition of purchasing competence as a multidimensional construct comprised of key enabling elements for which the purchasing function has a primary responsibility, the following is proposed:

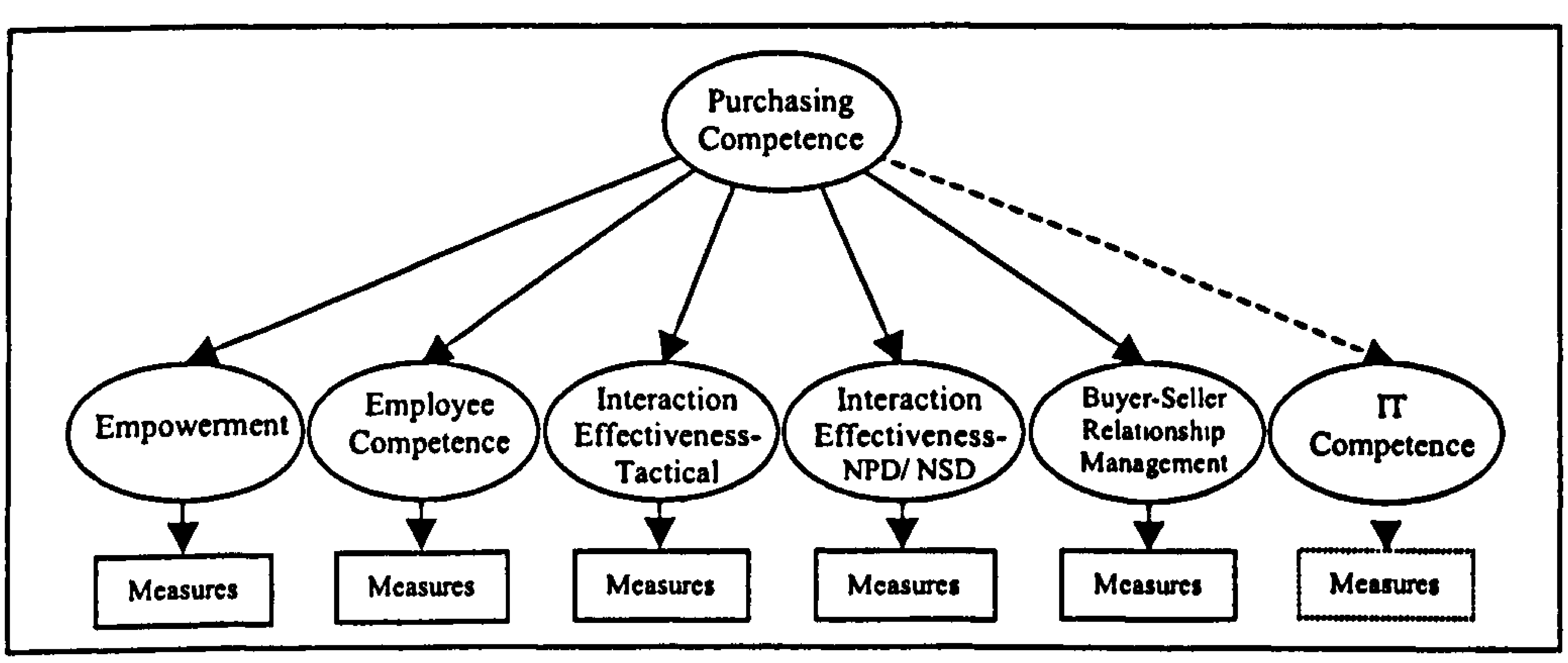
> Proposition 1: The purchasing competence construct of Narasimhan et al. (2001), as defined by five underlying dimensions and 15 associated purchasing practices, can be cross-validated with up-to-date international data.

Nevertheless, recent research does suggest that the addition of an information technology (IT) competence dimension could improve the scope and explanatory nature of the purchasing competence construct. The broader supply chain management literature abounds with examples as to the importance of IT. The extended enterprise model identifies IT as a key component (Bowersox & Daugherty, 1995; Edwards et al., 2001). Guimaraes et al. (2002) found a positive link between effective use of IT and supplier network performance. Sanders and Premus (2002) stated that IT is significantly changing the way in which supply chain partners do business. Frohlich (2002a) identified the lack of internet-related IT skills as significant barriers to supply-side activities. The purchasing function has not escaped this increase in IT importance. Sarkis and Talluri (2002) contend that increased investment in IT has played a significant role in enabling the purchasing function to meet its critical objectives. This increased role of IT has required the development of corresponding organizational and employee IT skill-based competence. Such IT competence is needed to carry-out the now common purchasing practices of: i) ensuring company wide spend and order tracking visibility, ii) obtaining best prices through e-auctions, iii) facilitating the buying of complex commodities, iv) streamlining the invoice to payment process, and v) enabling real-time buyer-supplier knowledge transfer. Therefore, the addition of an IT competence dimension, as defined by the above five modern purchasing practices, to the original Narasimhan et al. (2001) purchasing competence construct is proposed:

> Proposition 2: Purchasing competence can be defined in terms of six underlying dimensions, comprising the five original dimensions, plus an IT competence dimension defined by 5 more recent purchasing practices.

The above propositions are reflected in Figure 6.1.

Figure 6.1 Conceptual Model: Dimensions of Purchasing Competence



6.2.2 Purchasing Competence in Manufacturing and Service Contexts

The literature consistently contends that supply-side competence leads to operational benefits in manufacturing companies (Akinc, 1993; Lawrence & Hottenstein, 1995; Agrawal & Nahmias, 1997). Yet there is little research that explicitly addresses these issues within service-oriented organizations. This is despite service companies gaining importance in the role of economic growth (World Bank, 1983; Voss et al., 1997) and continuing to heed advice of academics such as Bowen and Youngdahl (1998) in adopting hitherto largely manufacturing-focused practices in purchasing and supply. Hence there is a growing need to consider purchasing issues in service companies and to draw comparisons with manufacturing within single studies.

Regarding the broader supply chain literature, differences between manufacturing and service customer-facing operations do complicate the task of drawing downstream comparisons (Zeithaml & Binter, 1996). Yet on the upstream- purchasing side, there are considerable operational similarities. Like manufacturing, service-oriented companies also rely on the provision of physical goods from suppliers. In fact, the motivations for developing effective purchasing competence appear to be the same for manufacturing and service contexts: reduced costs and lead times (Ansari & Modaress, 1990); improved supplier reliability (Carr & Pearson, 1999); and improved communications (Freeland, 1991). Krause et al. (1998) also point out that manufacturing and service companies seek benefits from supply-side practices. Clearly, practices such as frequent small deliveries, selecting suppliers on quality and delivery, establishing supplier contracts, and reducing inventories and paperwork could benefit both manufacturing and service organizations (Handfield, 1993). Furthermore, membership lists of professional institutes (e.g. Chartered Institute of Purchasing and Supply, CIPS, 2003) suggest that universal purchasing practices are promoted in both manufacturing and service firms. Generic or synonymous operational terminology is certainly used across the two contexts (e.g. Froehle et al., 2000), and the equivalence of operational competences between manufacturing and services have already been recognized by researchers studying issues such as TQM and technology (Sihra & Lutz, 1997; Silvestro, 1998). Thus with the same motivations, sources of advice and terminology for developing purchasing competence, we hypothesize the following:

> H1: The purchasing competence construct is stable across manufacturing and services.

6.2.3 Impact of Purchasing Competence Dimensions Upon Purchasing Performance

There is consistent implication in the operations management literature that competence development results in improved performance (e.g. Burt, 1984; Burton, 1988). Some empirical research has found significant positive links between purchasing competence and increases in operational performance. Testing for predictive validity of the purchasing competence construct, Narasimhan et al. (2001) found significant positive correlations with TQM and Customer Satisfaction Performance. They also found the dimensions of Empowerment and Buyer-Seller Relationship Management to be positively related to these general performance measures. Das and Narasimhan (2000) discovered that the dimensions of purchasing integration and supplier capability benefit manufacturing performance. Suarez et al. (1996) identified positive relationships between out-sourcing practices and manufacturing flexibility. Similarly, Narasimhan and Das (1999) found a positive correlation between supplier relationship management and manufacturing flexibility. Following this limited but important empirical evidence we hypothesize that similar positive links will be found between the underlying dimensions of purchasing competence and specific purchasing performance measures.

We sought to avoid using a single purchasing performance scale as the dependent variable- opting instead to identify impacts upon multiple purchasing performance measures. After all, just as a pilot needs to make judgments against an array of standardized flight gauges, purchasing professionals also need to simultaneously monitor multiple performance measures rather than a single measure. Such a set of purchasing performance measures was identified by Chao et al. (1993) in a cross-sector analysis including manufacturing and service companies. They found the most important measures to be: Quality, On-time Delivery, Accuracy, Purchase Order (PO) Cycle Time, Commodity Knowledge, Professionalism and Negotiating Ability. In the light of the previous discussion and issues emerging from the literature, we hypothesize:

H2a: Traditional dimensions of purchasing competence impact purchasing performance measures.

H2b: IT Competence positively impacts purchasing performance measures.

An additional, particularly striking issue emerges from the fact that the previously cited studies did not always find positive relationships between all dimensions of competence and performance. In fact, whilst rare, some operations management literature suggests that certain competency dimensions have negative impact upon performance. Upton (1995) found that workforce experience had a detrimental effect upon manufacturing flexibility. Also, Corbett and Van Wassenhove (1993) identified trade-offs between dimensions of manufacturing competence and competitiveness. Thus, it is reasonable to presume that not all purchasing competence dimensions will positively influence all performance measures- and some may even have a negative impact. Although this interesting issue has not been developed in the operations management literature, other business research has investigated negative competence-performance relationships. The strategic management literature has identified negative effects of competence dimensions upon performance, and proposed mechanisms to explain them. Work on 'learning curves' in organizations (Epple et al., 1991) indicate possible diminishing returns as competences depreciate over time, potentially becoming performance limiting phenomena (Brown & Duguid, 1991). Ingram and Baum (1997) demonstrated that a firm can develop competences that are beneficial in the short-term, but that in the long-term become performance reducing 'competency traps'. Research on 'corporate inertia' recognizes that although the development of a certain competence may make the organization better, it can also make it 'myopic' and rigid, and adversely affect performance (Levinthal & March, 1993; Miller & Chen, 1994).

In light of the above, two underlying dimensions of purchasing competence are particularly liable to have an adverse long-term association with certain purchasing performance measures. Firstly, in line with the findings of Upton (1995), employee competence can reach levels of diminishing returns and could become a competency trap. As training and evaluation systems become embedded, corporate inertia and organizational myopia can result in overly developed employee competence. Overqualified and over-experienced employees are likely to become de-motivated in the longer term, thus having a negative impact upon performance in mundane purchasing function tasks. One such task is purchase-order administration. Overly competent employees will find this administration boring, unstimulating, or simply 'beneath their level', and thus procrastinate. Conversely, an employee with a lower, more appropriate level of competence is liable to complete the administration quicker and more efficiently with a corresponding improved PO Cycle Time. Thus we hypothesize:

H2c: Employee Competence has a negative impact upon PO Cycle Time.

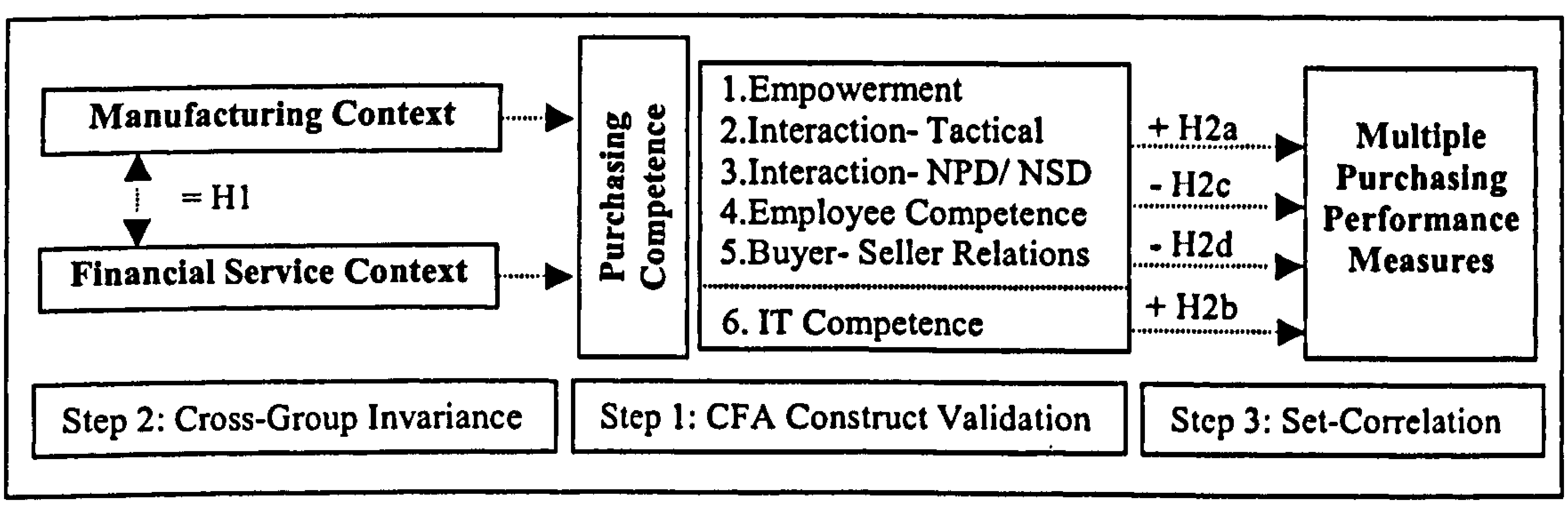
Secondly, for similar reasons high and sustained levels of risk sharing, technical information sharing, joint planning and shared cost savings could lead to overly 'cosy' buyer-seller relationships. This would initiate competence-performance trade-offs identified by Corbett and Van Wassenhove (1993). Whilst in the short-term there are clear benefits to developing strong buyer-seller relationships, the value of such competence would depreciate if corporate inertia and organizational myopia were to confine long-term purchasing options to suppliers who are no longer motivated by the commercial need to compete for and maintain a demanding customer. In this case, buyer-seller relationships would become a competency trap as buyers and sellers become over-comfortable, over-confident, and blasé in terms of Quality and On-time Delivery performance. This leads to the hypothesis:

H2d: Buyer-Seller Competence negatively impacts Quality and On-time Delivery

6.3 RESEARCH FRAMEWORK AND SELECTION OF ANALYSIS TECHNIQUES

The previous discussion of existing literature outlines the motivation for this study and forms the basis of the research framework. The investigation made use of the most appropriate analysis techniques and followed the three steps shown in Figure 6.2.

Figure 6.2 Essay 2 Research Framework



First, the empirical replication and cross-validation of the Narasimhan et al. (2001) purchasing competence construct was addressed by second-order confirmatory factor analysis (CFA). We followed the same procedure used by Narasimhan et al. (2001), which represents the most appropriate and informative methodology when testing theoretically derived propositions for construct validation and development (Bollen, 1989). The validity of adding the IT Competence dimension to the construct was assessed via the same process considering the model in Figure 6.1.

Second, testing the hypothesis (H1) of purchasing competence being the same across manufacturing and service contexts was addressed by the structural equation technique of group invariance analysis (Marsh, 1994). This is the best method with which to test such hypotheses of equivalence across populations (Joreskog, 1971). Invariance analysis involves a chi-square test of nested models, whereby non-rejection of a hypothesis of equal factor loadings and error terms provides strong support that the structure of the construct is equivalent (invariant) across groups (Bentler & Bonnet, 1980).

Third, we tested hypotheses (H2a, b, c, d) relating to the impact of purchasing competence dimensions upon multiple purchasing performance measures. Instead of performing multiple regressions of each single dependent measure onto independent variables, we opted instead for the more sophisticated technique of set correlation analysis (Cohen & Cohen, 1983; Vastag & Montabon, 2001). Set correlation analysis is a generalization of multiple regression/ correlation analyses such that a set of dependent variables can be related to a set of independent variables. Since set correlation analysis considers multiple dependent variables simultaneously, it is a truly multivariate method that addresses shortcomings of more common methods by providing a single measure of association between data sets and a single framework for variable association, parameter estimation, hypothesis testing, and statistical power analysis.

6.4 RESEARCH METHODS

6.4.1 Sampling Procedure and Measurement Issues

A purpose-designed telephone survey targeted heads of purchasing in European companies with revenues over £250 million. Two hundred full telephone interviews were completed of a stratified random sample, split equally between manufacturing and financial services companies. All interviews were completed over a period of 2 weeks in 2003 and comprised 50 from the UK, 50 from France, 50 from Germany, 25 from Italy and 25 from Benelux.

The survey methodology was executed strictly following existing guidelines for good practice (Malhotra & Grover, 1998; Frohlich, 2002b; Rungtusanatham et al., 2003). An extensive up-to-date source database, that had been compiled and refreshed by telephone interview over a number of years and that represented close to the entire population, was used. N^{th} number random sampling from this database and screening questions minimized sampling and coverage error. Analysis of the random sample indicated that spread of sub-sectors, company sizes, and locations did not differ markedly from the population.

Measurement error was considerably reduced through the survey not being self-completed. Trained interviewers guided respondents through a structured, closed questionnaire in which survey items had been pre-tested on a group of professionals. The first 20 interviews were piloted and the only amendment made was a minor simplification of wording in one item. Regarding interviewer error, 1 in 10 interviews were validated by a project leader, effectively re-interviewing the respondent. Each interview questionnaire was checked individually for 'branching errors' or omissions and the respondent was re-called if there were any problems. Non-response error was judged within acceptable limits. The overall response rate was 23%. The individual country sampling and response rates are given in Table 6.1.

Table 6.1 Analysis of Sampling and Response Rates

Country	A. Total Companies Supplied	B. Interviews Completed	C. Refusals	D. Callbacks	E. Rejected (not qualifying)	F. Unused Sample	G. Response Rate B/(A-E-F)
Germany	458	50	83	33	0	292	30%
France	407	50	84	115	19	139	20%
Italy	619	25	46	89	14	445	16%
Benelux	287	25	50	69	10	133	17%
UK	409	50	48	60	5	246	32%
Overall	**2180**	**200**	**311**	**366**	**48**	**1255**	**23%**

There were no significant differences in response rates between manufacturing and financial services. Analysing the range of companies, sub-sectors, locations and job-titles revealed no patterns for response or non-response. Responses to certain objective questions had strong relationships with those from a previous year's survey using different respondents- indicating that non-response of previously surveyed groups was not a problem. Whilst the survey was conducted confidentially, almost all respondents agreed to be re-interviewed in the event of unclear answers and requested a copy of the survey findings. This indicated an interest in providing accurate answers, and high overall interest in the survey. A summary report was given to respondents.

6.4.2 Measurement of Dependent Variables: Purchasing Performance

This study included the seven measures of purchasing performance deemed most important by Chao et al. (1993). These included objective measures for Quality, On-time Delivery, Accuracy and Purchase- Order Cycle Time. Five-point Likert scales (1-"Very Poor" to 5-"Very well") were used to rate the subjective aspects of Commodity Knowledge (knowing items, suppliers, prices), Professionalism (upholding standards of conduct, ethics, conventions, courtesy), and Negotiating Ability (negotiating prices, terms of sales, delivery dates). Certain items were reverse coded to prevent/ identify spurious responses. The means and standard deviations of the responses were as follows: Quality 79.3% (9.5), On-time delivery 82.6% (9.9), Accuracy 96.6% (2.6), PO Cycle Time 1.74 days (0.9), Commodity Knowledge 4.1 (0.7), Professionalism 4.4 (0.6), Negotiating Ability 3.9 (0.7).

6.4.3 Measurement of Independent Variables: Purchasing Competence

The survey instrument measured the twenty practices listed in Table 6.2. Fifteen of the items (1-15) replicated those used by Narasimhan et al. (2001) to create the five multi-item competence scales: Empowerment, Employee Competence, Tactical Interaction Effectiveness, New Product/ Service Development Interaction Effectiveness, and Buyer-Seller Relationship Management. The construct (face) validity of these fifteen survey items and corresponding competence dimension scales was re-confirmed for this study by a group of purchasing professionals and academics. Some minor wording changes were made to adapt these items to a telephone survey. Also, appropriate, synonymous terminology was included to ensure clarity of items to respective manufacturing and service respondents. The group of experts considered the final item wording to be true to the aims of replicating Narasimhan et al. (2001). Similarly, to ensure the content validity of a new multi-item IT Competence scale, an extensive literature search was carried out to identify potential item measures. Measurement options were discussed by the group of experts and five items chosen to reflect the concept being studied (Table 6.2 Variables 16 to 20).

Table 6.2 Descriptive Statistics and Correlations

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Involvement- Job related	3.51	1.07	1.00																		
2. Involvement- Operational	3.27	1.14	.52	1.00																	
3. Job autonomy	3.63	1.07	.31	.29	1.00																
4. Job security	3.49	1.26	.28	.22	.23	1.00															
5. Training- purchasing	3.51	1.07	.27	.26	.26	.21	1.00														
6. Training- suppliers	3.13	1.14	.17	.12	.08	.05	.34	1.00													
7. Performance Evaluation	3.68	1.11	.35	.28	.18	.20	.18	.31	1.00												
8. Interaction- Operations	3.70	1.13	.27	.23	.27	.10	.20	.13	.26	1.00											
9. Interaction- QC/ QA	3.61	1.26	.20	.21	.16	.11	.08	.09	.30	.46	1.00										
10. Interaction design function	3.29	1.32	.16	.20	.146	.125	.09	.08	.15	.36	.37	1.00									
11. Interaction- R&D/ research	3.07	1.38	.18	.28	.19	.17	.08	.08	.08	.33	.36	.73	1.00								
12. Risk sharing	2.62	1.39	.06	.13	.00	-.09	.14	.14	.13	.14	.20	.04	.05	1.00							
13. Tech. Assist./ Info. Sharing	3.27	1.30	.11	.08	-.01	.07	.06	.06	.19	.23	.26	.34	.29	.29	1.00						
14. Joint production planning	2.72	1.38	.18	.22	.05	.11	.08	.21	.24	.27	.32	.30	.36	.36	.46	1.00					
15. Share cost savings	3.04	1.36	.15	.16	.19	-.03	.10	.21	.20	.31	.25	.24	.25	.42	.37	.50	1.00				
16. Spend/ Order tracking	3.39	1.39	.13	.16	.22	.066	.02	.06	.19	.03	.20	.11	.09	.08	.08	.07	.08	1.00			
17. Prices e-auctions	2.07	1.40	.01	.11	.06	.01	.19	.15	.13	.09	.19	.05	.07	.17	.15	.20	.16	.31	1.00		
18. Complex commodities	2.56	1.38	-.02	.02	.13	-.02	-.01	.02	.12	.13	.16	.15	.08	.02	.17	.10	.13	.27	.34	1.00	
19. Streamline invoice-payment	3.31	1.44	.09	.12	.20	.09	.09	.13	.19	.10	.10	.10	.09	.03	.18	.17	.17	.46	.32	.29	1.00
20. Real-time know sharing	2.70	1.56	.05	.12	.10	-.08	.04	.13	.13	.11	.13	.09	.01	.15*	.12	.12	.07	.35	.46	.31	.32

Correlations in bold are significant at 0.05 level. Sample size = 2

The same question format was used for all independent variable survey items. Respondents indicated on a five-point scale (e.g. 1-"Strongly Disagree" to 5- "Strongly Agree") the level of interaction frequency, extent of use or degree of agreement with statements such as: "Purchasing personnel are involved in key decisions affecting their jobs." The respondent could reply 1, 2, 3, 4, 5 or 6 (for "don't know")- or have the question explained and repeated if necessary. Some items were reverse coded. Descriptive statistics and correlations of the independent variable items are presented in Table 6.2.

6.4.4 Missing Data

The problem of missing data is considerably reduced with telephone surveys since questions can be explained and respondents encouraged to give answers if they know them. Nevertheless, any 'don't know' responses were treated as missing data, and constituted 4% of total responses. This represents a very acceptable level of missing data yet still results in loss of statistical power and accuracy (Roth et al., 1999; Verma & Goodale, 1995; Quinten & Raaijmakers, 1999). We thus followed Tsikriktsis (2003) and Roth (1994) recommendations and applied hot-deck imputation to deal with the missing at random (MAR) pattern identified.

6.4.5 Reliability Analysis

Underlying statistical assumptions and adequacy of the data for creating multi-item competence scales were checked. Overall, a substantial number of significant correlations were identified; the Kaiser-Meyer-Olkin (KMO) sampling adequacy value of 0.80 is 'meritorious'; and Bartlett's test of sphericity was significant at the .001 level. For individual factors, Table 6.3 shows that Cronbach alpha values exceeded the lower acceptance level of 0.60 (Nunnally, 1979; Robinson, 1991). Only the Employee Competence value fell marginally short of this threshold. The overall high alpha values correspond well to those achieved by Narasimhan et al. (2001). Also the high item-to-total correlations, inter-item correlations exceeding 0.30, good KMO measures and highly significant Bartlett values indicate representative, unidimensional and practically significant factors. The sample size of 200 and all factor loadings above 0.564 indicate statistical significance at the .05 level and a power of over 80%. Thus, there is sufficient evidence to confirm that factors proposed by Narasimhan et al. (2001) are valid and reliable for our sample, along with the newly proposed IT Competence factor.

Table 6.3 Reliabilities of the Items for the Six Purchasing Factors

Factors	Items	Item-to-total Correlation	1st Item % Variance	KMO	Bartlett's Test X^2	df	p	Cronbach α
Empowerment	1. Involvement- Job related	0.800	48.7	0.669	109.77	6	0.000	0.63
	2. Involvement- Operational	0.767						
	3. Job autonomy	0.633						
	4. Job security	0.564						
Employee Competence	5. Training-purchasing	0.700	51.8	0.585	45.12	3	0.000	0.55
	6. Training- suppliers	0.794						
	7. Performance Evaluation	0.660						
Interaction Effectiveness - Tactical	8. Interaction- production/ operations	0.853	72.8	0.500	46.04	1	0.000	0.62
	9. Interaction- QC/ QA	0.853						
Interaction Effectiveness – NPD/ NSD	10. Interaction- engineering/ design	0.929	86.4	0.500	148.56	1	0.000	0.84
	11. Interaction- R&D/ research	0.929						
Buyer-Seller Relationship	12. Risk sharing	0.683	55.2	0.739	157.86	6	0.000	0.73
	13. Technical assistance/ Info. Sharing	0.703						
	14. Joint production planning	0.796						
	15. Share cost savings	0.783						
IT Competence	16. Spend/ Order tracking	0.697	47.6	0.764	176.45	10	0.000	0.72
	17. Prices e-auctions	0.711						
	18. Complex commodities	0.622						
	19. Streamline invoice-payment	0.696						
	20. Real-time knowledge sharing	0.718						

Sample size = 200

6.5 RESULTS AND DISCUSSION

6.5.1 Second-Order Factor Analysis

With the aims of: i) cross-validating the Narasimhan et al. (2001) 5-factor purchasing competence model for our sample, and ii) confirming the validity of adding the IT Competence dimension, two second-order factor models were subjected to the maximum likelihood method of estimation (Joreskog and Sorbom, 1989). This method was appropriate for our survey data (Bentler & Chou, 1987; Green et al., 1997). The total sample (200) exceeded the threshold of 100 needed to provide stable estimates (Boomsma, 1985; Hayduk, 1987), and was in line with the rule of thumb of approximately five observations per parameter estimate (MacCallum et al., 1992). The original Narasimhan et al. (2001) model estimated 35 parameters, and 46 parameters were estimated with the addition of IT Competence. Apart from the IT Competence endogenous variable both models were identical. The problem of correlated measurement errors was avoided since the second-order construct explained association amongst endogenous competence factors.

The validities of both models were assessed for the full sample data, and the results summarized in Tables 6.4 and 6.5. Both models demonstrated a very high degree of convergent validity as all first and second-order factor loadings were found to be positive and highly significant ($p<.001$). In addition, adequate squared multiple correlation (SMC) values were observed for first and second-order levels (Anderson & Gerbing, 1988). High levels of discriminant validity were demonstrated by all modification indices (MI) having values less than 10.

Validity of the two models, and cross-validation between them was assessed against the multiple fit criteria in Table 6.4 (Bollen, 1989; Hoyle, 1995; Marcoulides & Schumacker, 1996). Critical N values estimate the minimum sample size needed for adequate model specification, and show the sample of 200 is sufficient for both models (Hu & Bentler, 1995). Model 1 in Table 6.4 specifically addresses the first aim of the analysis. Chi-square, Goodness of Fit (GFI), Parsimony Goodness of Fit (PGFI), Comparative Fit Index (CFI), Incremental Fit Index (IFI), Tucker-Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA) statistics indicate that the Narasimhan et al. (2001) 5-factor model fitted our data well. The relatively low Normed Fit Index (NFI) did not give cause for concern since Bentler (1990) state that NFI tends to underestimate fit and recommended placing more emphasis on CFI. Thus cross-validation of the Narasimhan et al. (2001) 5-factor purchasing competence model with the data was confirmed and Proposition 1 is supported.

Table 6.4 Second-Order Factor Analysis: Summary Statistics

2nd Order Model	SMC range 1st Order	SMC range 2nd Order	Max MI	X^2	df	P	X^2/ df	GFI ~.90	PGFI >.50	NFI ~.90	CFI >.90	IFI >.90	TLI ~.95	RMSEA <.05	Critical N. ~200 .05	Critical N. ~200 .01
1. 5-Factor Model (Narasimhan et al., 2001)	.13-.73	.35-.80	6.83	130.1	85	.001	1.531	.924	.655	.833	.933	.935	.917	.052	165	181
2. 6-Factor Model (Including IT Competence)	.19-.74	.15-.78	6.76	215.6	164	.004	1.315	.906	.708	.794	.940	.941	.930	.040	180	193

[a] All loadings were significant at the p<.001 level. Criteria for Good Fit indicated for appropriate statistics.

Table 6.5 Second-Order Factor Analysis Results

		5- Factor Model			6- Factor Model		
Indicator/ Construct	**Construct**	**Standardized Factor Loading**	**Unstandardized Factor Loading**	**t-Value**	**Standardized Factor Loading**	**Unstandardized Factor Loading**	**t-Value**
Second-Order Results							
Buyer-Seller Relationship	Purchasing Competence	0.657	0.461	5.201***	0.671	0.471	5.296***
Interact Effectiveness- NPD/ NSD	Purchasing Competence	0.627	0.703	6.729***	0.609	0.688	6.641***
Interaction Effectiveness- Tactical	Purchasing Competence	0.893	0.686	7.533***	0.880	0.665	7.405***
Employee Competence	Purchasing Competence	0.633	0.302	4.002***	0.663	0.309	4.062***
Empowerment	Purchasing Competence	0.593	0.464	5.754***	0.596	0.464	5.794***
IT Competence	Purchasing Competence	-	-	-	0.386	0.318	3.723***
First-Order Results							
Involvement- Job related	Empowerment	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Involvement- Operational	Empowerment	0.695	1.011	6.598***	0.698	1.021	6.618***
Job autonomy	Empowerment	0.449	0.613	5.079***	0.452	0.622	5.113***
Job security	Empowerment	0.366	0.588	4.244***	0.364	0.589	4.226***
Training-purchasing	Employee Competence	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Training- suppliers	Employee Competence	0.527	1.250	3.799***	0.517	1.259	3.786***
Performance Evaluation	Employee Competence	0.584	1.350	3.871***	0.598	1.417	3.899***
Interaction- production/ operations	Interaction Effectiveness- Tactical	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Interaction- QC/ QA	Interaction Effectiveness- Tactical	0.666	1.089	6.384***	0.678	1.126	6.405***
Interaction- engineering/ design	Interaction Effectiveness- NPD/ NSD	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Interaction- R&D/ research	Interaction Effectiveness- NPD/ NSD	0.853	1.045	8.393***	0.847	1.031	8.234***
Risk sharing	Buyer-Seller Relationship	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Technical assistance/ Info. Sharing	Buyer-Seller Relationship	0.582	1.075	5.445***	0.584	1.076	5.466***
Joint production planning	Buyer-Seller Relationship	0.753	1.481	6.048***	0.753	1.478	6.071***
Share cost savings	Buyer-Seller Relationship	0.686	1.322	5.886***	0.685	1.318	5.902***
Spend/ Order tracking	IT Competence	-	-	-	n.a.	n.a.	n.a.
Prices e-auctions	IT Competence	-	-	-	0.620	1.052	6.003***
Complex commodities	IT Competence	-	-	-	0.501	0.839	5.235***
Streamline invoice-payment	IT Competence	-	-	-	0.595	1.034	5.867***
Real-time knowledge sharing	IT Competence	-	-	-	0.623	1.171	6 019***

1) *** p<0.001. 2) To define the measurement scales for the constructs, one of the links has to = 1. Thus these factor loadings & t-values have been marked as "not applicable" (n.a.)

Model 2 in Table 6.4 addresses the second aim of validating the addition of the IT Competence dimension to the purchasing competence construct. Values for chi-square, GFI, PGFI, CFI, IFI, TLI, and RMSEA indicate a good fit to the sample data and thus validity of the 6-factor model is confirmed. Closer inspection of the fit criteria in Table 6.4 indicates that Model 2 fits the data better than Model 1. Thus adding the IT Competence endogenous variable results in improved model specification and explanatory power without adversely affecting parsimony. Furthermore, adding IT Competence improves model fit without detracting from the importance of the other dimensions. Nesting Models 1 and 2 shows that, beyond the added IT Competence dimension, they are equivalent. The insignificant p-value (.290) corresponding to difference in chi-square and degrees of freedom failed to reject the hypothesis of equivalence of Empowerment, Employee Competence, Interaction Effectiveness and Buyer Seller Relationship parameters between the two models. In addition, the similar factor loadings and high significance levels for both models in Table 6.5 further indicate the cross-validity of the models. In sum, the IT Competence dimension is a substantively appropriate and valid extension to the original 5-factor Narasimhan et al. (2001) purchasing competence model and Proposition 2 is supported.

6.5.2 Group Invariance Analysis

Establishing validity of purchasing competence models on the full sample (200) does not guarantee the equivalence of measures and structures across manufacturing and financial services groups; hence this was explicitly tested via group invariance analysis (Marsh, 1987; Marsh, 1994; Byrne, 2001). Invariance analysis results are shown in Table 6.6.

We followed the procedure used by Doll et al. (1998) derived from the seminal work of Joreskog (1971). "Totally non-invariant" baseline models were simultaneously estimated for each group and subjective fit criteria (CFI, TLI, PGFI, IFI and RMSEA) showed these baseline models to adequately fit separate group data, thus qualifying for invariance testing (Bollen, 1989).

Table 6.6 Group Invariance Analysis for Manufacturing and Financial Services

Model Description	Comparative Model	X^2	df	ΔX^2	Δdf	p	CFI	TLI	PGFI	IFI	RMSEA
5-Factor Baseline- No constraints	-	215.608	170	-	-	-	0.923	0.905	0.621	0.928	0.037
Constrained Measurement Model	5-Factor Baseline	227.959	180	12.351	10	0.262	0.919	0.906	0.652	0.923	0.037
Constrained Factorial Structure	5-Factor Baseline	239.647	185	24.039	15	0.064	0.908	0.896	0.666	0.912	0.039
6-Factor Baseline- No constraints	-	415.421	328	-	-	-	0.891	0.874	0.653	0.898	0.037
Constrained Measurement Model	6-Factor Baseline	427.073	341	11.652	13	0.556	0.893	0.880	0.674	0.898	0.036
Constrained Factorial Structure	6-Factor Baseline	445.438	347	30.017	19	0.052	0.877	0.866	0.682	0.882	0.038

Equivalence between baseline and group parameter constrained nested models was tested by differences in chi-square values, degrees of freedom and the corresponding p-value (Bentler, 1990). Non-significant p-values ($p>.05$) for constrained factorial structure and measurement models failed to reject the hypotheses of equal factor loadings and error terms, and provide strong support that observed differences between group parameters are due to chance (Bentler & Bonnet, 1980; Marsh, 1987)). Therefore both 5- and 6-factor purchasing competence models are fully equivalent across manufacturing and financial services groups. Further statistical support for equivalence is given by the small variations in subjective fit criteria for constrained models in Table 6.6, suggesting that differences in factor loadings and error terms between groups are insubstantial (Doll et al., 1998). Thus the hypothesis (H1) that the purchasing competence construct is the same across manufacturing and services groups is statistically supported for both Narasimhan et al. (2001) 5-factor model and 6-factor model (including IT Competence).

6.5.3 Set Correlation Analysis

Relationships between competence dimensions and the top seven purchasing performance measures (Chao et al., 1993) were investigated simultaneously using set correlation (SC) analysis. The reasoning behind selecting SC analysis instead of several separate multiple regressions is discussed in Section 6.3. We conducted the analysis in line with Cohen and Cohen (1983) and Vastag and Montabon (2001) examples. Results are shown in Table 6.7.

The multivariate $R^2_{Y,X}$ quoted for SC is a generalization of the simple bivariate r^2 and multiple R^2 (Rozeboom, 1965; Van den Burg & Lewis, 1988). It represents the proportion of generalized variance of the dependent variable set accounted for by the independent variable set. The obtained value of 33.4 % indicates a high degree of multivariate association between performance measures and purchasing competence factor scores. The $\tilde{R}^2_{Y,X}$ value indicates "shrinkage" to be acceptable. Rao's F value of 1.90 rejects the null hypothesis of no association between sets at the $p<.001$ level (Rao, 1975). A statistical power estimate of 95% ($p = .05$) was obtained from (Cohen & Cohen, 1983) and we followed their suggestions for guarding against Type I errors. Therefore the good overall SC association is highly significant.

Table 6.7 Set Correlation Analysis: Purchasing Competence Dimensions and Purchasing Performance Measures

A. Correlations among basic variables

				Set Y_B						Set X_B		
	Y1	Y2	Y3	Y4	Y5	Y6	Y7	X1	X2	X3	X4	X5
Y1: Quality	1.000											
Y2: On-Time Delivery	0.246	1.000										
Y3: Accuracy	-0.233	-0.085	1.000									
Y4: PO Cycle Time	-0.004	-0.173	0.092	1.000								
Y5: Commodity Knowledge	0.028	0.098	-0.157	0.083	1.000							
Y6: Professionalism	0.103	0.014	0.006	0.052	0.310	1.000						
Y7: Negotiating Ability	0.146	0.106	-0.049	-0.049	0.387	0.301	1.000					
X1: Empowerment	0.171	0.072	0.020	-0.026	0.278	0.156	0.281	1.000				
X2: Employee Competence	0.135	0.141	0.004	-0.078	0.202	0.148	0.228	0.402	1.000			
X3: Int. Effectiveness- Tactical	0.150	0.097	0.015	-0.071	0.225	0.110	0.134	0.332	0.276	1.000		
X4: Int. Effectiveness- NPD/ NSD	0.221	0.113	-0.014	-0.067	0.108	0.146	0.158	0.282	0.136	0.446	1.000	
X5: Buyer-Supplier Relations	-0.005	-0.063	0.121	0.072	0.122	0.026	0.090	0.182	0.275	0.395	0.342	1.000
X6: IT Competence	0.192	0.046	-0.063	0.126	0.125	0.142	0.136	0.163	0.210	0.212	0.127	0.235

B. Set Correlation Analysis findings for simultaneous multiple dependent variables

Model $R^2_{Y,X} = .334$; $\widetilde{R}^2_{Y,X} = .171$; Rao $F = 1.898$; (df: $u = 42.0$, $v = 880.6$); $p < .001$

Variable	r^2 (Set X toY)	Empowerment	Employee Competence.	Int. Effectiveness- Tactical	Int. Effectiveness- NPD/ NSD	Buyer-Seller Relations	IT Competence
Y1: Quality	0.108***	0.07	0.077	0.043	0.207**	-0.166**	0.168**
Y2: On-Time Delivery	0.054*	-0.021	0.156**	0.07	0.124*	-0.178**	0.028
Y3: Accuracy	0.028	0.035	-0.026	-0.009	-0.062	0.169**	-0.093
Y4: PO Cycle Time	0.048*	0.028	-0.119*	-0.095	-0.079	0.13*	0.146**
Y5: Commodity Knowledge	0.106***	0.202**	0.075	0.137*	-0.03	0.009	0.05
Y6: Professionalism	0.059*	0.075	0.098	0.016	0.12*	-0.088	0.111*
Y7: Negotiating Ability	0.106***	0.2**	0.131*	-0.014	0.09	-0.025	0.073

*** p< .001. ** p< .05. * p< .1. Number of Cases = 200

Supplementary analysis of Table 6.7 B showed that three regression (Set X to Y) r^2 values were significant at $p<0.001$ level, and a further three at the $p<0.1$ level. This further supports the predictive validity of the purchasing competence dimensions. Levels of performance variance explained correspond well to those obtained by (Narasimhan et al., 2001).

Further refined assessment revealed specific impacts of competence dimensions upon the multiple performance measures. Nine of the SC partial regression coefficients were significant at the $p<0.05$ level, and a further seven at the $p<0.1$ level. Thus hypothesis H2a is strongly supported. Purchasing competence dimensions do have significant impact upon specific purchasing performance measures. Thirteen of these significant relationships were found to be positive, with each purchasing competence dimension loading significantly positively on at least one purchasing performance measure. Empowerment is positively correlated to both Commodity Knowledge ($p<0.05$) and Negotiating Ability ($p<0.05$). Employee Competence is positively related to On-time Delivery ($p<0.05$) and Negotiating Ability ($p<0.1$). Tactical Interaction Effectiveness is positively associated to Commodity Knowledge ($p<0.1$). New Product/ Service Development is positively related to Quality ($p<0.05$), On-time Delivery ($p<0.1$), and Professionalism ($p<0.1$). Buyer-Seller Relationship Management is positively correlated to PO Cycle Time ($p<0.1$), and to Accuracy ($p<0.05$). Each of these positive significant correlations makes substantive sense- supporting practical significance and relevance of the findings. In addition, IT Competence was found to be significantly positively correlated with Quality ($p<0.05$), PO Cycle Time ($p<0.05$), and Professionalism ($p<0.1$). This represents the most significant positive impact upon performance measures by any single competence dimension and thus hypothesis H2b is supported.

Interestingly, not all significant competence-performance relationships were found to be positive. Three significant negative effects were identified. Employee Competence was found to be significantly negatively related to PO Cycle Time ($p<0.1$). Thus hypothesis H2c is supported. Also, Buyer-Seller Relationship Management was identified as being significantly negatively correlated to Quality ($p<0.05$) and On-time Delivery ($p<0.05$). Therefore, hypothesis H2d is similarly supported.

6.5.4 Study Limitations and Evaluation of Compliance with Good Research Practice

There were some limitations to this study. The possibility of respondent bias cannot be ruled out as single respondents provided self-reported data for both independent and dependent variables. In addition, whilst the overall sample size (200) was sufficient for the analyses conducted, certain interesting avenues of investigation were hindered by the lower manufacturing and services sub-sample sizes of 100. For example, no meaningful analysis could be done of comparative competence-performance issues across sectors.

Despite the above limitations, the study complied with the Malhotra and Grover (1998) normative list of good survey research practice and hence the next section proceeds to draw conclusions that are relevant to academics and professionals.

6.6 THEORETICAL CONCLUSIONS AND MANAGERIAL IMPLICATIONS

Notwithstanding the limitations of survey-based research (outlined in Section 4.1.1), the empirical results of this study indicate that three broad conclusions may be drawn that support existing theory. First, this study has replicated the empirical work of Narasimhan et al. (2001) in different geographical and business environments, and considered alternative conceptualisations. The cross-validation of the Narasimhan et al. (2001) Purchasing Competence construct with up-to-date international manufacturing and service data may serve to justify continued recognition of this operational framework. The replication results indicate that academics and managers across broad geographical and business contexts could potentially benefit from knowledge of the underlying dimensions of competence in purchasing. Furthermore, a reliable IT Competence dimension is shown to be a potentially appropriate extension to the Purchasing Competence construct, resulting in possible increased scope and explanatory power. The inclusion of IT Competence does not detract from the original dimensions of purchasing competence, but rather supports and builds upon recent literature indicating the importance of IT to modern purchasing and supply operations.

Second, results of this study indicate that the Supply Chain Purchasing Competence construct applies equally across manufacturing and service contexts. This lends empirical support to literature and institutions promoting universal purchasing practices. To the author's knowledge, this is the first study to empirically indicate equivalence of an OM framework across manufacturing and service organizations, and could serve to motivate further comparative research. It would appear that service organizations are developing the same purchasing competencies that had hitherto been considered the domain of manufacturing organizations.

Third, the results indicate that underlying dimensions of purchasing competence have a significant impact upon multiple purchasing performance measures and account for a high degree of performance variance. Positive impacts of specific competence dimensions upon particular performance measures support the general OM literature notion of beneficial competence-performance relationships. The results indicate that each competence has significant beneficial impact upon at least one performance measure. Specific beneficial associations were found between the following: Empowerment and Commodity Knowledge/ Negotiating Ability; Employee Competence and On-time Delivery/ Negotiating Ability; Tactical Interaction Effectiveness and Commodity Knowledge; New Product/ Service Development Interaction Effectiveness and Quality/ On-time Delivery/ Professionalism; Buyer-Seller Relationship Management and PO Cycle Time/ Accuracy. Of particular note was that IT Competence was found to have the most significant beneficial impact- driving Quality, PO Cycle Time and Professionalism.

Whilst the majority of impacts observed were positive, the results also indicate certain negative impacts of specific purchasing competence dimensions upon performance measures. This exploratory survey-based evidence therefore appears to provide some support for business literature relating to performance diminishing phenomena such as 'competency traps'. The results indicate specific negative impacts associated with Buyer-Seller Relationship and Employee Competence dimensions. However, given the limitations of the survey-based methods used, and the specific contexts of the population studied, great care should be exercised in the literal generalization of such negative findings without more substantial research. Perhaps more detailed and profound case and/ or action research methodologies would be more appropriate to confirm, or refute such findings. Nevertheless, the preliminary results from this study do indicate that perhaps the OM literature should shed the overall presumption of competence being 'good' in favour of more careful 'contingency' driven analysis of appropriate competences for specific business scenarios. The identification of such multiple competence-performance relationships constitutes a potential refinement of existing literature and, to this end, it is suggested that researchers continue to study the impacts of competence factors upon multiple performance measures.

Finally, the results indicate several potential managerial implications regarding the strategic importance of the purchasing function. It would appear from the results of this study that professionals in both manufacturing and service organizations could consider competence in purchasing to consist of six underlying dimensions for audit and diagnostic purposes. Of particular interest to managers in such organizations is the potential impact of competence dimensions upon operational performance. Whilst care should be taken not to over-generalize specific findings from this investigation beyond the populations studied, the results suggest that managers perhaps should not run operations by relying on a single performance measure, but, instead, might tailor contingent 'competence configurations' to achieve those particular performance requirements that constitute organizational competitive performance priorities. Similarly, the results suggest that, for any given organization, competitive priorities should determine where competence-developing efforts might best be focused. The results from this study indicate that managers should perhaps combine their knowledge of the business context with their grasp of embedded competence dimensions in order to maximise the contribution of the purchasing function to strategic goals. For example, if performance in terms of quality were important to an organization fitting the population characteristics of this study, then effort might best be concentrated on new product/ service development interaction and IT related competences. Conversely, if a competence configuration were already ingrained and hard to change, it might be more feasible to adapt the organization's competitive strategy. For example, an organization with highly competent employees might find the best option is to shift competitive focus away from performance in terms of PO Cycle Time and towards On-Time Delivery and/ or Negotiating Ability. Of course this could introduce other challenges, and would possibly require purchasing representation at a strategic planning level.

6.7 FURTHER RESEARCH

The findings of this study have potential implications for theory and future research. The purchasing competence construct is apparently relevant across geographical and contextual boundaries, and thus possibly deserves further attention from researchers. Also, the results of this study indicate that perhaps it is no longer appropriate to ignore IT in purchasing or supply operations. Furthermore, given the apparent cross-sector functional equivalencies perhaps it is now inappropriate for the OM literature to regard manufacturing and services as discrete areas of research. In particular this study raises the prospect that the impact of competence upon performance might not always be beneficial and that a one-size-fits-all theory could be inappropriate. Further theory development should perhaps concentrate on establishing the contingent issues as to why certain competences might positively drive a specific performance measure, whilst others potentially have no effect (or perhaps even a detrimental effect.) Whilst the findings from this study indicate complications in the competence-performance research landscape, they could also open new avenues for exploration. It is hoped that such issues will attract other researchers. In particular, it is felt that the following could constitute insightful areas for further research:

1. Most current OM research focuses on studies of single sectors. Yet, this study indicates that interesting 'cross-fertilization' insights could be gleaned from bi- or multi-sector investigations. What OM concepts are being co-adopted by manufacturing and services, and other specific sectors such as healthcare and construction? What are the specific similarities and differences? Group invariance testing has proved a powerful tool in such cross-sector comparative study.

2. This study has just scratched the surface in terms of identifying impacts of operational competencies upon multiple performance measures. Considerable work is needed to further explore these important effects, and in particular to investigate particular contextual 'competence configurations' and contingency issues. Set correlation analysis is suggested as a particularly useful technique for such multiple dependent variable study.

3. This study has focused upon supply-side operations, and specifically the purchasing function, in order to compare a construct across manufacturing and services. Nevertheless, there are clear opportunities for more in-depth examinations of competence-performance issues in different operational areas throughout the supply chain.

CHAPTER 7 – ESSAY 3:

INVESTIGATING SUPPLY CHAIN MATURITY IN AN EVOLVING SERVICE CONTEXT: HEALTHCARE

7.1 INTRODUCTION

One of the primary goals of the operations management researcher is to make sense of the modern world, and it is difficult to do this without considering developments in supply chain ideas (New, 1997) . One such idea that has gained considerable attention from academics and practitioners is that of collaborative supply chain integration. Academics have viewed the positive impact of such collaboration and integration as leading to the supply chain, rather than the individual organisation, becoming the effective unit of future competition (Handfield, 2002). The related collaboration and integration concepts are integral to major paradigms such as lean production (Womack et al., 1990)- and the corresponding lean supply (Lamming, 1993). The need for collaborative integration with supply chain partners has been further reinforced with the continuing evolution of supply chain theory and practice and emergence of paradigms such as agile and leagile supply chains (Harrison et al., 1999).

Such theories have been rapidly adopted in certain sectors. The automotive sector for example gave birth to lean supply and has kept up at least with conceptual development. Few automotive, or wider manufacturing sector, managers are unaware of the importance of evolving supply chain philosophies. Yet, even in these more progressive industries, whilst managers may comprehend the potential benefits of supply chain ideas, practice implementation is often far from complete and full benefits remain elusive (Fawcett & Magnan, 2002). Furthermore, in other sectors such as those involving service-oriented operations, enormous potential benefits of supply chain management may be unrecognised and levels of ignorance relatively high. There are clear disparities both within and between sectors relating to practice implementation and 'proximity' to the goal of collaborative supply chain integration (Towill et al., 2002).Yet apparently no detailed frameworks exist to help with the question as to 'where' companies are now and 'what' has to occur to advance along the evolutionary continuum (Bowersox et al., 2000).

Thus to evaluate relative evolutionary progression, there is a need to formulate a conceptually robust supply chain maturity framework that is capable of assessing levels of adoption of collaborative and integrative practices. The need for such a maturity assessment framework has been recognised by supply chain researchers and this paper builds-upon the conceptual definition of Bowersox et al. (2000). They assess level of supply chain maturity in terms of 'realization' of modern collaborative and integrative supply chain practices on a subjective scale of 1 to 10. Whilst such a simple measure represents an important first step, it lacks important detail to facilitate improvements. The aim of this essay is therefore to further develop the supply chain maturity concept, creating more detailed measures, scales and constructs, and assessing their impact upon performance using empirical data.

To date, the development of a detailed maturity framework has possibly been hindered by the lack of understanding relating to fundamental, yet complex knowledge-based mechanisms underlying integration and collaboration. In this respect, research has identified that to gain the benefits of true collaboration, organisations need to expand their 'arcs of integration' beyond asset, data and information levels of exchange, to encompass exchange of opinions, expertise and knowledge (Frohlich & Westbrook, 2001). It seems obvious that collaboration requires development of knowledge-sharing, and yet little supply chain research has grappled with such dynamics (Giannakis & Croom, 2004). This is despite economic, strategic management and organisational learning literature streams recognising the key role of the knowledge dimension in the evolution of organisations all the way back to Adam Smith's "The Wealth of Nations" (Smith, 1776; Nelson & Winter, 1982; Postrel & Rumelt, 1992).

Bowersox et al. (2000) do recognise the importance of the knowledge dimension in the successful implementation of collaborative supply chain practices, and their maturity scale reflects this. This essay therefore adopts the same conceptual scope, operationalising supply chain maturity in terms of level of collaborative knowledge sharing with supply chain partners relating to the implementation of appropriate practices (Bessant et al., 2003). In this regard, the Supply Chain Council has established a reference model for practice implementation that is gaining acceptance amongst practitioners and we use this as a basis for developing the supply chain maturity framework (Supply Chain Council, 2004).

In commencing the quest for a detailed roadmap to help inform academics and practitioners regarding the collaborative supply chain 'integration journey' (Fawcett & Magnan, 2002), this essay identifies the evolving supply chain context of Healthcare as being particularly appropriate for study.

The next section reviews relevant academic literature from supply chain and other streams. In addition, practitioner literature pertaining to the implementation of established practices is assessed in order to inform scale and hypothesis development. The subsequent section outlines the innovative web-based survey methodology employed to address these intricate issues. A combination of confirmatory factor analysis and structural equation techniques empirically assess the validity of the supply chain maturity constructs. Set correlation analyses assess the simultaneous impact of multiple supply chain maturity dimensions upon multiple performance measures. Concluding discussion includes implications for supply chain academics and managers, and areas for further research are considered.

7.2 LITERATURE REVIEW

7.2.1 The Evolution of Supply Chains: Theory and Practice

Few supply chain researchers would disagree with the emerging tenet that future competition will be between whole supply chains rather than between individual companies (Handfield, 2002). Nevertheless, the state of development of this theoretical and practical inter-firm organisational evolution (Nelson & Winter, 1982) is apparently still in the nascent stages (Bowersox et al., 2000). For supply chain theory and practice to continue evolving it is essential to develop understanding of the complex dynamics underlying concepts such as collaborative supply chain integration (Narasimhan & Kim, 2002). Yet, on a theoretical level supply chain phenomena such as the 'bullwhip effect' (Lee et al., 1997a) are still only comprehended at a limited asset, data and information level of exchange. This is despite the fact that true collaboration requires going beyond this simplified level to the integration of opinions, expertise and knowledge (Frohlich & Westbrook, 2001). Theoretical understanding at this more complex knowledge-sharing level of collaborative integration has been identified as a significant gap in the literature (Giannakis & Croom, 2004) despite it being 15 years since Womack et al. (1990)

stressed the key to success is "managing the relationship" more collaboratively to encourage supply chain partners to "merge their learning curves".

Coming to terms with such complex knowledge-based issues is highly relevant as practitioners fight with the real-world intricacies of collaborating across sophisticated integration practices (Fisher, 1997). In this respect, supply chain researchers recognise the importance of adopting a more holistic approach to grapple with such profoundly important supply chain issues (Stock, 1997). The emerging field of knowledge management has been identified as a potential source of new insights (Amundson, 1998) with which to address difficult-to-answer questions such as: "Where are we now in the evolution of supply chains and what has to occur to advance along the continuum?" (Bowersox et al., 2000)

The related concepts of data and information integration and collaborative knowledge sharing with supply chain partners have been at the heart of recent evolution in supply chain management paradigms. Lean supply, born in the automotive sector of the 1980s, has long recognised the importance of collaborative relationships with the concept of 'beyond partnership' depending upon 'an integrated whole' (Lamming, 1993). Similarly, agile supply necessitates close collaborative links with supply chain partners, with "leveraging information and knowledge" being a primary dimension of the agility concept (Harrison, 1999; van Hoek et al., 2001). Continued evolution towards 'leagile' supply will entail ever-higher levels of collaborative integration between supply chain partners (Christopher & Towill, 2001).

Nevertheless, Lamming (1996) emphasises that "inter-firm supply relationships exhibit very different natures" between companies and sectors. Evidence is common of disparities in levels of collaborative relationships as supply chains evolve at differing rates. Lee and Billington (1996) evaluated the evolution of Hewlett-Packard's supply chain from high inventory levels and customer dissatisfaction in the 1980's to more 'mature' collaborative models and practices. Similarly, the successes of Dell have been attributed to highly evolved levels of collaborative knowledge-sharing (Magretta, 1998). Fawcett and Magnan (2002) state that: "early adopters of supply chain practice have discovered that real collaboration goes beyond information exchange and are working diligently to establish other integrative mechanisms to enhance coordination." Despite success stories there are also those that have not developed sufficient supply chain maturity, with consequential operational failure (Davenport, 1998).

A major cause of disparity in development relates to a lack of detailed understanding as to what constitutes, or needs to be done to attain, supply chain maturity (Bowersox et al., 2000). In essence, academics and practitioners are lacking a supply chain maturity 'roadmap' to guide the collaborative supply chain 'integration journey' (Fawcett & Magnan, 2002). This represents a possible stumbling block to further evolution of supply chain theory and practice. Bowersox et al. (2000) consider the crucial evolutionary role of developing supply chain maturity in terms of collaborative knowledge-sharing and integrative practice implementation. They argue that the development of supply chain maturity 'mega-trends' "represent the challenges of the emerging decade for logisticians and supply chain executives and identify the direction for change."

7.2.2 Developing the Supply Chain Maturity Concept

Bowersox et al. (2000) define supply chain maturity in terms of the level of adoption or 'realization' of modern collaborative and integrative supply chain 'mega-trend' practices. They allocate simple subjective scores on a scale of 1 (representing no development) to 10 (being total implementation) to assess differences in supply chain maturity levels across North American organisations. Other researchers have also identified discrepancies between levels of supply chain management development in different organisations. For example, Harrison and New (2002) identified a spread of relative supply chain 'sophistication' levels, and classified international manufacturing-based companies as: Supply chain leaders; Strong players; Weak players; Lagging players; or Non-players. Yet, whilst simple score and classification systems represent important first steps in differentiating levels of supply chain maturity in different contexts they lack important detail to facilitate improvements. Towill et al. (2002) state that: "real world supply chains differ not only in their current performance, but also in the most effective actions required to move each towards world class supply". Thus a more useful formulation of the supply chain maturity concept goes beyond an indication of relative development levels, to provide a multi-dimensional framework to help guide organisations along the evolutionary continuum.

Whilst Bowersox et al. (2000) identify both collaborative knowledge-development and integrative practices as important elements of supply chain maturity, the supply chain literature contains little conceptual foundation regarding the underlying knowledge-practice dynamics. The knowledge management literature, however, does recognise the inseparable nature of organisational knowledge development and practice implementation and thus provides theoretical support for such an organisational maturity framework. Miller and Chen (1994) suggest that as organisational maturity develops, problems associated with performance limiting phenomena such as 'corporate inertia', and 'competency traps' (Levinthal & March, 1993) are reduced. In a supply chain context, attaining maturity depends upon maintaining a balance between the exploitation of existing internal knowledge and the exploration of new knowledge possessed by supply chain partners (March, 1991). Exploring and gaining new external knowledge, entails elevated levels of collaboration that go beyond the transfer of explicit, codified knowledge (Zack, 1999), to also encompass the exchange of tacit 'know-how' (Nonaka, 1994).

Kogut and Zander (1992) reason that whilst explicit forms of knowledge reside in the relatively-easy-to-transfer codified data and information, tacit know-how is reflected in an organisation's practices. They specifically use supply chain inventory practices to explain different forms of declarative knowledge and procedural know-how development, thus grounding their relevance in a supply chain context. Specifically addressing the knowledge-practice link, Kogut and Zander (1992) state: "know-how, like procedural knowledge, is a description of what defines current practice." Furthermore, Szulanski (1996) describes four-stages relating to the transfer of practices and tacit know-how, with the culminating stage being organisational 'integration' that allows firms to capitalise upon the asymmetric knowledge strengths of different supply chain partners (Dussuage et al., 2000).

As one of the few supply chain studies to adopt a knowledge-based perspective, Bessant et al. (2003) outline the importance of sustained supply chain learning to organisational development, and argue that this occurs through knowledge-sharing related to practices. They recognise that the term 'best practice' is widely used, but argue that this implies a generic and static frontier that is not suited to the wide variety of supply chain contexts and configurations. Instead they elaborate that supply chain development relates to knowledge sharing across 'appropriate practices'.

Supply chain and knowledge management literatures therefore parallel each other in proposing that collaborative knowledge-sharing and practice integration are two faces of the same supply chain maturity coin. An inter-disciplinary operationalisation of the supply chain maturity construct therefore captures level of collaboration across 'appropriate' practices. In line with Bowersox et al. (2000) therefore, 'mature' organisations demonstrate extensive collaborative two-way communication with supply chain partners to ensure "shared vision and objectives" relating to appropriate "adoption of integrative supply chain management operating practices".

With regard to identifying appropriate practices, the Supply Chain Council (2004) 'Supply Chain Operations Reference' (SCOR) model provides an established framework for "all organisations interested in applying and advancing state-of-the-art supply chain management systems and practices." The SCOR model has been adopted by many leading companies to evaluate and improve collaborative supply chain integration efforts and therefore is consistent with the aims of developing the maturity concept. In addition to an extensive review of the academic literature, and in line with recent calls to stay abreast of practitioner developments (Meredith, 2002; Handfield, 2002), a review of practices promoted by major supply chain consulting firms (Oracle, 2003; SAP, 2003; JD Edwards/ Peoplesoft, 2003; i2, 2003; PRTM, 2003; Manugistics, 2003) was conducted. Whilst acknowledging the limitations of such literature and exercising caution regarding the caveats raised in Section 2.1.6, this review of practitioner-oriented literature added relevance to the supply chain maturity concept formulation, and revealed distinct practices associated with each of the SCOR dimensions of Plan, Source, Make, Deliver and Returns. In addition, academics propose a further dimension for New Product Development (Petersen et al., 2003; Joglekar & Rosenthal, 2003).

7.2.3 Maturity in an Evolving Supply Chain Context: Healthcare

Suitable levels of collaboration and appropriate practices will be contingent upon the specific supply chain context and operational characteristics in any given sector. The development of a supply chain maturity framework is best achieved therefore by considering a pertinent sector and a variety of operational configurations. Since the majority of existing supply chain studies concern relatively mature manufacturing sectors, it was deemed fitting to investigate the maturity construct in an evolving service-oriented context. The study of supply chain issues in service-oriented sectors has been identified as a specific gap in the literature (Croom et al., 2000), and in particular, the supply of products to service providers (Giannakis, 2001).

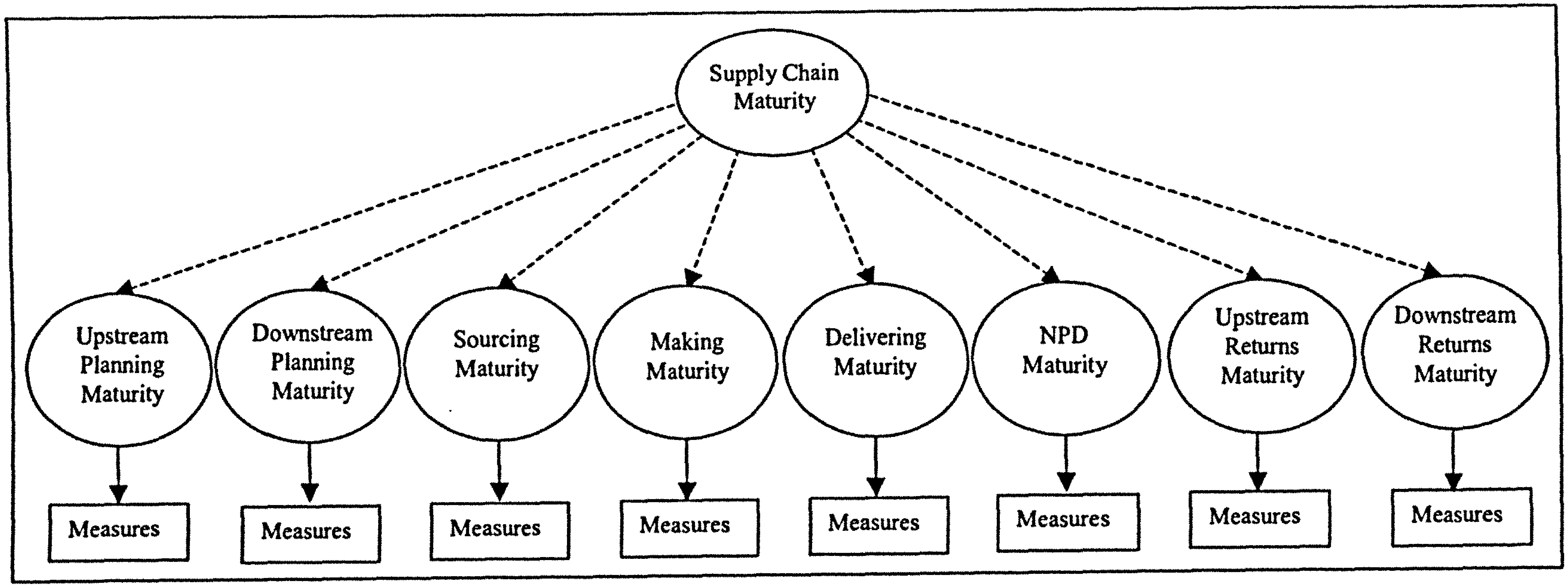
Healthcare is one such rapidly evolving sector that depends heavily upon the supply of products. For example, a sector-wide initiative was recently commenced within the UK Healthcare sector, motivated by a need to modernise supply and championed by the National Health Service (NHS) Purchasing and Supply Agency (National Health Service, 2002; Argyle, 2002). The NHS has scaled-up major efforts specifically to develop collaborative supply chain integration with over 1,600 1st tier suppliers of products and services to an annual value of approximately £11 billion ($18 billion). Whilst the NHS is the largest healthcare provider in the UK, similar, albeit smaller, initiatives are being promoted by other providers such as BUPA and BMI-General. This provides an ideal arena for exploring the maturity concept given the likely spread of collaborative supply chain integration practices.

7.3 CONCEPTUAL MODEL AND HYPOTHESIS DEVELOPMENT

7.3.1 The Supply Chain Maturity Construct in Healthcare

This essay operationalises supply chain maturity in terms of levels of collaborative inter-firm communication relating to appropriate SCOR model integrative practices. The UK Healthcare sector, with particular focus on 1st tier product suppliers to major healthcare service providers, represents an interesting study domain. It also presents excellent scope for developing the supply chain maturity concept across practices related to all SCOR dimensions. Figure 7.1 shows the full conceptual model of supply chain maturity comprising potential underlying SCOR maturity dimensions relating to Upstream Planning, Downstream Planning, Sourcing, Making, Delivering, NPD, Upstream Returns and Downstream Returns.

Figure 7.1 Essay 3 Conceptual Model: Dimensions of Supply Chain Maturity



An important point to note is that the supply chain maturity construct is not universally applicable in its full form, but context dependent and based upon appropriate practices. Given the different permutations of real-world supply chain positions, configurations and operations; practices associated with each SCOR dimension are unlikely to be appropriate in all contexts. For example, the Downstream Planning and Delivering dimensions are unlikely to be appropriate for end customers/ consumers that do not have any further downstream supply chain partners. Similarly, for suppliers that do not depend upon further upstream supply chain partners the Upstream Planning and Sourcing dimensions are unlikely to be appropriate. Also, practices associated with the dimensions of Making, Returns and NPD are only likely to be appropriate for those companies that engage in these respective supply chain operations. (As with the Planning dimension, Returns also divides into appropriate upstream and downstream practices.) Such context-related appropriateness is indicated in Figure 7.1 by the dotted lines linking the SCOR endogenous maturity dimensions.

The previous literature discussion leads to the following overall proposition:

> **Proposition 1:** Supply Chain Maturity can be defined in terms of the level of collaborative knowledge sharing across appropriate SCOR dimensions.

Similarly, since distinct practices are associated with each of the SCOR dimensions:

> **Proposition 2:** The underlying maturity dimensions of Planning, Sourcing, Making, Delivering, NPD and Returns can be defined in terms of collaborative knowledge sharing across associated practices.

7.3.2 Practices Associated With the Underlying SCOR Maturity Dimensions

Academic literature suggests that Planning be divided into downstream (customer facing) and upstream (supplier facing) practices (Frohlich & Westbrook, 2001). Regarding the Downstream Planning dimension, supply chain researchers propose specific customer-oriented collaborative integration practices associated with: 1. Downstream Future Demand Planning (Smaros et al., 2003; Finarelli & Johnson, 2004) to reduce customer-oriented crises situations, to predict future demand and to coordinate delivery dates; and 2. Downstream Customer Satisfaction Planning (Mentzer & Moon, 2004) to calculate inventory levels to match customer needs, to align the supply chain with sales and marketing activities and to create customer service and parts systems. Thus we hypothesize:

H1a: Downstream Planning Maturity can be defined by the levels of customer collaboration associated with Future Demand Planning and Customer Satisfaction Planning.

Regarding the Upstream Planning dimension, supply chain academics propose specific supplier-oriented collaborative integration practices associated with: 1. Upstream Future Supply Planning (Svensson, 2004) to reduce supply-related future crises, to agree supply levels, and to coordinate supply dates; and 2. Upstream Supply Satisfaction Planning (Wright, 2003) to design supply networks, calculate inventories to match supply needs, and create supply service and parts systems. Thus we hypothesize:

H1b: Upstream Planning Maturity can be defined by the levels of supplier collaboration associated with Future Supply Planning and Supply Satisfaction Planning.

Regarding the Sourcing dimension, supply chain academics propose collaborative integration practices associated with: 1. Sourcing Knowledge Sharing (Akacum & Dale, 1995) relating to sharing of supply inventory and delivery knowledge, and formulation of agreements and contracts; and 2. e-Sourcing (Disney et al., 2004) pertaining to up-to-date practices such as participation in online auctions, the use of supplier exchanges and portals, and the use of 'next-generation' vendor managed inventory (eVMI) systems. Thus we hypothesize:

H1c: Sourcing Maturity can be defined by the levels of collaboration with suppliers associated with Sourcing Knowledge Sharing and e-Sourcing.

For the Making dimension, academics propose the following modern practices: 1. Lean Manufacturing (Shah & Ward, 2003) relating to the implementation of pull production (e.g. reducing batch size/ set-up, Kanban systems), and reengineering from functional to process-orientation (e.g. plant-within-a-plant restructuring, cellular manufacturing); and 2. Production Knowledge Sharing (Hines et al., 2004) relating to practices such as IT communications and enterprise resource planning (ERP) systems, programmes for quality improvement and control (e.g. TQM, 6-Sigma), and creating a dedicated 'supply chain champion' position within manufacturing. Thus we hypothesize:

> H1d: Making Maturity can be defined by the levels of collaboration associated with Lean Making and Production Knowledge Sharing.

Similar to the Sourcing dimension, for the Delivering dimension the academic literature notes specific collaborative integration practices associated with: 1. Delivery Knowledge Sharing (Steckel et al., 2004) relating to the sharing of delivery and downstream inventory knowledge, and the nurturing of long-term downstream relationships; and 2. e-Delivery (Disney et al., 2004) relating to up-to-date practices such as participation in online auctions, the use of customer exchanges and portals, e-procurement/ automated transactions and the use of 'next-generation' vendor managed inventory (eVMI) systems. Thus we hypothesize:

> H1e: Delivering Maturity can be defined by the levels of collaboration with the customer associated with Delivery Knowledge Sharing and e-Delivery.

Whilst a New Product Development (NPD) dimension is not incorporated within the SCOR model, the academic literature review identified the promotion of NPD practices (Petersen et al., 2003; Joglekar & Rosenthal, 2003). Practices associated with NPD include collaboration to design and improve the product, to control an engineering change order system, to coordinate purchasing for prototypes and to design 'for' effective supply chain management. Thus we hypothesize:

> H1f: NPD Maturity can be defined by the levels of collaboration associated with the new product development process.

For the Returns dimension both downstream and upstream practices are proposed by the academic literature. Collaboration across practices associated with returns from the downstream customer fall into two groups: 1. Downstream Product Returns (Morton, 2003) such as coordinating product returns from the customer and end users, and maintaining customer confidence in the product returns process; and 2. Downstream Packaging Returns (Rogers & Tibben-Lembke, 1999) practices such as coordinating returns of packaging (e.g. reusable Kanban containers, empty boxes, dispensers, pallets etc.) from the customer and end users, and ensuring sufficient packaging process capability. Thus we hypothesize:

H1g: Downstream Returns Maturity can be defined by the levels of collaboration with the customer associated with Downstream Product Returns and Downstream Packaging Returns.

Similarly, the academic literature proposes that collaboration across practices associated with returns to upstream suppliers fall into two groups: 1. Upstream Product Returns (Tibben-Lembke, 2002) such as coordinating product returns from customers to suppliers, and identifying legitimate product returns; and 2. Upstream Packaging Returns (Rogers & Tibben-Lembke, 1999) practices such as coordinating packaging returns (e.g. reusable Kanban containers, empty boxes, dispensers, pallets etc.) to suppliers, and reducing the package returns process cycle time. Thus we hypothesize:

H1h: Upstream Returns Maturity can be defined by the levels of collaboration with the suppliers associated with Upstream Product Returns and Upstream Packaging Returns.

The derivation of the above hypotheses from the academic literature, is given further relevance by the review of practitioner literature (e.g. Supply Chain Council, 2004) and promotional literature from leading supply chain consulting firms (Oracle, 2003; SAP, 2003; JD Edwards/ Peoplesoft, 2003; i2, 2003; PRTM, 2003; Manugistics, 2003). Whilst respecting the caveats in Section 2.1.6, it is noteworthy that such practitioner-based literature promotes specific practices corresponding to each of the above hypotheses.

7.3.3 The Impact of Supply Chain Maturity Dimensions Upon Performance

The underlying proposition of Bowersox et al. (2000) is that companies and sectors can improve their supply chain performance through the evolution and development of supply chain maturity. In turn this implies increased levels of collaborative knowledge sharing across a range of appropriate integrative supply chain practices. According to Bowersox et al. (2000) high levels of maturity reflect fundamental shifts already "exhibited by leading firms as they transform their supply chain capabilities". Conversely, low supply chain maturity levels are observed in "lagging" companies or sectors. Thus we hypothesize:

H2a: Supply Chain Maturity will have a significant impact upon supply chain performance measures.

More specifically, knowledge sharing across certain SCOR-related practice dimensions will have significant impact upon particular supply chain performance measures. For example, practices associated with the underlying e-Sourcing dimensions (i.e. use of 'next generation' vendor managed inventory (eVMI), participating in on-line auctions, use of supplier exchanges and portals) have a beneficial impact upon increasing inventory turns since they permit a supplier to hold a reduced level of stock whilst maintaining supply requirements (Disney et al., 2004). Thus we hypothesize:

> H2b: The underlying e-Sourcing dimension will have a significant beneficial impact upon Inventory Turns.

Similarly, practices associated with the underlying Make Knowledge Sharing dimension (i.e. use of IT communication technologies (ERP), programmes for quality improvement and control (TQM/ 6-sigma), dedicated supply chain "champions") are designed to help improve stock keeping operations and thus levels of inventory turns performance (Hines et al., 2004) . We thus hypothesize:

> H2c: The underlying Make Knowledge Sharing dimension will have a significant beneficial impact upon Inventory Turns.

Also, collaboration with the customer across practices associated with Downstream Future Demand Planning (i.e. optimise the supply chain to reduce future crisis situations, predict future demand, coordinate delivery dates) serve to reduce stock levels needed to cope with uncertain demand fluctuations. These specific practices are particularly beneficial in reducing levels of Days Finished Goods (Smaros et al., 2003; Finarelli & Johnson, 2004). Thus:

> H2d: The underlying Downstream Future Demand Planning dimension will have a significant beneficial impact upon reducing Days Finished Goods.

Collaborative practices associated with the underlying dimension of Sourcing Knowledge Sharing (i.e. sharing inventory and delivery knowledge, formulating supplier agreements and contracts) have a beneficial impact upon operational efficiency (Akacum & Dale, 1995). Such practices cultivate confidence that upstream suppliers will deliver materials, components, sub-assemblies etc. as required, with corresponding reduction in Days WIP Inventory waiting to be finished. Thus:

H2e: The underlying Sourcing Knowledge Sharing dimension will have a significant beneficial impact upon reducing Days WIP Inventory.

Similar downstream collaboration across practices associated with Delivery Knowledge Sharing also have a beneficial impact upon inventory level efficiency, cultivating confidence in terms of when the customer will actually need and buy the finished product (Steckel et al., 2004). Thus raw materials can be acquired as necessary and work-in-progress can be trimmed to downstream delivery needs. Thus:

H2f: The underlying Delivery Knowledge Sharing dimension will have a significant beneficial impact upon reducing Days Raw Materials Inventory and Days WIP Inventory.

Other beneficial impacts upon multiple performance measures occur with practices associated with Downstream Customer Satisfaction Planning (i.e. calculating inventory levels to match customer needs, aligning the supply chain with sales and marketing activities, creating a coordinated customer service and parts system). As stock keeping is kept in line with customer requirements, destabilising 'peaks and troughs' of sales and marketing promotions are avoided, and an effective service and parts system is created, both Inventory Turns and Percentage Customer Orders Fulfilled will be positively affected. Also, implementing practises to align operations, sales and marketing with downstream demand will have a beneficial impact upon Percentage Demand Forecast Accuracy (Mentzer & Moon, 2004). Thus we hypothesize:

H2g: The underlying Downstream Customer Satisfaction Planning dimension will have a significant beneficial impact upon Inventory Turns, Percentage Customer Orders Fulfilled, and Percentage Demand Forecast Accuracy.

There are however, those practices that, whilst appropriate, cannot, by their nature have a beneficial impact upon certain performance measures. For example, engaging in product returns is unlikely to improve the efficiency of operations. In fact, appropriate but potentially disruptive practices associated with the Downstream Product Returns dimension (i.e. coordinating product returns from the customer and end-users, maintaining customer confidence in the returns and repair process) are likely to have a detrimental effect upon performance efficiency measures such as Days WIP Inventory, as returned products are reworked (Rogers & Tibben-Lembke, 1999; Morton, 2003).Thus we hypothesize:

H2h: The underlying Downstream Product Returns dimension will have a significant detrimental impact upon Days WIP Inventory.

Finally, whilst both practitioner and academic supply chain literatures propose universal benefits of collaborative integration practices, the knowledge management literature warns of potential negative impacts. Certainly, a beneficial impact cannot always be assumed. Previous operations management studies have identified negative impacts of operational practices upon performance (Corbett & Van Wassenhove, 1993; Upton, 1995). The knowledge management literature goes further and has long recognised the potential negative impact of certain knowledge-practice dimensions. Diminishing performance returns as an organisation evolves have been recognised in the learning curve literature (Epple et al., 1991). Similarly, whilst practice-related competencies can be beneficial in the shorter term, in the longer-term they can become 'competency traps' that detrimentally affect performance. Myopia and rigidity in their evolutionary development can lead organisations to overlook such negative impacts, and thus continue with detrimental practice implementation (Levinthal & March, 1993). For example, collaborative practices associated with Delivery Knowledge Sharing (i.e. establishing downstream relationships, sharing inventory and delivery knowledge with the customer) may not in the longer-term benefit a 1st tier supplier on certain performance criteria. In the longer term, a customer is liable to exploit an overly dependent and trusting supplier, pushing their own inventory problems and inefficiencies onto the supplier- with corresponding detrimental impact upon the supplier's level of Inventory Turns. Thus:

H2i: The underlying Delivery Knowledge Sharing dimension will have a significant detrimental impact upon Inventory Turns.

7.4 RESEARCH METHODS

7.4.1 Survey Design

In order to adequately capture both knowledge sharing and appropriate practice aspects of the supply chain maturity construct a new form of survey instrument was devised to go beyond typical static dyadic survey limitations. A web-based survey instrument was purpose-designed, programmed, developed and pre-tested over the course of 12 months in line with guidelines proposed by Frohlich and Done (2004). A comprehensive review of supply chain practices informed the formulation of survey items to encompass the dimensions of Plan, Source, Deliver, Make, New Product Development and Returns. Both academics and practitioners were involved in the development of this innovative survey instrument to ensure relevance and validity of approach and content. Two key features of the adaptive instrument included: i) respondents constructing their own specific supply chain configuration for a major product line and responding to survey items for that specific configuration; and ii) respondents selecting optional survey sections according to those practices they deemed appropriate to their specific operations. After several software development phases to ensure functionality a full pilot test confirmed high interest and usability levels amongst practitioners, as well as the ability of the instrument to generate quality academic data.

7.4.2 Sample

A comprehensive listing of 957 1st tier product suppliers was obtained from the major UK healthcare service providers (NHS, BUPA and BMI-General). This constituted the majority of the respective UK supplier population across the healthcare supplier divisions of: Diagnostic and Medical Equipment; Medical and Surgical Equipment; Pharmaceuticals; Food and Nutrition; Textiles and Domestics; Facilities Management and Utilities; IT Equipment; Office Services; Rehabilitation; Professional Services. Across all divisions, 596 Supply Chain Directors were invited and given access to the online survey. 154 full responses were received constituting a good overall response rate of 25.8%. Whilst response rates varied to an acceptable degree across supplier categories each was adequately represented in the final sample. Non-response bias was judged to be within acceptable limits. Mean sales for the sample was £440 million with a standard deviation of £2,426 million. The mean number of employees was 3,035 with a standard deviation of 13,589. Furthermore, the sample of 154 respondents represented four distinct classes of supply chain configuration and the full range of SCOR practices across Plan, Source, Make, Deliver, NPD and Returns dimensions.

Table 7.1 Analysis of Sample and Responses to Optional Survey Sections

Supply Chain Configuration S4 S3 S2 S1 C	Total in Sample	Plan	Source	Make	Deliver	NPD	Returns
●○	60	60	-	21	60	26	33
○●○	55	55	55	29	55	30	32
○○●○	28	28	28	8	28	8	14
○○○●○	11	11	11	7	11	5	7
Total	154	154	94	65	154	69	86

C- Healthcare Provider, S1- Surveyed 1st Tier Supplier, S2- 2nd Tier Supplier, S3- 3rd Tier Supplier, S4- 4th Tier Supplier

Table 7.1 indicates a detailed breakdown of the sample responses obtained for each of the optional survey sections. Of the total sample of 154 1st tier suppliers, 60 opted only to respond to survey questions relating to the healthcare service provider (C) and not for further upstream suppliers (S1, S2 etc.) Thus these respondents were excluded from subsequent analysis relating to Upstream Planning and Sourcing practices. Nevertheless, 94 1st tier suppliers did chose to respond to survey sections relating to further upstream suppliers- 55 for one further supplier level, 28 for two further supplier levels, and 11 for 3 further supplier levels. These respondents were included in subsequent analysis of Upstream Planning and Sourcing. Also, a total of 65 of the 1st tier suppliers sampled were involved in manufacturing the product; 69 in new product development activities; and 86 in the returns of products and/ or packaging. For these companies the relevant Make, NPD and Returns sections of the survey were considered appropriate and duly completed. These respondents were included in subsequent analysis of the respective Make, NPD and Returns practices. Finally, Downstream Planning and Delivering practices were considered appropriate, and the respective survey sections completed, by all 154 companies. Thus the full sample of 154 1st tier suppliers were included in subsequent analysis of these Downstream Planning and Delivering practices.

7.4.3 Measurement Issues

7.4.3.1 Measurement of Dependent Variables: Performance

We adopted the same objective performance metrics used by Harrison and New (2002) to formulate their 'level of sophistication' classification, with the following modifications: 1. a survey item for Demand Forecast Accuracy was included given the overwhelming evidence regarding the importance of accurate demand forecasts (e.g. Lee et al., 1997a);

2. measures for Customer and Supplier Delivery Performance were omitted given that they are largely captured within Customer and Supplier Order Fulfilment; 3. the overall measure of Inventory Days of Supply was divided into separate items for Days Raw Materials, Work-in-Progress, and Finished Goods. The means and standard deviations of the responses were as follows: Inventory Turns per Year 61.7 (166.1), Percentage Orders Fulfilled by Supplier 88.9% (12.5), Percentage Customer Orders Fulfilled 91.3% (12.5), Days Lead-Time 12.9 days (28.1), Percentage Demand Forecast Accuracy 81.1% (14.7), Days Raw Materials 29.5 days (50.0), Days WIP 13.7 days (21.3), Days Finished Goods 29.9 days (37.0).

7.4.3.2 Measurement of Independent Variables: Knowledge Sharing across Appropriate Practices

The survey instrument measured the level of collaborative knowledge sharing across practice items associated with each dimension as identified by an extensive literature review. Levels of collaboration were captured using 1 to 7 Likert scales. For the Plan dimension respondents were asked how frequently their company communicated with respective supply chain partners in order to execute each planning related practice item (1- Never, 2- Annually, 3- Quarterly, 4- Monthly, 5- Weekly, 6- Daily, 7- Hourly). For the Source, Deliver, NPD and Returns dimensions respondents were asked to what degree their company collaboratively shared knowledge with respective supply chain partners for each of the associated practices (1- Not at all, 2- Very little, 3- Little, 4- Average, 5- Quite a lot, 6- A lot, 7- Completely.) On the same 1-7 Likert scale, respondents were asked to what extent their company implemented the Make related practices. For those companies with more than one upstream supplier the Upstream Planning, Sourcing and Upstream Returns responses were summed to give a total level of upstream collaborative knowledge sharing.

7.4.3.3 Missing Data and Limitations to Analysis

The adaptive survey instrument allowed respondents to skip sections of the survey. Whilst the total response sample consisted of 154 companies, certain respondents chose not to answer survey sections relating to Upstream Planning or Sourcing. Also, respondents could choose whether sections relating to Making, NPD or Returns were applicable to their respective company supply chain operations and could skip these sections accordingly. Thus whilst the response sample sizes for certain sections were reduced, the skip function and explanatory pop-up windows decreased levels of uncontrolled missing data. Missing data was further reduced by requiring respondents to complete each chosen section before being able to proceed or to receive any feedback. In view of the type of ensuing data analysis an awareness of the sub-sample sizes for each survey section was important. The sub-sample sizes and missing data analysis are presented in Table 7.2.

Table 7.2 Sub-sample Sizes and Missing Data Analysis for Optional Survey Sections

Survey Section	Case Responses Per Section	Total Survey Items	Missing Items	% Missing Items	Incomplete Cases	% Incomplete Cases
Performance	154	1232	0	0%	-	0%
Upstream Planning	94	940	118	12.6%	13	13.8%
Downstream Planning	154	1540	163	10.6%	17	11.0%
Sourcing	94	1128	334	29.6%	28	29.8%
Delivering	154	1848	507	27.4%	44	28.6%
Making	65	390	0	0%	0	0%
Upstream NPD	43	301	6	2.0%	1	2.3%
Internal NPD	69	483	20	4.1%	2	2.9%
Downstream NPD	69	483	13	2.7%	3	4.3%
Upstream Returns	53	530	130	24.5%	15	28.3%
Downstream Returns	86	860	210	24.4%	21	24.4%
Total	**1035**	**9735**	**1501**	**15.4%**	**144**	**13.9%**

Diagnostic tests showed that the missing data due to drop-outs were 'missing completely at random' (MCAR) (Hair et al., 1998). Of the various imputation methods available for MCAR missing data, mean substitution was selected as the most appropriate, given the acceptable levels of missing items and cases, and to maintain adequate sample size for analysis. The small sample sizes corresponding to certain sections represent a limitation to the permissible complexity of data analysis techniques such as structural equation modelling. Nevertheless, there is considerable support that the sample sizes attained are adequate for the purposes of confirming factors in a model of low complexity and with relatively few parameters. Whilst Boomsma (1985) advocate a sample size of at least 100 for full structural equation modelling, MacCallum et al. (1992) suggest at least 5 responses per parameter. These thresholds were exceeded and we took extra care not to "overfit" the data limitations with overly complex SEMs. The maximum likelihood estimation procedure used has been found to produce valid results with sample sizes as small as 50 (Hair et al., 1998).

7.5 RESULTS AND DISCUSSION

The analysis of the empirical data followed three steps:

1. The creation of valid and reliable multi-item scales for the underlying maturity dimensions using confirmatory factor analysis techniques (hypotheses H1a-h.)
2. The validation of appropriate second-order supply chain maturity constructs using hierarchical structural equation modelling.
3. The investigation of the impact of underlying maturity dimensions upon multiple performance measures using set correlation analysis (hypotheses H2a-i.)

7.5.1 Underlying Maturity Dimensions (Hypotheses H1a-h)

The sample of 154 healthcare product suppliers was sufficiently large for the purposes of identifying an underlying factor structure through data summarisation and for confident interpretation of results. To ensure that derived factors would be generalisable, a parsimonious set of variables was selected through conceptual and practical considerations.

7.5.1.1 Reliability Analysis

Diagnostic checks ensured that underlying statistical assumptions were met and that the data was adequate for creating multi-item maturity scales through principle component factor analysis. Inspection of the full survey data correlation matrices revealed all correlations to be significant and greater than 0.30 (Hair et al., 1998). Partial/ anti-image correlations were small, indicating high degree of suitability for factor analysis. Bartlett's test indicated that correlations were significant at the 0.001 level. Similarly the overall Keiser-Meyer-Olkin (KMO) measures of sampling adequacy of 0.80 and over corresponded to the "meritorious" level. The measure of sampling adequacy (MSA) for individual variables also indicated high suitability of the data for factor analysis. None of the selected items fell into the unacceptable range for exclusion.

Factor extraction was undertaken in accordance with established practice and determined by a combination of criteria (Cattell, 1966; Hair et al., 1998). Weak or redundant items were selectively dropped to form parsimonious, interpretable and reliable factors.

Varimax orthogonal rotation of factors maximised the sum of variances of required loadings of the factor matrix. Table 7.3 shows that Cronbach alpha values for all individual factors exceeded the lower acceptance level of 0.60 (Nunnally, 1979; Robinson, 1991). Also the high item-to-total correlations, inter-item correlations exceeding 0.30, good KMO measures and highly significant Bartlett test values indicate representative, unidimensional and practically significant factors. In terms of statistical significance, Cliff (1967) demonstrated that factor loadings should be strictly evaluated according to the effective sample size. All factor loadings for respective survey section sample sizes (n= 53 to 154) exceeded requirements to achieve a statistical power of 80% and 0.05 significance level.

Table 7.3 Reliability Analysis of Maturity Scales

Construct	Scale	Items	Item-to-total	1st Item % Variance	KMO	Bartlett's Test X^2	df	p	Cronbach α
Down-stream Planning	Downstream Future Demand Planning (DFDP) n=154	DP1: Reduce future crises	.873	72.047	.657	169.537	3	.000	.801
		DP2: Predict future demand	.903						
		DP5: Coordinate delivery dates	.764						
	Downstream Customer Satisfaction Planning (DCSP) n=154	DP8: Inventory to match customer needs	.880	73.012	.670	175.882	3	.000	.811
		DP9: Align SC to sales/ marketing	.901						
		DP10: Customer service/ parts system	.777						
Upstream Planning	Upstream Future Supply Planning (UFSP) n=94	UP1: Reduce future crises	.906	82.483	.747	162.316	3	.000	.888
		UP3: Agree future supply	.899						
		UP5: Coordinate supply dates	.920						
	Upstream Supply Satisfaction Planning (USSP) n=94	UP7: Design supply networks	.788	62.513	.670	48.002	3	.000	.692
		UP8: Calculate supply inventory	.774						
		UP10: Supply service/ parts system	.810						
Sourcing	Sourcing Knowledge Sharing (SKS) n=94	S4: Share inventory knowledge	.846	73.474	.699	99.668	3	.000	.815
		S5: Share delivery knowledge	.892						
		S7: Formulate agreements/ contracts	.833						
	e-Sourcing (eS) n=94	S8: Participate in on-line auctions	.713	58.050	.618	36.627	3	.000	.605
		S10: Use exchanges/ portals	.742						
		S11: Use e-Vendor Managed Inventory (eVMI)	.826						
Delivering	Delivery Knowledge Sharing (DKS) n=154	D3: Nurture long-term relationships	.886	75.527	.686	198.621	3	.000	.835
		D4: Share inventory knowledge	.808						
		D5: Share delivery knowledge	.910						
	e-Delivery (eD) n=154	D8: Participate in on-line auctions	.696	51.233	.666	102.369	6	.000	.667
		D9: Use e-procurement/ automated transactions	.804						
		D10: Use exchanges/ portals	.653						
		D11: Use e-Vendor Managed Inventory (eVMI)	.701						

Table 7.3 Reliability Analysis of Maturity Scales (Continued)

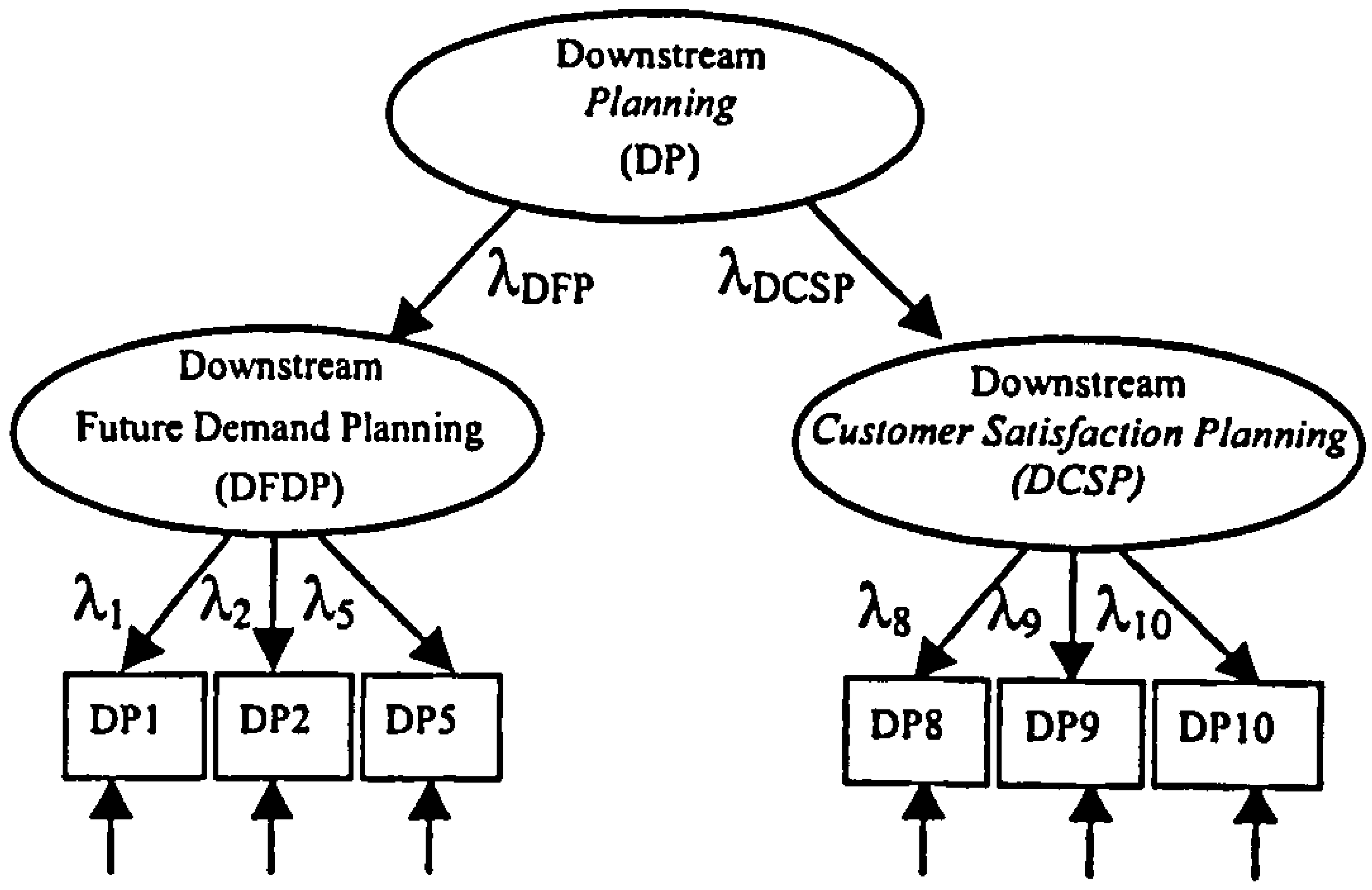
Construct	Scale	Items	Item-to-total	1st Item % Variance	KMO	Bartlett's Test X^2	df	p	Cronbach α
Making	Lean Making (LM) n=65	M2: Implement Pull production	.908	82.463	.500	34.211	1	.000	.787
		M4: From functional to process orientation	.908						
	Production Knowledge Sharing (PKS) n=65	MI: IT communications/ ERP	.768	60.945	.629	31.391	3	.000	.676
		M3: Programmes for quality and control	.842						
		M6: Dedicated Supply Chain Champions	.727						
NPD	NPD (NPD) n=69	INPD1: Product design/ improvement	.691	59.885	.726	76.514	6	.000	.775
		INPD2: Control Engineering Change Order System	.811						
		INPD4: Coordinate Purchasing for Prototypes	.857						
		INPD6: Design "for" effective SCM	.725						
Upstream Returns	Upstream Product Returns (URP) n=53	UR1: Coordinate product returns to supplier/s	.867	82.806	.706	99.975	3	.000	.894
		UR2: Coordinate product returns from/ to end users	.944						
		UR7: Identify legitimate returns	.917						
	Upstream Packaging Returns (URPK) n=53	UR3: Coordinate packaging returns to supplier/s	.916	82.508	.667	106.658	3	.000	.892
		UR4: Coordinate packaging returns from/ to end users	.955						
		UR8: Reduce returns processing cycle time	.851						
Down-stream Returns	Downstream Product Returns (DRP) n=86	DR1: Coordinate product returns from customer	.906	72.706	.671	91.035	3	.000	.811
		DR2: Coordinate product returns from end users	.842						
		DR10: Maintain customer confidence in returns process	.810						
	Downstream Packaging Returns (DRPK) n=86	DR3: Coordinate packaging returns from customer	.864	77.332	.726	111.000	3	.000	.853
		DR4: Coordinate packaging returns from end users	.899						
		DR5: Ensure sufficient processing capability	.875						

7.5.1.2 Maturity Scale Validity

The requirements for validity are twofold. A scale must truly measure what it is supposed to measure, and it must not measure anything else (Flynn et al., 1990). To satisfy these two requirements several facets of validity were tested. Content or face validity was determined through a non-statistical assessment of the correspondence of the variables in each scale and its conceptual definition. The scales formed were discussed with experienced academics and practitioners in the field and it was agreed that the scale items extended past empirical issues to also include theoretical and practical considerations (Churchill, 1979; Robinson, 1991). Further forms of validity were measured empirically through second order confirmatory factor analysis (CFA).

Optimally, factor analysis should always be followed by some form of CFA, which is particularly useful in the validation of scales emerging from more exploratory analysis (Kim & Mueller, 1978; Gerbing & Hamilton, 1996). Repeated CFA runs similar to that shown for the Downstream Planning construct in Figure 7.2 were conducted for all the SCOR maturity dimensions to assess convergent and discriminant validity.

Figure 7.2 Example of Second Order CFA- Downstream Planning Maturity



Downstream Future Demand Planning (DFDP):
How frequently does your company communicate with supply chain partners to:
(1-7 Likert scale: 1- Never, 2- Annually, 3- Quarterly, 4- Monthly, 5- Weekly, 6- Daily, 7- Hourly)

DP1: optimise the supply chain to reduce future crisis situations?	1	2	3	4	5	6	7
DP2: predict future demand?	1	2	3	4	5	6	7
DP55: coordinate delivery dates?	1	2	3	4	5	6	7

Downstream Customer Satisfaction Planning (DCSP):
How frequently does your company communicate with supply chain partners to:
(1-7 Likert scale: 1- Never, 2- Annually, 3- Quarterly, 4- Monthly, 5- Weekly, 6- Daily, 7- Hourly)

DP8: calculate inventory levels to meet customer requirements?	1	2	3	4	5	6	7
DP9: align the supply chain with sales/ marketing activities?	1	2	3	4	5	6	7
DP10: create service and parts systems to sustain customer satisfaction?	1	2	3	4	5	6	7

Convergent validity refers to the extent to which varying approaches to construct measurement yield the same results (Churchill, 1979). By treating each item in a scale as a different approach to measuring the same construct, convergent validity is assessed by verifying whether each indicator's estimated pattern coefficient on its hypothesized underlying construct factor is significant (Anderson & Gerbing, 1988). The knowledge-sharing/ practice survey items relating to each of the SCOR maturity dimensions were subjected to second-order CFA using the maximum likelihood method of estimation (Joreskog & Sorbom, 1989). In the second-order factor model, it is hypothesized that the second-order maturity construct explains the association among the first-order dimensions, avoiding the problem of correlated measurement errors. The results of the CFA are shown in Tables 7.4 and 7.5.

Table 7.4 Confirmatory Factor Analysis (CFA): Summary Statistics

CFA Model	SMC range 1st Order	SMC range 2nd Order	Max MI	X^2	df	p	X^2/ df	NFI ~.90	CFI >.90	RFI >.90	IFI >.90	TLI ~.95	RMSEA <.05
Downstream Planning	.325-.912	.552-.991	-	10.010	8	.264	1.25	.975	.995	.953	.995	.990	.043
Upstream Planning	.290-.768	.352-1.921	4.25	11.597	8	.170	1.45	.956	.985	.917	.973	.973	.075
Sourcing	.306-.731	.143-1.188	9.09	12.168	8	.144	1.52	.896	.959	.805	.923	.923	.090
Delivering	.242-.828	.401-.543	-	17.146	13	.193	1.32	.931	.982	.888	.982	.970	.054
Making	.241-.815	.338-1.004	-	5.763	4	.218	1.44	.936	.978	.839	.979	.945	.083
NPD	.331-748	-	-	2.382	2	.304	1.19	.970	.995	.910	.995	.984	.054
Downstream Returns	.472-.761	.301-2.713	-	10.708	8	.219	1.34	.955	.988	.916	.988	.977	.072
Upstream Returns	.571-.936	.122-3.008	-	10.630	8	.224	1.33	.945	.985	.897	.986	.972	.092

Criteria for Good Fit indicated for appropriate statistics. (Bollen, 1989; Hoyle, 1995; Marcoulides & Schumacker, 1996).

The overall validities of the CFA models were tested using multiple fit criteria in Table 7.4 (Bollen, 1989; Hoyle, 1995; Marcoulides & Schumacker, 1996). The highly insignificant p-values associated with chi-square and degrees of freedom indicate a failure to reject the null hypothesis that the CFA models represent a good fit to the data. Further to the chi-square value, analysis of the subjective fit criteria Normed Fit Index (NFI), Comparative Fit Index (CFI), Relative Fit Index (RFI), Incremental Index of Fit (IFI), Tucker-Lewis Index (TLI) and Root Mean Square Error of Approximation (RMSEA) indicates high validity of CFA models for all of the SCOR maturity dimensions.

Table 7.5 CFA Loadings for Underlying Dimensions of Supply Chain Maturity

Construct	Construct/ Indicator	Factor Loading	t-Value
Downstream Planning			
	Second-Order Results		
Downstream Planning	Downstream Future Demand Planning (DFDP)	.990	4.195***
Downstream Planning	Downstream Customer Satisfaction Planning (DCSP)	1.000	n.a.
	First-Order Results		
Downstream Future Demand Planning (DFDP)	DP1: Reduce future crises	1.410	6.714***
	DP2: Predict future demand	1.559	7.059***
	DP5: Coordinate delivery dates	1.000	n.a.
Downstream Customer Satisfaction Planning (DCSP)	DP8: Inventory to match customer needs	1.738	7.116***
	DP9: Align SC to sales/ marketing	1.455	7.105***
	DP10: Customer service/ parts system	1.000	n.a.
Upstream Planning			
	Second-Order Results		
Upstream Planning	Upstream Future Supply Planning (UFSP)	3.654	4.7050***
Upstream Planning	Upstream Supply Satisfaction Planning (USSP)	1.000	n.a.
	First-Order Results		
Upstream Future Supply Planning (UFSP)	UP1: Reduce future crises	.917	11.196***
	UP3: Agree future supply	.708	9.958***
	UP5: Coordinate supply dates	1.000	n.a.
Upstream Supply Satisfaction Planning (USSP)	UP7: Design supply networks	.485	4.409***
	UP8: Calculate supply inventory	.599	4.920***
	UP10: Supply service/ parts system	1.000	n.a.
Sourcing			
	Second-Order Results		
Sourcing	Sourcing Knowledge Sharing (SKS)	.969	2.045*
Sourcing	e-Sourcing (eS)	1.000	n.a.
	First-Order Results		
Sourcing Knowledge Sharing (SKS)	S4: Share inventory knowledge	.784	5.741***
	S5: Share delivery knowledge	1.000	n.a.
	S7: Formulate agreements/ contracts	.935	5.615***
e-Sourcing (eS)	S8: Participate in on-line auctions	.461	2.914***
	S10: Use exchanges/ portals	1.000	n.a.
	S11: Use e-Vendor Managed Inventory (eVMI)	1.239	2.893***
Delivering			
	Second-Order Results		
Delivering	Delivery Knowledge Sharing (DKS)	1.158	3.249***
Delivering	e-Delivery (eD)	1.000	n.a.
	First-Order Results		
Delivery Knowledge Sharing (DKS)	D3: Nurture long-term relationships	1.632	7.316***
	D4: Share inventory knowledge	1.000	n.a.
	D5: Share delivery knowledge	1.631	7.339***
	D8: Participate in on-line auctions	.378	4.470***
	D9: Use e-procurement/ automated transactions	1.000	n.a.
e-Delivery (eD)	D10: Use exchanges/ portals	.519	4.045***
	D11: Use e-Vendor Managed Inventory (eVMI)	.565	4.435***
	DR4: Coordinate packaging returns from end users	1.069	7.309***
	DR5: Ensure sufficient processing capability	1.074	7.304***

1) *** p<0.001. 2) ** p<0.01. 3) * p<0.05. 4) To define scales, one link has to = 1. These t-values are marked "not applicable" (n.a.)

Table 7.5 CFA Loadings for Underlying Dimensions of Supply Chain Maturity (Continued)

Construct	Construct/ Indicator	Factor Loading	t-Value
Making			
	Second-Order Results		
Making	Lean Making (LM)	1.067	2.517**
Making	Production Knowledge Sharing (PKS)	1.000	n.a.
	First-Order Results		
Lean Making (LM)	M2: Implement Pull production	.862	4.051***
	M4: From functional to process orientation	1.000	n.a.
Make Communications (MC)	MI: IT communications/ ERP	1.000	n.a.
	M3: Programmes for quality and control	1.680	3.405***
	M6: Dedicated Supply Chain Champions	.965	3.105***
NPD			
	First-Order Results		
NPD (NPD)	INPD1: Product design/ improvement	.474	4.113***
	INPD2: Control Engineering Change Order System	1.000	n.a.
	INPD4: Coordinate Purchasing for Prototypes	1.086	5.490***
	INPD6: Design 'for' effective SCM	.598	4.333***
Upstream Returns			
	Second-Order Results		
Upstream Returns	Upstream Product Returns (URP)	4.392	2.936***
Upstream Returns	Upstream Packaging Returns (URPK)	1.000	n.a.
	First-Order Results		
Upstream Product Returns (URP)	UR1: Coordinate product returns to supplier	.883	6.253***
	UR2: Coordinate product returns from/ to end users	1.198	8.490***
	UR7: Identify legitimate returns	1.000	n.a.
Upstream Packaging Returns (URPK)	UR3: Coordinate packaging returns to supplier	1.000	n.a.
	UR4: Coordinate packaging returns from/ to end users	1.019	9.288***
	UR8: Reduce returns processing cycle time	.814	6.121***
Downstream Returns			
	Second-Order Results		
Downstream Returns	Downstream Product Returns (DRP)	2.610	3.916***
Downstream Returns	Downstream Packaging Returns (DRPK)	1.000	n.a.
	First-Order Results		
Downstream Product Returns (DRP)	DR1: Coordinate product returns from customer	1.250	6.143***
	DR2: Coordinate product returns from end users	1.135	5.698***
	DR10: Maintain customer confidence in returns process	1.000	n.a.
Downstream Packaging Returns (DRPK)	DR3: Coordinate packaging returns from customer	1.000	n.a.
	DR4: Coordinate packaging returns from end users	1.069	7.309***
	DR5: Ensure sufficient processing capability	1.074	7.304***

1) *** $p<0.001$. 2) ** $p<0.01$. 3) * $p<0.05$. 4) To define scales, one link has to = 1. These t-values are marked "not applicable" (n.a.)

Furthermore, Table 7.5 indicates high degrees of convergent validity in both first and second-order constructs for all of the SCOR maturity dimensions. All of the first and second-order factor loadings were statistically significant and positive. Also, squared multiple correlations for the indicators were found to be within acceptable ranges. Discriminant validity, which measures the extent to which the constituent items of a scale measure only one distinct construct (Campbell & Fiske, 1959; Robinson, 1991) was ascertained by examining modification indices. These results are shown in Table 7.4 and reveal a high degree of divergence across factors as indicated by the lack of cross-loadings. The rule of thumb for evidence of lack of discriminant validity is modification indices that are higher than 10. As the largest modification index encountered was 9.1, with most models lacking any cross-loadings, there is a high degree of discriminant validity among all SCOR maturity dimension constructs and measures.

The results of the second-order CFA therefore indicate high levels of validity, and provide strong statistical support for the hypotheses H1a to H1g. Thus the underlying SCOR maturity dimensions of Upstream/ Downstream Planning, Sourcing, Making, Delivering, NPD and Upstream/ Downstream Returns can be defined in terms of collaborative knowledge sharing across associated practices.

7.5.2 Validating the Supply Chain Maturity Construct

Structural equation modelling (SEM) is an appropriate technique to validate a latent higher-order construct such as supply chain maturity (Bollen, 1989). This analysis did not, however, seek to validate the full supply chain maturity construct (Figure 7.1) on the full sample of 154 companies for two reasons. Firstly, validation of a 'one size fits all' maturity construct is not appropriate given the diverse operational configurations present within the sample. No single construct encompassing all practice dimensions applies across all Healthcare supply chain situations. Secondly, a one-step validation of the full supply chain maturity construct was not possible due to sample size limitations relating to the Upstream Planning, Sourcing, Making, NPD and Returns dimensions.

Therefore a hierarchical SEM procedure was followed to establish validity of appropriate supply chain maturity constructs for different supply chain configurations and operations. Second-order hierarchical models using the previously defined maturity scale factor scores were subjected to the maximum likelihood method of estimation (Joreskog & Sorbom, 1989). A baseline supply chain maturity model comprising Downstream Planning and Delivering factor scores was first validated on the whole sample of 154. The validity of adding appropriate Upstream Planning, Sourcing, Making, NPD, Downstream Returns and Upstream Returns factor scores in turn to this baseline model was assessed on the reduced sample sizes of companies engaged in such operations. As with the CFA analysis above, the problem of correlated measurement errors was avoided by the second-order supply chain maturity construct explaining association among first-order dimensions. The results of the hierarchical SEMs are shown in Tables 7.6 and 7.7.

Table 7.6 Supply Chain Maturity Structural Equation Models: Summary Statistics

SEM Model	n	SMC range 1st	SMC range 2nd	Max MI	X^2	df	p	X^2/df	NFI ~.90	CFI >.90	RFI >.90	IFI >.90	TLI ~.95	RMSEA <.05
1. Baseline: Downstream Plan & Deliver	154	.222-.748	.460-2.08	-	1.02	1	.313	1.02	.995	1.00	.969	1.00	.999	.011
2. Baseline + Upstream Plan	94	.162-2.50	.054-.375	-	7.16	7	.412	1.02	.944	.999	.833	.999	.996	.017
3. Baseline + Sourcing	94	.006-27.3	.000-2.14	-	7.71	6	.260	1.29	.966	.992	.916	.992	.980	.055
4. Baseline + Making	65	.379-.792	.109-1.70	-	10.6	7	.155	1.52	.925	.970	.774	.973	.909	.090
5. Baseline + NPD	69	.212-.755	.000-4.51	-	31.0	18	.029	1.72	.898	.951	.796	.955	.903	.069
6. Baseline + Downstream Returns	86	.398-.922	.379-1.32	7.30	20.5	7	.005	2.93	.920	.944	.828	.946	.880	.150
7. Baseline + Upstream Returns	53	.288-1.25	.129-.998	-	8.43	7	.296	1.21	.942	.989	.875	.990	.976	.063

Criteria for Good Fit indicated for appropriate statistics. (Bollen, 1989; Hoyle, 1995; Marcoulides & Schumacker, 1996).

For the baseline Model 1 in Table 7.6, incorporating Downstream Planning and Delivering, the highly insignificant chi-square p-value failed to reject the null hypothesis of the model being a good fit to the data. Further analysis of subjective fit criteria NFI, CFI, RFI, IFI, TLI and RMSEA also indicated high validity of this model. This baseline model indicated high degrees of convergent validity given that first and second-order factor loadings were statistically significant and positive (Table 7.8). Squared multiple correlations were within acceptable ranges. Discriminant validity for the baseline model was established by a lack of modification indices. The results for the baseline model therefore provided strong statistical support that Downstream Planning and Delivering represent appropriate dimensions of supply chain maturity for all 1st tier product suppliers to the healthcare sector.

Similarly Models 2 to 7 in Table 7.6 indicate the validity of adding appropriate Upstream Planning, Sourcing, Making, NPD, Downstream Returns and Upstream Returns dimensions to the baseline Model 1, for the respective reduced sample sizes. In all cases, subjective fit criteria, SMC values, and modification indices all demonstrate valid models that fit the data. Chi-square values are sensitive to small sample sizes and therefore for these models more emphasis was placed upon subjective fit criteria (Byrne, 2001). Nevertheless, with the exception of NPD and Downstream Returns, the insignificant chi-square values further confirm well-fitting models.

Table 7.7 SEM Loadings for Appropriate Supply Chain Maturity Constructs

'Appropriate' Supply Chain Maturity Construct	Construct/ Indicator	Factor Loading	t-Value
Model 1: Downstream Planning + Delivering (n=154)			
	Second-Order Results		
Supply Chain Maturity	Downstream Planning (DP)	1.000	n.a.
Supply Chain Maturity	Delivering (D)	.319	4.318***
	First-Order Results		
Downstream Planning (DP)	Downstream Future Demand Planning (DFDP)	1.243	8.233***
	Downstream Customer Satisfaction Planning (DCSP)	1.000	n.a.
Delivering (D)	Delivery Knowledge Sharing (DKS)	1.657	5.308***
	e-Delivery (eD)	1.000	n.a.
Model 2: Downstream Planning + Delivering + Upstream Planning (n=94)			
	Second-Order Results		
Supply Chain Maturity	Downstream Planning (DP)	1.000	n.a.
Supply Chain Maturity	Delivering (D)	.227	2.530**
Supply Chain Maturity	Upstream Planning (UP)	.366	3.840***
	First-Order Results		
Downstream Planning (DP)	Downstream Future Demand Planning (DFDP)	.840	5.391***
	Downstream Customer Satisfaction Planning (DCSP)	1.000	n.a.
Delivering (D)	Delivery Knowledge Sharing (DKS)	1.023	2.345**
	e-Delivery (eD)	1.000	n.a.
Upstream Planning (UP)	Upstream Future Supply Planning (UFSP)	.253	1.309
	Upstream Supply Satisfaction Planning (USSP)	1.000	n.a.
Model 3: Downstream Planning + Delivering + Sourcing (n=94)			
	Second-Order Results		
Supply Chain Maturity	Downstream Planning (DP)	.439	4.385***
Supply Chain Maturity	Delivering (D)	1.000	n.a.
Supply Chain Maturity	Sourcing (S)	.060	.878
	First-Order Results		
Downstream Planning (DP)	Downstream Future Demand Planning (DFDP)	1.418	7.147***
	Downstream Customer Satisfaction Planning (DCSP)	1.000	n.a.
Delivering (D)	Delivery Knowledge Sharing (DKS)	1.505	7.841***
	e-Delivery (eD) [a]	1.000	n.a.
Sourcing (S)	Sourcing Knowledge Sharing (SKS)	1.000	n.a.
	e-Sourcing (eS) [a]	.015	.013
Model 4: Downstream Planning + Delivering + Making (n=65)			
	Second-Order Results		
Supply Chain Maturity	Downstream Planning (DP)	.636	4.081***
Supply Chain Maturity	Delivering (D)	1.000	n.a.
Supply Chain Maturity	Making (M)	.218	1.850*
	First-Order Results		
Downstream Planning (DP)	Downstream Future Demand Planning (DFP)	1.372	6.503***
	Downstream Customer Satisfaction Planning (DCP)	1.000	n.a.
Delivering (D)	Delivery Knowledge Sharing (DKS)	1.247	6.455***
	e-Delivery (eD)	1.000	n.a.
Making (M)	Lean Making (LM)	.924	1.771*
	Production Knowledge Sharing (MKS)	1.000	n.a.

1) *** $p<0.001$. 2) ** $p<0.01$. 3) * $p<0.05$. 4) To define scales, one link has to = 1. These t-values are marked "not applicable" (n.a.).
5) [a] Indicates residual error correlation between items.

Table 7.7 SEM Loadings for Appropriate Supply Chain Maturity Constructs (Continued)

'Appropriate' Supply Chain Maturity Construct	Construct/ Indicator	Factor Loading	t-Value
Model 5: Downstream Planning + Delivering + NPD (n=69)			
	Second-Order Results		
Supply Chain Maturity	Downstream Planning (DP)	.319	4.324***
Supply Chain Maturity	Delivering (D)	1.000	n.a.
Supply Chain Maturity	NPD (NPD)	.032	.267
	First-Order Results		
Downstream Planning (DP)	Downstream Future Demand Planning (DFDP)	1.246	8.222***
	Downstream Customer Satisfaction Planning (DCSP)	1.000	n.a.
Delivering (D)	Delivery Knowledge Sharing (DKS)	1.651	5.323***
	e-Delivery (eD)	1.000	n.a.
NPD (NPD)	INPD1: Product design/ improvement	.434	3.965***
	INPD2: Control Engineering Change Order System	.915	5.482***
	INPD4: Coordinate Purchasing for Prototypes	1.000	n.a.
	INPD6: Design "for" effective SCM	.546	4.412***
Model 6: Downstream Planning + Delivering + Downstream Returns (n=86)			
	Second-Order Results		
Supply Chain Maturity	Downstream Planning (DP)	.893	7.309***
Supply Chain Maturity	Delivering (D)	1.000	n.a.
Supply Chain Maturity	Downstream Returns (DR)	.507	4.607***
	First-Order Results		
Downstream Planning (DP)	Downstream Future Demand Planning (DFDP)	.863	10.456***
	Downstream Customer Satisfaction Planning (DCSP)	1.000	n.a.
Delivering (D)	Delivery Knowledge Sharing (DKS)	.969	8.209***
	e-Delivery (eD)	1.000	n.a.
Downstream Returns (DR)	Downstream Product Returns (DRP)	1.203	6.781***
	Downstream Packaging Returns (DRPK)	1.000	n.a.
Model 7: Downstream Planning + Delivering + Upstream Returns (n=53)			
	Second-Order Results		
Supply Chain Maturity	Downstream Planning (DP)	1.220	6.332***
Supply Chain Maturity	Delivering (D)	1.000	n.a.
Supply Chain Maturity	Upstream Returns (UR)	.402	2.950***
	First-Order Results		
Downstream Planning (DP)	Downstream Future Demand Planning (DFDP)	.785	8.696***
	Downstream Customer Satisfaction Planning (DCSP)	1.000	n.a.
Delivering (D)	Delivery Knowledge Sharing (DKS)	.967	6.299***
	e-Delivery (eD)	1.000	n.a.
Upstream Returns (UR)	Upstream Product Returns (URP)	.475	1.667*
	Upstream Packaging Returns (URPK)	1.000	n.a.

1) *** p<0.001. 2) ** p<0.01. 3) * p<0.05. 4) To define scales, one of links has to = 1. These t-values are marked "not applicable" (n.a.) 5) * Indicates residual error correlation between items.

Significant factor loadings for Models 2 to 7 in Table 7.7 further confirm convergent validity of the appropriate Downstream Planning, Delivering, Making, Downstream Returns and Upstream Returns dimensions. Three insignificant factor loadings related to the Upstream Planning, Sourcing and NPD dimensions may have been due to confounding effects of a reduced sample size, complexities relating to the different upstream configurations, and the internal nature of the NPD survey measures. These insignificant dimensions are discussed further in Section 7.6.

7.5.3 Impact of Supply Chain Maturity Dimensions upon Multiple Performance Measures (Hypotheses H2a-i)

Relationships between the underlying maturity dimensions and multiple supply chain performance measures were investigated simultaneously using set correlation (SC) analysis. SC analysis is a sophisticated technique that permits a set of dependent variables to be simultaneously related to a set of independent variables (Cohen et al., 2003). It is a truly multivariate method that addresses shortcomings of more common methods by providing a single measure of association between data sets and a single framework for variable association, parameter estimation, hypothesis testing, and statistical power analysis. We conducted the SC analyses in line with Cohen et al. (2003) and Vastag and Montabon (2001) examples.

Due to sample size constraints two separate SC analyses were undertaken:

1. A full consideration of all 15 underlying dimensions against all 8 performance measures, on the very reduced sub-sample of 33 companies for whom all dimensions were appropriate. Whilst this analysis proved insightful, it resulted in a low statistical power, higher likelihood of Type I errors (invalid null hypothesis rejection) and thus permitted only restricted interpretation of results.
2. A reduced consideration of only the 'baseline' practice dimensions relating to Downstream Plan and Deliver against a reduced set of performance measures, on the full sample of 154 companies. This analysis resulted in high statistical power, reduced likelihood of Type I errors and thus improved interpretation.

Table 7.8 shows the results for the first SC analysis. The multivariate $R^2_{Y,X}$ quoted for SC is a generalization of the simple bivariate r^2 and multiple R^2 (Rozeboom, 1965; Van den Burg & Lewis, 1988). It represents the proportion of generalized variance of the dependent variable set accounted for by the independent variable set. The obtained $R^2_{Y,X}$ value of 99.9% and 'shrinkage' $\tilde{R}^2_{Y,X}$ value of 97.4% indicate an extremely high degree of multivariate association between performance measures and supply chain maturity dimensions. Rao's F value of 2.14 rejects the null hypothesis of no association between sets at the p<.001 level (Rao, 1975).

Table 7.8 Set Correlation Analysis 1: All Supply Chain Maturity Dimensions and Performance Measures

A. Correlations among basic variables

	Set Y_B								Set X_B													
	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
Y1: Inventory Turns	1.00																					
Y2: % Orders Fulfilled by Supplier	.25	1.00																				
Y3: % Customer Orders Fulfilled	.26	.94	1.00																			
Y4: Lead-Time	-.08	.23	.07	1.00																		
Y5: % Demand Forecast Accuracy	.24	.94	.92	.21	1.00																	
Y6: Days Raw Material Inventory	-.13	.45	.45	.14	.47	1.00																
Y7: Days Work in Progress Inventory	-.05	.40	.40	-.09	.32	.43	1.00															
Y8: Days Finished Goods Inventory	-.05	.44	.31	.10	.42	.40	.10	1.00														
X1: Downstream Future Demand Plan (DFP)	.01	.10	-.02	.25	.02	-.35	-.22	.16	1.00													
X2: Downstream Customer Satisf. Plan (DCP)	.21	-.02	-.04	.08	.03	-.39	-.33	.02	.64	1.00												
X3: Upstream Future Demand Planning (	-.08	-.10	.02	.16	.03	.36	-.15	-.02	.08	.31	1.00											
X4: Upstream Customer Satisfaction Planning	.01	-.01	.07	-.04	.08	-.01	-.30	-.14	.30	.60	.71	1.00										
X5: Sourcing Knowledge Sharing	.05	-.11	-.01	-.07	-.10	-.16	-.19	-.41	.27	.46	.51	.77	1.00									
X6: e-Sourcing	.48	.01	.03	.12	.11	.09	-.16	-.12	.00	.30	.48	.38	.28	1.00								
X7: Delivery Knowledge Sharing	-.23	.01	.04	-.02	-.11	-.33	.16	-.25	.31	.26	.01	.10	.40	-.01	1.00							
X8: e-Delivery	.45	.10	.05	-.15	.07	-.22	.08	-.08	.12	.30	-.12	-.07	.04	.55	.24	1.00						
X9: Lean Making	.38	.23	.30	.10	.25	-.14	-.12	-.03	.14	.35	.14	.19	.25	.38	.22	.15	1.00					
X10: Make Knowledge Sharing	.39	.20	.25	-.00	.17	-.57	-.02	-.14	.35	.58	-.23	.09	.17	.08	.36	.53	.36	1.00				
X11: NPD	.37	.08	.11	-.12	.07	-.07	-.02	-.02	-.07	.31	.01	.21	.32	.28	-.01	.19	.45	.26	1.00			
X12: Upstream Product Returns	.02	-.10	-.03	.15	.04	.05	-.22	-.17	.05	.43	.68	.79	.65	.56	.07	.08	.07	.06	.34	1.00		
X13: Upstream Packaging Returns	.14	.09	.11	-.02	.13	-.07	-.04	-.06	.29	.56	.45	.76	.68	.41	.2	.29	.12	.38	.41	.77	1.00	
X14: Downstream Product Returns	-.00	.17	.08	.03	.16	-.17	.02	.19	.42	.36	.07	.26	.37	.30	.39	.43	.17	.28	.42	.41	.56	1.00
X15: Downstream Packaging Returns	.11	.09	.02	-.06	.09	-.03	-.06	.17	.55	.56	.38	.51	.45	.37	.21	.47	.12	.25	.31	.45	.73	.69

B. Set Correlation Analysis findings for simultaneous multiple dependent variables

Model $R^2_{Y,X} = .999$; $\tilde{R}^2_{Y,X} = .974$; Rao $F = 2.140$; (*df:* $u = 83.4, v = 120.0$); $p < .001$

Variable	r^2 (Set X to Y)	DFP	DCP	UFP	UCP	SKS	eS	DKS	eD	LM	MKS	NPD	URP	URPK	DRP	DRPK
Y1: Inventory Turns	0.68**	.13	-.22	-.12	.01	.29	.77*	-.35*	-.08	-.08	.56*	.28	-.43	-.05	-.26	.09
Y2: % Orders Fulfilled by Supplier	0.31	.26	-.63	.20	.73	-.59	-.17	-.04	.22	.28	.22	.12	-.43	.37	.31	-.32
Y3: % Customer Orders Fulfilled	0.38	.09	-.81*	.42	.95*	-.48	-.07	-.01	.07	.16	.61	.21	-.60	.12	.31	-.27
Y4: Lead-Time	0.53	.77**	.03	.25	-1.3**	-.01	-.02	-.16	-.16	.37	-.15	-.23	.96*	.46	-.11	-.43
Y5: % Demand Forecast Accuracy	0.30	-.03	-.34	.22	.58	-.53	-.14	-.22	.09	.35	.25	-.11	-.29	.29	.45	-.25
Y6: Days Raw Materials	0.58	-.04	-.20	.71**	-.12	-.36	-.24	-.10	.26	.14	-.55	.11	-.34	.67	.04	-.24
Y7: Days WIP Inventory	0.60*	-.01	.41	.46	-.23	-.78**	-.39	-.26	.06	.26	-.45	-.10	-.51	.70	.66**	-.31
Y8: Days Finished Goods	0.38	-.03	-.35	.45	-.10	-.31	-.21	.30	.21	-.03	-.10	.17	-.47	.87	.06	-.31

*** p< .001. ** p< .05. * p< .1. Number of Cases = 33

The r^2 (set X to Y) values in Table 7.8 B gives the equivalent measure of association to that of a multivariate regression R^2, and is significant for Inventory Turns and Days WIP. A very high proportion of the variance for Inventory Turns (68%) and Days WIP (60%) was explained by the supply chain maturity dimensions. Thus the hypothesis (H2a) that the dimensions underlying supply chain maturity will have a significant impact upon supply chain performance measures is supported.

At the individual scale levels, several significant impacts were observed. Cohen et al. (2003) advise the prudence of requiring the multivariate test be significant as a precondition for assessing tests on individual variables. Thus for the significant multivariate associations, the following impacts were observed at individual variable levels and corresponding hypotheses supported: weakly significant beneficial impacts of e-Sourcing and Make Knowledge Sharing dimensions upon Inventory Turns (H2b, H2c); weakly significant detrimental impact of Delivery Knowledge Sharing upon Inventory Turns (H2i); significant beneficial impact of Sourcing Knowledge Sharing in reducing Days WIP Inventory (H2e); and significant detrimental impact of Downstream Product Returns upon Days WIP Inventory (H2h). However, with large sets and smaller sample sizes such as this Cohen et al. (2003) warn against Type I error inflation. Furthermore the statistical power estimate of only 25% ($p = .05$) for the first SC analysis cautions against over-interpretation of the results. Hence the second SC analysis was conducted with reduced sets using the full sample size.

Table 7.9 shows the results for the second SC analysis. The multivariate $R^2_{Y,X}$ value of 30.6% and 'shrinkage' $\tilde{R}^2_{Y,X}$ value of 15.3% indicate acceptable degrees of multivariate association between performance measures and Downstream Planning and Delivering related maturity dimensions. Rao's F value of 1.88 rejected the null hypothesis of no association between sets at the $p<.008$ level. Several r^2 (set X to Y) values were significant and indicated acceptable levels of explained variance for Inventory Turns (8.8%), Percentage Customer Order Fulfilment (5.2%), Percentage Demand Forecast Accuracy (10.6%), Days WIP Inventory (4.8%) and Days Finished Goods Inventory (5.7%). Thus the hypothesis that the SCOR dimensions underlying supply chain maturity will have a significant impact upon supply chain performance measures is further supported by this SC analysis. This SC analysis followed the Cohen et al. (2003) guidelines to guard against Type I error and achieved a statistical power estimate of 95% ($p = .05$).

Table 7.9 Set Correlation Analysis 2: Downstream Planning and Delivering Maturity Dimensions and Performance Measures

A. Correlations among basic variables

	Set Y_B						Set X_B			
	Y1	Y2	Y3	Y4	Y5	Y6	X1	X2	X3	X4
Y1: Inventory Turns	1.00									
Y2: % Customer Orders Fulfilled	-.05	1.00								
Y3: % Demand Forecast Accuracy	-.02	.46	1.00							
Y4: Days Raw Material Inventory	-.09	.01	.04	1.00						
Y5: Days Work in Progress Inventory	.02	-.18	.07	.44	1.00					
Y6: Days Finished Goods Inventory	-.09	-.02	-.09	.20	.07	1.00				
X1: Downstream Future Demand Plan (DFP)	.13	-.04	-.02	-.08	.04	-.16	1.00			
X2: Downstream Customer Satisf. Plan (DCP)	.28	.13	.24	-.04	.02	-.14	.59	1.00		
X3: Delivery Knowledge Sharing	.10	.07	.05	-.16	-.09	-.01	.67	.51	1.00	
X4: e-Delivery	.18	.03	-.01	.05	.11	.03	.44	.44	.48	1.00

B. Set Correlation Analysis findings for simultaneous multiple dependent variables

Model $R^2_{Y,X} = .306$; $\tilde{R}^2_{Y,X} = .153$; Rao $F = 1.880$; (df: $u = 24.0$, $v = 409.4$); $p < .008$

Variable	r^2 (Set X to Y)	DFP	DCP	DKS	eD
Y1: Inventory Turns	.088**	-.052	.300***	-.057	.094
Y2: % Customer Orders Fulfilled	.052*	-.268**	.224**	.152	-.024
Y3: % Demand Forecast Accuracy	.106***	-.252**	.405**	.069	-.113
Y4: Days Raw Materials	.047	.025	.002	-.256**	.159
Y5: Days WIP Inventory	.048*	.148	-.005	-.267**	.173
Y6: Days Finished Goods	.057*	-.232*	-.136	.158	.112

*** p< .001. ** p< .05. * p< .1. Number of Cases = 154

Thus results from the SC analysis in Table 7.9 can be further interpreted at the individual variable levels and corresponding hypotheses supported: Downstream Customer Satisfaction Planning had significant beneficial impact upon the multiple performance measures Inventory Turns, Percentage Customer Orders Fulfilled and Percentage Demand Forecast Accuracy (H2g); Delivery Knowledge Sharing had a significant beneficial impact in terms of reducing Days Raw Materials Inventory and Days WIP Inventory (H2f); and Downstream Future Demand Planning had a weakly significant impact upon Days Finished Goods Inventory (H2d).

In addition, a further two surprising results were identified relating to the unpredicted significant negative impacts of the underlying Downstream Future Demand Planning maturity dimension upon Percentage Customer Orders Fulfilled and Percentage Demand Forecast Accuracy. These results could not be ignored given the high statistical significance and power of this SC model, as well as the significance of respective multivariate associations. Conventional supply chain wisdom would expect that collaborative knowledge-sharing across associated practices of optimising the supply chain to reduce future crisis situations, predicting future demand and coordinating future delivery dates would have a positive impact upon customer order fulfilment and demand forecast accuracy. One possible explanation in an evolving supply chain context such as healthcare could be simply that 1st tier suppliers and healthcare customer organisations are still not very good at these practices. In which case, if the respective supply chain partners are currently incapable of accurately predicting future demand, of foreseeing potential crisis situations or of coordinating required deliveries, then no amount of collaborative knowledge-sharing across these practices will lead to improved performance. In fact, high levels of knowledge-sharing in such instances is liable to compound the problem resulting in deteriorating performance. This highlights a possible area of underdeveloped supply chain maturity.

7.6 THEORETICAL CONCLUSIONS AND MANAGERIAL IMPLICATIONS

This study has achieved its aim of further developing the supply chain maturity concept. Valid and reliable maturity measures, scales and constructs have been formulated and their impact upon performance in the evolving Healthcare supply chain context has been assessed. This investigation builds-upon existing literature to formulate a conceptual framework of supply chain maturity. The development of this framework pertains to collaborative knowledge-sharing across appropriate practices, and thus is potentially applicable to differing supply chain operational permutations. More specifically, the role of supply chain maturity in the UK Healthcare service sector has been assessed through empirical investigation of specific supply chain operations relevant to 1st tier product suppliers.

In developing the maturity framework this study has gone beyond asset, data, and information levels of exchange to encompass explicit and tacit dimensions of collaborative knowledge exchange. The conceptual development has drawn upon both the supply chain management and knowledge management streams of literature, and is based upon the Supply Chain Council SCOR model. Thus the supply chain maturity concept is potentially robust across multi-functional academic and practitioner communities. Furthermore, by addressing appropriate practices relating to differing supply chain operations, this study contributes to supply chain research through developing survey techniques that go beyond dyadic restrictions and could open up further areas of study (discussed in Section 7.7.)

Whilst recognising the limitations of survey-based research (outlined in Section 4.1.1), and emphasising that care be exercised not to over-generalise specific findings beyond the UK Healthcare contexts sampled, the empirical results of this study indicate three broad theoretical conclusions. Firstly, the results indicate that the SCOR model constitutes an appropriate practice framework upon which to build a knowledge-based supply chain maturity concept. Answering recent calls to pay closer attention to practitioner developments, a review of practices has identified maturity measures related to each dimension of Plan, Source, Make, Deliver, NPD and Returns. Through confirmatory factor analysis (CFA) techniques, valid and reliable scales were formulated for each of these dimensions. All related hypotheses relating to the detailed composition of these scales were strongly supported by statistical analysis.

Secondly, results from the hierarchical structural equation modelling indicate high statistical validity of the supply chain maturity framework as pertaining to knowledge sharing across appropriate practice dimensions. More specifically, Downstream Planning and Delivery dimensions constitute a baseline supply chain maturity framework for the 1st tier healthcare product suppliers sampled. Furthermore, the validity of adding appropriate Make and Upstream/ Downstream Returns maturity dimensions to relevant supply chain operational contexts was empirically supported. Nevertheless, whilst knowledge-sharing across each of the dimensions is indicated to be valid and substantively important, not all dimensions could be assumed to represent a significant addition to the framework. Results indicate Upstream Planning and Sourcing dimensions to be insignificant despite apparent appropriateness. There are three possible explanations: i) reduced sample sizes could have resulted in failure to identify significant relationships with appropriate dimensions; ii) confounding effects of differing upstream configurations could prevent knowledge-sharing with all upstream partners across all appropriate dimensions from being significant; or iii) levels of maturity for these dimensions are possibly not sufficiently developed in this sample of 1st tier healthcare suppliers for them to be a significant addition to the framework. These issues possibly merit further investigation.

Similarly, whilst its inclusion creates a valid model, results indicate that the NPD dimension is not a significant component of the supply chain maturity framework despite apparent appropriateness to many suppliers. In addition to the above mentioned effects of reduced sample size or insufficient levels of development, possible explanations for such insignificance of the NPD maturity dimension could include: i) additional complexities relating to the extensive internal and external nature of NPD operations that were not picked-up in this study; or ii) a vindication for the Supply Chain Council not including the NPD dimension in their SCOR model. These uncertainties possibly warrant further research.

Thirdly, the results from this empirical investigation indicate strong statistical support regarding the significant impact of supply chain maturity dimensions upon performance. Furthermore, the results indicate the possibility of supply chain maturity being underdeveloped, aptly developed or overdeveloped in an evolving context such as Healthcare. Aptly developed maturity dimensions are indicated as potentially positively driving performance measures. For example, e-Sourcing and Make Knowledge Sharing maturity were indicated to beneficially effect inventory turns. Maturity dimensions of Sourcing Knowledge Sharing and Downstream Future Demand Planning were indicated as beneficially reduced work-in-progress and finished goods inventories respectively. The results indicate that Delivery Knowledge Sharing maturity has a beneficial effect in reducing both raw materials and WIP inventories. Also, the results indicate that Maturity in terms of Downstream Customer Satisfaction Planning potentially has the most significant positive impact upon performance, driving inventory turns, customer order fulfilment and demand forecast accuracy.

Nevertheless, the results also indicate that not all potentially aptly developed supply chain maturity dimensions can be assumed to have beneficial impact upon all performance measures. Engaging in particular supply chain operations might have unavoidable detrimental impacts upon certain performance measures. For example, the results indicate that Downstream Product Returns maturity could cause an adverse effect upon work-in-progress possibly as a consequence of returned product being reworked.

The study results also indicate the potential for over- or underdeveloped maturity dimensions that could have a significant detrimental impact upon certain performance measures. The empirical analysis indicates a possible over-development of Delivery Knowledge Sharing maturity that could have a negative impact upon inventory turns. Such potential maturity over-development could be the result of 'corporate myopia' and/ or 'organisational inertia' phenomena recognised by the knowledge management literature. This is similar to the 'competency trap' phenomena discussed in Essay 2 (Chapter 6) in that the customer could feasibly exploit excessive knowledge sharing across delivery practices to push inventory problems onto the supplier. A potential under-development of supply chain maturity was found in the surprising results indicating adverse effects of Downstream Future Demand Planning upon customer order fulfilment and demand forecast accuracy. These effects are counter-intuitive to conventional supply chain wisdom but could be a signal of 1st tier suppliers and Healthcare service provider customers that are relatively immature in this dimension. It could be argued that knowledge sharing may only be worthwhile with supply chain partners that have valuable knowledge. Attempting to leverage knowledge from a customer that is relatively ignorant of future demand might be counter-productive. Thus the analysis indicates that demand planning could be a potential area for further maturity development in the Healthcare sector.

Finally, the results of this investigation indicate the following possible managerial implications:

1. Managers should perhaps seek to develop apt levels of supply chain maturity across those dimensions appropriate to their own supply chain configurations and operations.

2. Specific maturity dimensions are indicated to drive particular performance measures. Supply chain managers should perhaps attempt to develop those dimensions most likely to have beneficial impact upon priority performance criteria.

3. Certain maturity dimensions might not always have a positive impact upon all performance measures. Trade-offs may exist. Developing apt maturity in certain supply chain operations, such as product returns may lead to unavoidable inefficiencies in other areas.

4. Myopic knowledge sharing could result in the possible under- or over-development of certain maturity dimensions and potential negative impact upon performance measures. For example, over-developed or excessive levels of delivery knowledge sharing could lead to opportunistic supply chain partners pushing inventory inefficiencies onto others. Also, maturity dimensions might remain under-developed, with potential consequential loss in performance, if efforts are made to leverage knowledge from relatively ignorant supply chain partners. In the Healthcare supply chain, downstream demand knowledge appears to represent an area for possible further development.

7.7 FURTHER RESEARCH

Whilst this study has made specific contributions to identified literature gaps, it also indicates scope for further research in two areas: 1. To further conceptual understanding of knowledge mechanisms underlying collaborative supply chain integration; and 2. To improve contextual understanding of supply chain management in service-oriented sectors.

In addition to the areas identified in the above discussion, it is hoped that other researchers will be attracted to the following specific issues:

A. Uncertainties remain concerning the significance of specific dimensions to the supply chain maturity concept. Replicating this research study using larger sample sizes could clarify whether the observed insignificances where due to methodological constraints or other phenomena.

B. This study indicates a need for further research to identify specific contingency effects of collaborative supply chain integration. It may no longer be sufficient to assume positive impact upon performance of all supply chain practices in all contexts. When are there negative impacts? What are the trade-offs?

C. Applying other analysis techniques, such as cluster analyses or multidimensional scaling, could provide further insights as to relative levels of supply chain maturity development between organisations. Furthermore, the study of supply chain maturity across different sectors and replication across geographical areas could provide interesting comparative opportunities and lessons to be learned. Possible sectors for analysis include manufacturing, construction, retail, financial services, and government organisations such as national defence logistics.

D. The web-based survey methodology developed in this study could present potentially insightful avenues for further research. For example, does the supply chain position have an impact upon appropriate maturity development and performance? The new research methodologies also present new potential opportunities for expanding the scope and complexity of investigation. One area that could benefit from such methodologies would be to expand the unit of analysis from the individual firm to the whole supply chain.

CHAPTER 8 – OVERALL CONCLUSIONS

This thesis set out to empirically investigate "where are we now in the evolution of supply chains and what has to occur to advance along the continuum?" (Bowersox et al., 2000). The broad literature review in Chapter 2 outlined the development of important supply chain paradigms such as lean, agile and leagile, and the twinned concepts of collaboration and integration that underpin much of modern supply chain thinking. Two important conceptual and contextual gaps in the literature were identified as presenting potential barriers to the continued evolution of supply chain theory and practice. The first gap related to the conceptual need for supply chain research to go beyond the analysis of assets, data and information to encompass the exchange and development of knowledge dimensions. The second gap related to the evolution of new supply chain contexts that extend beyond manufacturing into service-oriented sectors. This study sought to explore these gaps in supply chain understanding through the adoption of relevant theories and concepts particularly from the knowledge management stream of literature. A conceptual framework for supply chain knowledge management was formulated in Chapter 3, comprising mechanisms associated with the dimensions of knowledge transfer between supply chain partners; the development of supply chain competence; and the evolution of supply chain maturity. Appropriate research methodologies were identified in Chapter 4 and three separate mail, telephone and Internet survey data collections were employed. Empirical analysis of the three data collections constituted the basis of the consecutive essays in Chapters 5, 6 and 7 investigating the impact upon performance of each knowledge dimension within appropriate manufacturing and/ or service contexts. This final chapter draws upon the findings from the three essays to present the overall contributions of the study at three levels: firstly to the supply chain management literature; secondly methodological contributions; and thirdly, managerial implications. The chapter closes by indicating the limitations of the study and provides suggestions for future research.

8.1 CONTRIBUTIONS TO THE SUPPLY CHAIN MANAGEMENT LITERATURE

This thesis considered the 'where are we now' aspect of the above Bowersox et al. (2000) question through an extensive review of supply chain management theory and practice. The review found a growing recognition amongst researchers that much of the existing literature is limited to analysing efficiency of asset, data and information flows within manufacturing contexts. Furthermore, the review identified that many organisations still struggle with implementing supply chain management concepts in the real-world, and that there is significant potential for continued evolution of supply chain theory and practice. Further synthesis of seminal supply chain and strategic management literatures, identifies that to 'advance along the evolutionary continuum' more profound understanding is needed regarding the exploitation of expertise and leveraging of knowledge across traditional and emerging supply chain contexts.

Through empirical analysis of such evolutionary issues, this doctoral study has sought to contribute to two recognised gaps in the supply chain literature relating to:

1. The exchange and development of knowledge dimensions in supply chains,
2. The consideration of manufacturing and evolving service-oriented supply chain contexts.

This study aims to contribute to the first gap by answering calls from operations management and supply chain researchers to bring new perspectives into the field. By adopting relevant theories from the knowledge management stream of literature this study intends to help extend the conceptual scope of existing supply chain management research. Similarly, this study aims to contribute to the second gap and help expand the contextual range of supply chain management research by conducting empirical investigations across manufacturing, services and healthcare contexts.

Building upon existing literature to investigate the above gaps, this study has made broad potential contributions towards developing supply chain theory with a view to improving performance. These broad potential contributions are outlined in Section 8.1.1. Furthermore, each of the individual empirical essays in Chapters 5, 6 and 7 has identified possible new phenomena relating to the impact of knowledge dimensions in manufacturing and service supply chains, and proposed possible theoretical explanations. The most significant of these specific findings are summarised in Section 8.1.2.

8.1.1 Broad Contributions

Relating to the above supply chain literature gaps, this study makes four broad potential contributions. Firstly, this study explicitly combines supply chain and knowledge management literatures and formulates a unifying conceptual framework for supply chain knowledge management. The unifying framework incorporates several organisational learning and knowledge management theories that are relevant to supply chain contexts. Each of the knowledge management concepts is consistent with and meaningful in the field of operations/ supply chain management. The three-stage framework has helped guide the empirical analyses of this study and may help with future research combining supply chain and knowledge management perspectives. In addition to answering calls from operations management researchers to adopt conceptual perspectives from the field of knowledge management, the framework has been supported by the separate empirical analyses indicating the importance of managing knowledge dimensions in supply chain contexts. Each of the sequential essays in Chapters 5, 6 and 7 indicate that the 'knowledge lens' reveals potentially important supply chain phenomena and possibly provides new insights for further theory development. Each essay indicates specific supply chain knowledge transfer, competence and maturity dimensions to be significant drivers of supply chain performance. Whilst observed impacts upon performance support existing supply chain theory, several of the findings indicate complex dynamics that go beyond conventional supply chain wisdom. The rationale behind the conceptual extension of arcs of integration to encompass the collaborative exchange and development of expertise and knowledge has thus been empirically supported.

By explicitly bringing the discipline of knowledge management to bear on issues of supply chain management, a second broad potential contribution of this study is a more profound understanding of the knowledge-based dynamics underlying collaborative supply chain integration. The empirical analyses indicate significant beneficial impacts associated with leveraging knowledge and exploiting expertise wherever it lies in the supply chain. These empirical results indicate support for the further development of supply chain paradigms such as lean, agile and leagile that propose extensive levels of coordination and collaboration beyond the exchange of assets, data and information. Findings from the investigation of knowledge transfer, competence and maturity dimensions indicate the need to manage more complex mechanisms in order to maximise benefits from collaborative integration. These mechanisms represent potentially important areas for continued evolution of the supply chain.

Having indicated the possible importance of the extended knowledge-based perspective within manufacturing contexts, the third broad potential contribution of this study is to expand contextual scope of supply chain research into service-oriented operations. Whilst recognising that the intangible aspects of service delivery are beyond the scope of this thesis, it signals that a good starting point for improving understanding of service supply chains lies in the upstream supply of physical goods. This has been identified as a specific gap in the supply chain literature as few services do not depend to some extent upon product suppliers. The investigations of financial services and healthcare service sectors in this study indicate a dependence upon product suppliers in order to facilitate service delivery. This study sought to contribute to the contextual expansion of existing supply chain literature in two ways; firstly by comparing and cross-validating the application of an established supply chain competence construct across upstream facing functions of both manufacturing and service sectors; and secondly, by explicitly developing the supply chain maturity concept within an evolving service-oriented context.

A fourth broad potential contribution lies in the rigorous empirical investigations and underlying methodologies developed as part of this study. Hypotheses and models derived from multi-disciplinary literature, explaining the scope, form, costs and benefits of supply chain knowledge management across different contexts are supported with empirical data, thus potentially contributing in a scientific manner to the continuing development and refinement of supply chain theory. Furthermore, the empirical investigations in this study take tentative steps towards the possibility of considering and measuring the whole supply chain. Whilst the data collected for this doctoral study is restricted to individual organisations, the underlying methodologies have been developed with a view to conducting more holistic supply chain research. This could represent a significant methodological contribution for future research to test theories relating to business dynamics moving towards supply chains (not individual organisations) being the effective unit of competition. This potential methodological contribution and implications for further research are discussed further in Sections 8.2 and 8.4.

8.1.2 Specific Contributions

Beyond the broad potential contributions of the study as a whole, each of the three individual essays in Chapters 5, 6 and 7 makes more specific potential contributions to the supply chain management literature. These essay-specific findings are summarised in the following sub-sections.

8.1.2.1 Knowledge Transfer in Manufacturing Supply Chains

The essay in Chapter 5 investigated knowledge transfer in manufacturing supply chains and sought to make three specific literature contributions. Firstly, the results indicate empirical support for existing supply chain and knowledge management literatures proposing that knowledge obtained from external supply chain partners does have a beneficial impact upon internal operating performance.

Secondly, the investigation possibly extends the existing literature by indicating that there are directional implications as to the value of the knowledge obtained from different supply chain partners. The findings indicate that, whilst all external knowledge inflows are beneficial to some degree, knowledge emanating from downstream supply chain partners is potentially more valuable in terms of improving operating performance than that coming from upstream suppliers. This indicates the possibility that the 'bullwhip effect' is prevalent beyond the data and information levels at which it has previously been observed- and distortion of upstream knowledge could also occur.

The third specific potential contribution of the essay in Chapter 5 is to provide empirical support for the goal of broad 'arcs' of supply chain integration from a knowledge-based perspective. Knowledge derived from an integrated supply chain, in which suppliers, manufacturers and customers work together to coordinate knowledge and reduce uncertainty or non-value adding activities, is indicated to have most beneficial impact upon operational performance.

8.1.2.2 Competence in Manufacturing and Service Supply Chains

The essay in Chapter 6 investigated competence within the upstream-facing purchasing function of manufacturing and financial services companies, and potentially makes three specific contributions to the operations management, supply chain and purchasing literatures. Firstly, the Narasimhan et al. (2001) supply chain purchasing competence construct that had been empirically developed for US manufacturing organisations is replicated and conceptually extended using European data. Furthermore, the construct is contextually expanded to incorporate manufacturing and service contexts. This potentially increases the scope and explanatory power of this supply chain competence construct.

Secondly, the results indicate the purchasing competence framework to be equally valid for both manufacturing and financial service organisations. No other studies have been found that empirically demonstrate equivalence of an operations management or supply chain framework across manufacturing and service contexts. Whilst perhaps significant in itself, this potential contribution also suggests the possibility of transferring other conceptual constructs from manufacturing to service operations, and vice versa.

Thirdly, results indicate that specific supply chain competence dimensions significantly drive operational performance measures in manufacturing and service contexts. Operations management, supply chain and purchasing literatures are empirically supported by results indicating that each of the observed competence dimensions has a significant beneficial impact upon at least one supply chain performance criteria. Thus the development of supply chain competences is apparently warranted. A possible further extension to the literature is suggested by results indicating that not all competence dimensions have a significant positive impact upon all of the multiple performance measures. Evidence was also found of no significant impacts, or possible significant negative impacts. Whilst limitations of the survey-based methods used do not permit firm conclusions to be drawn on this point, these results do indicate some support for knowledge management literature warnings of 'competency trap' performance diminishing phenomena. More research is perhaps needed to confirm or refute these specific findings. Nevertheless the results from this study do indicate that perhaps supply chain academics and practitioners cannot expect generic development of supply chain competences to result in improvements on all performance measures. Rather, these results suggest a contingent approach of tailoring specific competence configurations to improve those areas of performance that are most crucial to competitive success in any given situation.

8.1.2.3 Maturity in the Evolving Healthcare Supply Chain

The essay in Chapter 7 builds-upon existing definitions of supply chain maturity relating to levels of collaboration across appropriate integrative practices, and develops the concept by empirically formulating measures, scales and constructs and assessing impact upon performance. Specific potential contributions to the literature are threefold. Firstly, a detailed knowledge-based supply chain maturity construct is proposed and statistically validated. Valid and reliable underlying maturity scales are created for collaboration across practices related to the dimensions of Plan, Source, Make, Deliver, New Product Development and Returns. Being derived from supply chain management and knowledge management academic literatures and the Supply Chain Council SCOR model, this maturity construct is potentially robust across multi-functional academic and practitioner communities.

Secondly, empirical results indicate that the supply chain maturity framework is valid within the context of UK Healthcare. The analysis indicates each of the maturity dimensions to be statistically valid and substantively appropriate components of the framework. Downstream Planning and Delivering dimensions are found to represent a baseline maturity framework for the 1st tier product suppliers sampled. Furthermore, the results indicate that Making and Returns dimensions are significant constituents of the maturity framework where operations call for such practices. However, Upstream Planning, Sourcing and NPD maturity dimensions are indicated to be insignificant despite apparent appropriateness to those companies engaged in related operations. Conflicting possible explanations for these surprising results perhaps warrant further research.

Thirdly, whilst limitations of survey-based research methods must be recognised and specific results not over-generalised beyond the population sampled, findings relating to impact of maturity dimensions upon performance indicate support and potential extension of supply chain understanding. The empirical analysis suggests that maturity may be underdeveloped, aptly developed or overdeveloped in an evolving context such as UK Healthcare. Results indicate that aptly developed maturity dimensions may positively drive performance measures. For example, maturity in terms of Customer Satisfaction Planning is indicated as having a beneficial impact upon several performance improvements. However, results also indicate that potentially over- or under-developed maturity dimensions could have a negative impact upon certain performance measures. Results indicating a potentially detrimental impact of over-developed maturity dimensions resemble specific detrimental impacts indicated by the purchasing competence investigation in Chapter 6. Similar explanations might be provided by the knowledge management concepts of 'competency traps', 'corporate myopia' and/ or 'organisational inertia', whereby an opportunistic supply chain partner could possibly exploit excessive knowledge sharing. Finally, the results indicate that an area of potentially under-developed maturity in UK Healthcare relates to Downstream Future Demand Planning. The possible negative impact of such under-developed maturity might be the result of attempting to leverage demand-related knowledge from a customer that is relatively ignorant of future demand. Thus this could represent a potential area for maturity development in the UK Healthcare supply chain.

8.2 METHODOLOGICAL CONTRIBUTIONS

As identified above, one of the potential contributions of this doctoral thesis lies in the investigations based upon good quality empirical survey data. The survey data collections in this study have been implemented to follow recognised guidelines and 'ideal attribute' criteria for survey research in the operations management field. By applying established best practice this thesis indicates that good quality data can be obtained through mail, telephone and Internet survey techniques.

Through the development of the web-based survey for the third essay, this doctoral study has attempted to improve upon existing Internet survey practice. A presentation of the new online methodology raised interest at the 2004 Decision Sciences Institute conference, and an invitation has been accepted to present the methodology in a professional development workshop at the 2005 DSI conference. Lessons from this development have also been incorporated within a forthcoming methodological note.

This web-based survey methodology development makes a further possible contribution to the supply chain literature by indicating the potential for extending the unit of analysis to the whole supply chain. Whilst this has remained an optimistic goal for some time amongst supply chain researchers, it would seem a distinct possibility in the future if such web-based survey methods can be developed to their full potential.

A final potential methodological contribution of this study lies in the empirical analysis techniques used. In particular, two proven, yet still relatively novel techniques within the operations and supply chain management literatures, are applied. Firstly, the structural equation modelling technique of group invariance analysis was selected to test the equivalence of a supply chain competence construct across both manufacturing and service contexts. Secondly, the technique of set correlation analysis overcomes several shortcomings of more common multiple regression/ correlation methods and was chosen to simultaneously investigate the impact of supply chain competence and maturity dimensions upon multiple performance measures. Both of these techniques are recommended for use in future operations and supply chain management research.

8.3 MANAGERIAL IMPLICATIONS

The study's results may be used to help inform supply chain practice at different levels. Whilst the efficient flow of assets, data and information is apparently important to supply chain management, further evolution of practice and performance benefits would appear to be possible through learning how to most effectively leverage and develop the knowledge that potentially resides throughout the extended supply chain organisation. At a general level, this study indicates that the effective management of knowledge across the supply chain potentially has significant beneficial impacts upon performance. More specifically this study indicates that knowledge transfer, competence development and maturity evolution involve potentially important mechanisms that possibly require careful management to ensure improved performance in manufacturing and service supply chain contexts.

The results of the individual investigations in Chapters 5, 6 and 7 indicate the following more specific potential implications for managers:

a. The first essay indicates that manufacturing companies may benefit from sharing explicit knowledge with their external supply chain partners. Results indicate that those manufacturing companies that share explicit knowledge are most likely to make potential internal operational performance improvements. Results also suggest that whilst supply chain integration may be seen as the goal, limited resources might initially be focused on sharing explicit knowledge with specific supply chain partners in order to maximise return on effort.

b. The second essay indicates that supply chain managers could work to develop functional competence configurations aimed at maximising contribution to contingent operational performance goals. Resources might best be allocated to develop those competences that potentially drive performance criteria related to specific competitive priorities. (Alternatively, if competences are deeply ingrained, a decision might be taken as to the feasibility of shifting the organisation's competitive strategy.) To do this, managers may need to combine knowledge of strategic priorities and embedded competence levels.

c. The third essay indicates that managers may develop supply chain maturity through suitable collaboration with supply chain partners to implement appropriate integrative practices. Results indicate that apt development of specific maturity dimensions can potentially lead to predictable performance benefits for differing supply chain operations.

8.4 LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

To complement the specific suggestions for future research at the end of each essay in Chapters 5, 6 and 7, the following sections outline broad areas for possible further investigation. Section 8.4.1 discusses some areas of future research that could help overcome certain limitations of this doctoral investigation. Section 8.4.2 suggests ideas for potentially insightful exploration related to the continuing evolution of supply chains.

8.4.1 Suggested Further Research to Address Limitations of this Study

Whilst this study makes potential contributions to the existing literature, it indicates considerable remaining scope regarding the investigation of knowledge-dimensions within supply chain contexts. There are important limitations with regard to what this study has achieved in terms of considering knowledge-based concepts within supply chains. Potential opportunities remain for future research in these areas. For example, the 'tacit' dimension of knowledge is potentially important and yet has only been superficially considered on a broad level within the competence and maturity dimensions of the second and third essays. The first essay concentrated purely upon codified knowledge transfer. The research approaches adopted in this study have thus touched-upon, but not enabled the full capture of more profound tacit knowledge components. This also apparently represents a limitation in much of the knowledge management literature at-large, and considerable potential scope remains for improved research approaches to study such complex issues.

The nature of the empirical methodologies carried out in this study enable the findings to be generalised with high degree of confidence to the specific populations being considered (i.e. 1. European manufacturing ISIC Division 38; 2. Large European manufacturing and financial services with turnovers in excess of £250m; and 3. 1st tier product suppliers to UK Healthcare). Nevertheless, generalisation of the findings beyond these geographic and business sector characteristics should be undertaken with care. As Essay 2 constitutes the replication and cross-validation of an existing US manufacturing construct, the findings from that sub-study can, perhaps, be more liberally generalised. In the same vain, future international research aimed at empirical replication and cross-validation across different geographical and business areas could help refine the ranges of generalisability, and support or refute the findings of this doctoral study. In particular, both manufacturing and service supply chain studies would benefit from the inclusion of countries such as China and India. Similarly, comparative studies in other supply chain contexts such as Construction and Retail would possibly be illuminating.

An additional methodological limitation inherent in survey data collection is respondent bias. Single respondents provide self-reported data for both independent and dependent variables, thus potentially introducing a bias that may skew the magnitude of empirical relationships. This is a limitation of almost all operations management survey research, nevertheless future empirical investigations should employ more sophisticated research designs such as obtaining and incorporating external secondary data on firm performance or involving multiple respondents from any organization.

To further gauge relevance and validity of the study findings in specific contexts, methodological 'triangulation' is suggested for future research through careful design and implementation of field-based methods such as case research or action research. Such research methods would also provide greater depth of understanding surrounding the knowledge-based mechanisms indicated by this investigation (e.g. organisational 'myopia'). The results from this doctoral study could be used to identify potentially interesting and illuminating cases for further research. Furthermore, there is potential for enriching the basic theoretical constructs identified by this investigation through detailed case studies of several partner companies within a single supply chain.

A final methodological limitation is related to the sample sizes achieved in this investigation. Whilst the sample sizes were adequate for each of the analyses conducted in Chapters 5, 6 and 7, certain interesting avenues of investigation requiring larger samples were not possible. For example, with an increased sample size, a more detailed investigation could have been carried-out in Essay 2 regarding comparative competence-performance issues across manufacturing and financial service sectors. With sub-sample sizes of only 100, more elaborate structural equation and set correlation applications would have overstretched the data. Similarly, with a full sample size of 154 healthcare suppliers (which was correspondingly smaller for certain supply chain practices) the full supply chain maturity construct could not be validated in a single step in Essay 3. Future survey-based research could take account of these issues and attempt to obtain larger samples.

8.4.2 Additional Ideas for Future Research

Future research could continue to combine knowledge-based and supply chain perspectives. The implications of collaboratively integrating knowledge across supply chain partners will possibly have more far reaching implications than the integration of data and information considered in the existing supply chain literature. Continued knowledge-based research could be important to continue adding depth to supply chain understanding. The supply chain knowledge management framework formulated in this doctoral study may provide an initial basis for such future research. This study has identified several parallel concepts (such as the benefits of inter-firm collaboration) between supply chain and knowledge management research streams, and the potential exists to further explore such inter-disciplinary cross-fertilisation between these literatures. The knowledge management stream has the potential of providing many more profound new insights to enhance supply chain understanding- and vice versa.

Many opportunities appear to remain for investigating service supply chains. This study has identified upstream-facing functions such as purchasing, and upstream product suppliers as being valid starting-points for research into improving understanding of service-oriented supply chains. Since most service organisations depend upon the supply of goods in order to deliver a service, there are potentially more opportunities for such research. For example, upstream supply chain issues for travel and entertainment sectors such as airlines, restaurants and theme parks could be interesting areas of investigation. Also, notwithstanding research challenges surrounding the issue of 'intangibility' there are also considerable potential opportunities for developing supply chain theory surrounding service delivery. The obvious area for studying service delivery would be within service organisations, however additional research opportunities could be presented by the increasing importance of service delivery to traditionally manufacturing-oriented companies.

The upstream supply chain appears to offer considerable opportunities for comparative research opportunities between manufacturing and specific service sectors- and particularly the study of product suppliers. Previous research has identified that very few business exchanges involve pure service or pure product offerings. The fact that most exchanges increasingly involve a bundle of goods and services could present challenges and opportunities for supply chain researchers to identify and analyse the contingencies that exist when a particular construct is transferred to a different setting. Researchers have investigated the transfer between manufacturing and services of theories from TQM and technology areas, and there remains potential scope for such research in supply chain management.

The literature review also identified significant gaps relating to understanding of knowledge dimensions at the network level of analysis. Networks have not been considered in this thesis and present potential challenges and opportunities for future research. Most of the preceding suggestions for future research could possibly also be applied to organisational networks, although considerable complexities of research design would perhaps have to be overcome.

Finally, greater understanding as to the continuing evolution of supply chain theory and practice could perhaps be achieved through ongoing longitudinal studies. Whilst they represent considerable implementation challenges, longitudinal investigations can be powerful in identifying changes over time. As such they represent a much sought after, but nevertheless rare, form of empirical data collection. It could be particularly interesting to compare ongoing evolutionary trends of supply chain practices and performance across business sectors.

8.5 CHAPTER SUMMARY

This thesis aims to contribute to two gaps in the literature relating to:

1. The exchange and development of knowledge in supply chains,
2. Consideration of manufacturing and evolving service-oriented supply chains.

These have been identified as important areas relating to the continued evolution of supply chain theory and practice. Within these gaps, this thesis makes four broad potential contributions to the conceptual and contextual scope of existing supply chain management literature:

A. This study combines supply chain and knowledge management literatures and formulates a unifying conceptual framework for supply chain knowledge management.

B. By bringing knowledge management concepts to bear on supply chain contexts, this study helps develop understanding of collaborative supply chain integration. The investigation results indicate several impacts of leveraging knowledge and expertise in the supply chain, and thus the possible need to manage mechanisms beyond the exchange of assets, data and information.

C. This study indicates that a good starting point for expanding contextual understanding into service-oriented supply chains lies in the upstream supply of physical goods. The investigations indicate that Financial Services and Healthcare depend heavily upon product suppliers to facilitate service delivery.

D. Multi-disciplinary hypotheses and models are statistically supported with empirical data collection and analysis, thus potentially contributing to the development of supply chain theory.

In addition, results from each of the investigations developed within this thesis indicate the following specific findings:

<u>Essay 1- Explicit Knowledge Transfer in Manufacturing Supply Chains:</u>

i) Explicit knowledge obtained from external supply chain partners is potentially beneficial.
ii) Explicit knowledge emanating from downstream has potentially greater positive impact upon operating performance than that from upstream.
iii) Knowledge derived from an integrated supply chain potentially has greatest positive impact upon operating performance.

<u>Essay 2- Competence in Manufacturing and Service Supply Chains:</u>

i) The Narasimhan et al. (2001) supply chain purchasing competence construct is replicated and extended in European manufacturing and service contexts.
ii) The competence construct is equally valid for manufacturing and services.
iii) Competence dimensions have a potentially beneficial impact upon at least one, but not all, performance criteria. Thus contingent 'competence configurations' could be developed.

<u>Essay 3- Maturity in the Evolving Healthcare Supply Chain:</u>

i) The supply chain maturity concept is developed.
ii) A detailed supply chain maturity framework is validated within the evolving UK Healthcare supply chain. This includes dimensions of Planning, Sourcing, Making, Delivering, New Product Development and Returns.
iii) Supply chain maturity dimensions can be potentially 'underdeveloped', 'aptly developed', or 'overdeveloped', with possible consequential impacts upon performance.

This doctoral thesis also makes several potential methodological contributions. By applying existing guidelines, the investigation indicates that good quality data may be obtained through mail, telephone and Internet survey techniques. The development of the web-based survey represents a further possible contribution to supply chain research, offering the potential for future studies to extend the unit of analysis to the whole supply chain. A final possible methodological contribution is the adoption of new, sophisticated analysis techniques.

Managerial implications are indicated regarding the potential for effective leveraging of knowledge residing in the extended supply chain organisation.

Finally, suggestions are made for future research that could address limitations of this study, as well as to further explore new, potentially insightful, areas revealed by the findings.

APPENDICES

APPENDIX 1.

THE 'INTERNATIONAL MANUFACTURING STRATEGY SURVEY' (IMSS) ADMINISTRATION AND PROTOCOL

1. Population definition

IMSS is oriented to single plants or Business Units within the company. Data in section A and D refer to the competitive and market strategy, and performance of the Business Unit, while data in section B and C refer to single plants. If more than one plant in a company is surveyed, more than one questionnaire needs to be completed.

The following population definition was used for sampling companies:

International Standard Industrial Classification of Economic Activities (ISIC- 1968):	
Major Division 3.	Manufacturing
Division 38.	Manufacture of Fabricated Metal Products, Machinery and Equipment

ISIC	Definition
381	Manufacture of metal products, except machinery and equipment
382	Manufacture of machinery, except electrical
383	Manufacture of electrical equipment apparatus, appliances and supplies
384	Manufacture of transportation equipment
385	Manufacture of professional and scientific and measuring and controlling equipment not elsewhere classified, and of photographic and optical goods.

2. Sample selection

The IMSS target was of 30 to 50 companies within each country. The major guidelines for selecting companies were the following:

i) The sample was somewhat biased towards best practice companies within each country.

ii) There was no specific orientation to larger companies. However, in order to preserve the comparability of data, a limit of minimum 100 employees was set.

iii) IMSS is a longitudinal project, thus, for the countries that participated to IMSS I and/or II, all the companies that were in the database in the previous releases were targeted, in order to keep maximum the overlapping between the samples.

iv) Companies belong to ISIC 38 industry sectors (ISIC 381 to 385). A balanced number of companies was gathered in each of the above 5 sub-industries (e.g. at least 5 units in each sub-industry):

v) Convenience sampling (selecting companies with which you have preferred relationships) was accepted. However, adding to the convenience sample a number of randomly selected companies within the target population specified and verifying the homogeneity of the two sub-samples was encouraged.

vi) If companies of country samples represent only one region of the country, this was specified in the information enclosed to the database.

3. Planning and management

i) The time schedule for the survey was specified from February to July 2001. The national research groups at their convenience defined the specific timing of the survey activities.

ii) The questionnaire was completed by operations, manufacturing or technical managers of the company. In some cases (medium-sized companies), the general manager could answer most of the questions. Sometimes other functional area managers filled in some parts of the questionnaire.

iii) The IMSS questionnaire was in English. The national research groups could translate the questionnaire in order to ensure a higher reliability of the answers by the companies.

iv) The suggested methodology for survey administration was a mail survey. The target response rate for IMSS was around 40 to 50%. In order to maximise the response rate the following indications were made. In some cases, where the national research group considered it necessary, the questionnaire was filled in through personal interview by the researchers (this applied mainly in the cases where it is very difficult to have responses to mail surveys, or in the case there was the risk of low reliability of the answers by the companies).

- A cover letter was prepared to explain the project, highlighting the success of previous experiences and promising some form of feedback to the company (e.g. blind benchmarking on performance or practices, etc.). It was important to highlight that data would be treated as anonymous.

- Addressed to the right person within the company. It was suggested to make preliminary contact with the company to identify the name of the right respondent and then address the cover letter to him/her.
- Sometimes a preliminary phone call to explain the project could give more probability of answer by the company.
- After the first mailing, a reasonable amount of time was given to complete the questionnaire, but not too long, in order to put some pressure on the company.
- Follow-up letters or phone calls were made. (e.g. first reminder one week or so after the deadline)
- If there was the chance, the company had the opportunity to be supported in filling the questionnaire by a researcher (by phone and/or through personal visit).
- A second wave of questionnaires was sent if the target number of companies in the sample was not reached.
- Questionnaires could be send out by ordinary mail, by fax or by e-mail (avoiding the use of the questionnaire on the web which would introduce some bias, methodology and comparison problems that were to be avoided in this release of IMSS).
- Non-respondent bias was checked.

4. Data quality control

Before final release of the IMSS data, several phases of checks of the quality of the data gathered were carried out. These checks involved the following points:

i) Incomplete questionnaires: (if more than 40% of answers are missing) the questionnaire was returned to companies in order to have more information, or discarded.

ii) In general, missing answers were limited as much as possible. In some cases, a simple look at the questionnaire could translate missing in responses. Also a quick phone call to the company could solve most of the missing problems.

iii) Check all the possible unreliable answers (e.g. all items = 5, too big or too small numbers compared to scale, sum of % equal to 100, etc.). In this case, companies were asked to correct the data, cancel the unreliable data or discard the questionnaire.

iv) Several iterations of the international data set were made to clean the data. The following are examples of how the data was cleaned:

Section A:
A2: Spanish companies reclassified in 381 to 385 format
A6: Norway. Misclassification of "change in last 3 years". Changed from 0 No Change, 1 Lower, 2 Higher classification to 1 Lower, 2 No Change, 3 Higher
A91: SPA9 30-40% changed to 35%,
A92: SPA9 10-20% changed to 15%,

Section B:
PT2&3: Denmark: Percentages do not add up to 100%. Corrected by proportionalising absolute numbers into percentage figures.
PC24a/b: DK4, 11, 17 Put "flexible worktime" in place of numeric 1-5. This information captured in PC23a/b anyway, so removed.

Section D:
D14: N1 Absolute figure of $50,000 converted to ROS of 16%
D13 Italy- quoted in billions of Lira. Divided by 2000 to get $.

5. UK Specific IMSS Methodology

Data was collected from UK companies in line with the overall IMSS methodology guidelines. A target sample of UK companies was put together from:

1. 19 companies of the 24 that responded to the 1997 UK IMSS survey, and
2. 85 manufacturing companies that responded to a recent CBI industry survey carried out within London Business School.

These companies were pre-checked for:

a) The company still being in existence,

b) An approximately even balance between the ISIC classifications,

c) Correct contact details of an appropriate person,

d) The company still being in the appropriate ISIC classification.

The total sample thus comprised 104 manufacturing companies falling within the ISIC classifications appropriate to the IMSS survey. The survey methodology employed was at all times as close as possible to that of the "total design method" of Dillman (1977) (as outlined above.) Also most techniques from Frohlich (2002) were used to improve survey response.

APPENDIX 2.

THE 'EUROPEAN SPEND AGENDA' TELEPHONE SURVEY INSTRUMENT

The following scripted questions were presented to targeted respondents by a trained telephone survey administrator from the reputable market research company 'Vanson Bourne':

"Good morning/afternoon, my name is............ from Vanson Bourne. Please could I speak to (either named contact or) the person responsible for procurement and purchasing for the company?

INTRODUCTION TO RESPONDENT

I'm calling from Vanson Bourne. We are an independent market research company, and are currently talking to heads of purchasing & procurement in companies across Europe about how procurement & purchasing are managed. We are doing this research as part of an academic study on behalf of the London Business School.

Please confirm that you are head of purchasing & procurement? IF NOT, SEEK ALTERNATIVE RESPONDENT

I have a few questions, which should take about 10-12 minutes to complete. In return for your co-operation we would be happy to send you a summary copy of the report, so that you can compare your own situation with more than 250 companies like yours across Europe. I should also say that your responses will be treated confidentially and no one from the two sponsoring companies will receive or be able to get access to your individual responses.

Firstly, please confirm the following information..."

Name of Respondent:
Job Title:
Name of Organisation:
Address:
Tel. No.:
Sector: 1. Financial Services 2. Manufacturing
Turnover: 1. £250m-£500m (Euro 400m-800m)
2. £500m-£1bn (Euro 800m-1.5bn)
3. £1bn-£2bn (Euro 1.5bn-3bn)
4. More than £2bn (Euro 3bn)

"Now I have a few statements about how a company might manage its purchasing personnel and I'd like to know, on a scale of 1-5, how well each one describes the situation in your company. Score 1 means you strongly disagree with the statement in relation to your company, a score 5 means you strongly agree with it..." (6= don't know or refused)

Employee Competence

Purchasing personnel receive adequate training in quality and customer satisfaction

1	2	3	4	5	6

Suppliers receive adequate training in quality and customer satisfaction

1	2	3	4	5	6

Purchasing performance evaluation is closely related to quality improvements

1	2	3	4	5	6

Purchasing personnel have capacity to apply innovative ideas

1	2	3	4	5	6

Empowerment

Purchasing personnel are involved in key decisions affecting their jobs

1	2	3	4	5	6

Purchasing personnel are involved in key operational decisions

1	2	3	4	5	6

Purchasing personnel have autonomy in their jobs

1	2	3	4	5	6

Purchasing personnel have job security

1	2	3	4	5	6

The following questions were asked of manufacturing companies regarding collaboration for production and new product development:

"These questions relate to how frequently purchasing is involved with other activities in the company. Again the scale is 1 to 5, where 1 is very infrequently and 5 is very frequently." (6= don't know or refused)

Collaboration for Daily Production

So, can you score how frequently……?

…does purchasing share knowledge with production?	1	2	3	4	5	6
…does purchasing share knowledge with quality control?	1	2	3	4	5	6
…does purchasing collaborate in implementing production improvements?	1	2	3	4	5	6

Collaboration for New Product Development

So, can you score how frequently......?

...does purchasing share knowledge with engineering/manufacturing?	1	2	3	4	5	6
...does purchasing share knowledge with R&D?	1	2	3	4	5	6
...does purchasing collaborate in the creative phases of new product development?	1	2	3	4	5	6

The following questions were asked of financial services companies regarding collaboration for service operations and new service development:

Collaboration for Daily Service Operations

So, can you score how frequently....?

...does Purchasing share knowledge with operational departments?	1	2	3	4	5	6
...does Purchasing share knowledge with the Quality Assurance department?	1	2	3	4	5	6
...does Purchasing collaborate in implementing operational improvements?	1	2	3	4	5	6

Collaboration for New Product or Service Development

So, can you score how frequently....?

...does purchasing share knowledge with departments that design new products or services?	1	2	3	4	5	6
...does purchasing share knowledge with departments that research future products or services?	1	2	3	4	5	6
...does purchasing collaborate in the creative phases of new product or service development?	1	2	3	4	5	6

Buyer - Supplier Relationship Management

"Now I am going to read out a series of statements that relate to how purchasing relates to its suppliers and I'd like to know, on a scale of 1-5, how well each one describes the situation in your company. Score 1 means you strongly disagree with the statement in relation to your company, a score 5 means you strongly agree with it." (6= don't know or refused)

Purchasing is actively involved in sharing risk with suppliers for capital investments	1	2	3	4	5	6
Purchasing is actively involved in technical assistance and knowledge sharing with suppliers	1	2	3	4	5	6
Purchasing is actively involved in joint production planning with suppliers	1	2	3	4	5	6
Purchasing is actively involved in sharing cost savings with suppliers	1	2	3	4	5	6

IT Competence

"On a scale of 1-5, where 1 is not at all and 5 is completely, to what extent does your current purchasing system do the following:" (6= don't know or refused)

Provide company-wide visibility on spend and order tracking	1	2	3	4	5	6
Drive best prices through open market e-auctions	1	2	3	4	5	6
Facilitate buying of complex commodities	1	2	3	4	5	6
Streamline the complete invoice to payment process	1	2	3	4	5	6
Enable real-time knowledge transfer between buyer & supplier	1	2	3	4	5	6

Performance measures

"What is the percentage of items obtained or orders made by your purchasing department that meet quality requirements?"

All	1
More than 90%	2
80%-90%	3
70%-80%	4
Less than 70%	5
Don't know or refused	6

"What is the percentage of purchase orders that arrive at the scheduled time (neither too early or too late)?"

All	1
More than 90%	2
80%-90%	3
70%-80%	4
Less than 70%	5
Don't know or refused	6

"What is the approximate percentage of purchase orders emitted that contain errors in specifications, quantity, price, due date, or suchlike?"

None	1
Less than 5%	2
5%-10%	3
10%-15%	4
15%-20%	5
More than 20%	6
Don't know or refused	7

"What is the average time from the receipt of a purchase requisition until the purchase order is sent to a supplier?"

Same day	1
1-2 days	2
3-5 days	3
Moe than 5 days	4
Don't know or refused	5

"And on a scale of 1-5, where 1 is very poorly and 5 is very well, please rate the following..."

How well do your buyers know the items, suppliers, prices, and so on for which they are responsible?	1	2	3	4	5	6
How well does purchasing uphold standards of conduct, ethics, conventions, courtesy and other dimensions of professionalism?	1	2	3	4	5	6
How well do buyers negotiate prices, terms of sales, delivery dates and other conditions with suppliers?	1	2	3	4	5	6

"Thank you, that's all the questions.

As I mentioned at the beginning of the interview, the responses you have given will remain completely confidential.

Would you like to receive a copy of the summary report? Yes/ No

Could I take your email address so that it can be sent to you?

On behalf of Vanson Bourne and London Business School, thank you for your time."

APPENDIX 3.

THE 'EUROPEAN SPEND AGENDA' TELEPHONE SURVEY ADMINISTRATION AND PROTOCOL

1. Population definition

This telephone survey was oriented towards heads of purchasing in European manufacturing and financial services companies with a turnover in excess of £250 million. The countries being considered were: France, Germany, Italy, Benelux and the UK.

2. Sample selection

A stratified, random sample was created from a source database of 2180 manufacturing and financial services companies across the relevant countries. The target response of 200 companies was achieved- equally divided between the manufacturing and financial services sectors. The survey administrator ensured that the correct person was responding to the survey.

3. Planning and management

Key elements of the telephone survey implementation included the following:

i) The telephone survey items were purpose-designed for this study.

ii) Survey items were discussed and pre-tested on a group of academics and practitioner professionals.

iii) All interviews were completed over a period of 2 weeks in December 2003.

iv) Survey methodology was executed strictly following good-practice (Malhotra & Grover, 1998; Frohlich, 2002b; Rungtusanatham et al., 2003).

v) An extensive up-to-date source database was used that had been compiled and refreshed by telephone interview over a number of years and that represented close to the entire population.

vi) N^{th} number random sampling was carried-out from the above source database.

vii) Trained interviewers guided respondents through the structured, closed questionnaire items.

viii) The first 20 interviews were piloted and the only amendment made was a minor simplification of wording in one item.

ix) Whilst the survey was conducted confidentially, almost all respondents agreed to be re-interviewed in the event of unclear answers.

x) A summary report was given to respondents.

4. Data quality control

Key elements in ensuring that the data generated from the telephone survey was of high quality and appropriate for subsequent analysis included the following:

i) Screening questions minimized sampling and coverage error.

ii) Analysis of the random sample indicated that spread of sub-sectors, company sizes, and locations did not differ markedly from the population.

iii) Measurement error was considerably reduced through the survey not being self-complete.

iv) To minimize interviewer error, 1 in 10 interviews were validated by a project leader, effectively re-interviewing the respondent. Each interview questionnaire was checked individually for 'branching errors' or omissions and the respondent was re-called if there were any problems.

v) Non-response error was judged within acceptable limits. The overall response rate was 23%.

vi) The individual country sampling and response rates were analysed and no significant differences in response rates between manufacturing and financial services or between countries were found. Analysing the range of companies, sub-sectors, locations and job-titles revealed no patterns for response or non-response. Furthermore, responses to certain objective questions had strong relationships with those from a previous year's survey using different respondents- indicating that non-response of previously surveyed groups was not a problem.

APPENDIX 4.

THE 'SUPPLY CHAIN OPERATIONAL PERFORMANCE EVALUATOR' (SCOPE) ONLINE SURVEY INSTRUMENT

The web-based survey instrument included the following core questions:

Performance Metrics

1. What is the number of inventory turns per year in ABC Company? (Click here for explanation.)
1. What percentage of ABC Company orders are perfectly fulfilled by your supplier on time and to required specification? (%)
2. What percentage of your customer orders are perfectly fulfilled by ABC Company on time and to required specification? (%)
3. What is the lead-time ABC Company requires to fulfil an order? (Days)
4. How closely does actual demand match forecasts? (%- Where 100% represents a perfect forecast/ actual demand match.)
5. How many days of supply (on average) do you carry in the following inventories?
   a. Raw material/components _______ Days
   b. Work-in-process _______ Days
   c. Finished goods _______ Days

Planning

Scale: 1- Never, 2- Annually, 3- Quarterly, 4- Monthly, 5- Weekly, 6- Daily, 7- Hourly

How frequently does ABC Company communicate with each supply chain partner to:

1. optimise the supply chain to reduce future crisis situations?
2. predict future demand?
3. agree on future demand levels?
4. plan sourcing, manufacturing and deployment for production sites?
5. coordinate future delivery dates based upon real constraints?
6. create factory production schedules?
7. design transport networks?
8. calculate finished goods inventory level to meet future customer requirements?
9. align the supply chain with future sales and marketing activities?
10. create service and parts systems to sustain customer satisfaction?

Sourcing and Delivering

Scale: 1- Not at all, 2- Very little, 3- Little, 4- Average, 5- Quite a lot, 6- A lot, 7- Completely

To what degree does ABC company.... with each supply chain partner:

1. share capital investment, inventory risks and cost savings?
2. share production planning and demand forecast knowledge?
3. nurture long-term relationships?
4. share inventory level knowledge?
5. share delivery frequency knowledge?
6. engage in joint-venture operations?
7. coordinate agreements and formulate contracts?
8. participate in on-line auctions?
9. make use of e-procurement and automated transactions?
10. make use of exchanges and supplier portals?
11. use 'next generation' Vendor Managed Inventory (eVMI)?
12. outsource to 3rd Party Logistics companies (3PL's)?

Making

Scale: 1- Not at all, 2- Very little, 3- Little, 4- Average, 5- Quite a lot, 6- A lot, 7- Completely

To what extent does ABC Company do the following:

1. implement IT communications technologies and/ or Enterprise Resource Planning?
2. implement "pull" production (e.g. reducing batch size/ set-up time, Kanban systems)?
3. implement programmes for quality improvement and control (e.g. TQM, 6 sigma)?
4. reengineer from functional towards process orientation (e.g. plant-within-a-plant restructuring, cellular manufacturing)
5. increase levels of delegation to and knowledge of workforce (e.g. training, empowerment, autonomous teams)
6. create dedicated positions for supply chain professionals or "supply chain champions"?

New Product Development

Scale: 1- Not at all, 2- Very little, 3- Little, 4- Average, 5- Quite a lot, 6- A lot, 7- Completely

To what extent do ABC Company personnel collaborate and share knowledge, both within the company and with supply chain partners, in order to:

1. design and improve the product?
2. control an engineering change order system?

3. coordinate production capacity for NPD prototypes?
4. coordinate purchasing for prototypes?
5. coordinate ramping-up/ priming of the supply chain for product launch?
6. design "for" effective supply chain management?
7. coordinate production of new products?

Returns

Scale: 1- Not at all, 2- Very little, 3- Little, 4- Average, 5- Quite a lot, 6- A lot, 7- Completely

To what extent does ABC Company work with supply chain partners to:

1. coordinate collection, sorting and routing of PRODUCTS returned by SUPPLY CHAIN PARTNERS? (e.g. due to stock balancing, excess from marketing promotions, end-of-season, end-of-product life, transit damage)
2. coordinate collection, sorting and routing of PRODUCTS returned by END USERS? (e.g. due to defective/ unwanted products, warranty returns, recalls, environmental disposal issues)
3. coordinate collection, sorting and routing of PACKAGING returned by SUPPLY CHAIN PARTNERS? (e.g. due to reusable totes, multi-trip packaging, disposal requirements)
4. coordinate collection, sorting and routing of PACKAGING returned by END USERS? (e.g. due to reuse, recycling, disposal restrictions)
5. ensure processing capability is sufficient to deal with product/ packaging return levels?
6. reduce returns inventory held?
7. identify and authorise legitimate returns?
8. reduce returns processing cycle times?
9. calculate the cost of the returns process?
10. maintain customer confidence in the returns process?

APPENDIX 5.

THE 'SUPPLY CHAIN OPERATIONAL PERFORMANCE EVALUATOR' (SCOPE) ONLINE SURVEY ADMINISTRATION AND PROTOCOL

1. Population

The population of interest for this study was all 1st tier product suppliers to the main UK Healthcare providers. A comprehensive contact listing of 1,611 suppliers was put together by approaching the department in charge of Supply Chain Logistics for each of the major UK Healthcare providers- the National Health Service (NHS), BUPA, and BMI-General. These 1,611 suppliers to the healthcare sector were considered to constitute a significant proportion of the UK supply base, and covered the NHS Purchasing and Supply Agency (PASA) Healthcare supply divisions of:

- Diagnostic and Medical Equipment
- Medical and Surgical
- Pharmaceuticals
- Food and Nutrition
- Textiles and Domestics
- Facilities Management and Utilities
- IT
- Office Services
- Rehabilitation Services
- Professional Services

2. Sample selection

Within each of the above classifications were companies that did not actually supply physical products but provided a whole range of services such as equipment maintenance and testing services, drug trials, consulting, equipment hire and so on. The PASA supplier classification of 'Professional Services' consisted exclusively of service suppliers of services (such as contract nursing, private physiotherapists, independent clinics, consulting firms etc.) and as such this classification was omitted from the listing. With regards to the other supplier classifications a thorough screening was carried out to ensure only product suppliers were included in the sample. This screening resulted in 654 largely service oriented suppliers being removed from the listing- leaving a sample of 957 1st tier product suppliers.

3. Planning and management

To all those supplier contacts with an email address, an invitation was sent via email to the Supply Chain/ Logistics/ Distribution Manager or Director. This first emailing rapidly confirmed the problem (that had been articulated in communications with NHS, BUPA and BMI-General) of obtaining up-to-date contact databases. Many of the email contacts were out-of-date and/ or unrecognised by email servers and returned as 'recipient unknown'. Since time and resources did not permit a full follow-up to establish up-to-date contacts for these companies, they were removed from the sample. When no response was obtained from apparently valid contacts, a follow-up email was sent a week later.

For those supplier contacts without email addresses, as well as those that had not responded to previous email invitations, an invitation to participate was sent by post. Again many letters were returned as 'recipient unknown at this address' and these were removed from the sample. In all, a total of 361 (22.4%) of the original contacts were found to be out-of-date or unusable. Lacking resources to further investigate them, they were removed from the sample under the assumption that the underlying processes for the contact information to be unsuitable were random.

Several telephone conversations were conducted to confirm whether suppliers fitted the product supplier requirements, to ascertain whether survey invitations had been received by targeted contacts and simply to answer particular questions or concerns of certain participants. The effective sample size consisted of 596 Supply Chain Managers/ Directors that were given access to the online survey. 154 full responses were received constituting a 25.8% response rate. The breakdown of this sample and response rate analysis is shown in Table 4.7 of Section 4.2.3.4.

All responses were collected within the six-month period between January and June 2004.

4. Data quality control

Key elements in ensuring that the data generated from the web-based survey was of high quality and appropriate for subsequent analysis included the following:

i) A full analysis of pilot study data confirmed suitability for the creation of valid and reliable scales.

ii) Screening questions minimized sampling and coverage error.

iii) Analysis of the sample indicated that spread of sub-sectors, company sizes, and locations did not differ markedly from the population.

iv) Measurement error was considerably reduced through 'pop-up' explanations at distinct points during the web-based survey, and the facility of respondents to 'skip' irrelevant sections.

v) 'Pop-up' and 'skip' functions also reduced the problem of uncontrolled missing data. Missing data was further reduced through requiring respondents to complete sections before allowing them to proceed to subsequent sections and feedback. The overall level of missing data due to drop-outs was found to be 13.9% and diagnostic tests showed it to be 'missing completely at random' (MCAR). Following established multivariate analysis protocol, mean substitution was deemed the most appropriate manner in which to maintain adequate sample size.

vi) Non-response error was judged within acceptable limits. The overall response rate was 25.8%.

vii) All individual supplier category samples were adequately represented in the total sample. Category response rates were analysed and no significant differences between categories were found.

viii) Analysing the range of companies, sub-sectors, turnovers, locations and job-titles revealed no discernable patterns for response or non-response.

ix) Analysis of means and standard deviations for all variables indicated no discernable data problems.

x) Adequacy of reduced sample sizes relating to 'optional' survey sections was checked for suitability for subsequent analysis techniques. Correspondingly, multivariate analysis procedures were applied with care so as not to 'overstretch' data limitations.

REFERENCES

AGRAWAL, N. AND S. NAHMIAS (1997), "Rationalisation of the Supplier Base in the Presence of Yield Uncertainty," *Production and Operations Management,* 6, 3, 291-308.

AHUJA, G. (2000), "Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study," *Administrative Science Quarterly,* 45, 425-55.

AKACUM, A. AND B. DALE (1995), "Supplier Partnering: Case Study Experiences," *International Journal of Purchasing and Materials Management,* 31, 1, 38-6.

AKINC, U. (1993), "Selecting a Set of Vendors in a Manufacturing Environment," *Journal of Operations Management,* 11, 107-22.

ALBINO V., GARAVELLI A. C., AND SCHIUMA G. (1999), "Knowledge Transfer and Inter-Firm Relationships in Industrial Districts: the Role of the Leader Firm," *Technovation,* 19, 53-63.

ALCHIAN, A. A. (1950), "Uncertainty, Evolution and Economic Theory," *Journal of Political Economy,* 57, 211-21.

ALMEIDA, P. (1996), "Knowledge Sourcing by Foreign Multinationals: Patent Citation Analysis in the U.S. Semiconductor Industry ," *Strategic Management Journal,* 17, Special Issue (Winter), 155-65.

AMOAKO-GYAMPAH, K. AND J. R. MEREDITH (1989), "The Operations Management Research Agenda: An Update," *Journal of Operations Management,* 8, 3, 250-62.

AMUNDSON, S. D. (1998), "Relationships Between Theory-Driven Empirical Research in Operations Management and Other Disciplines," *Journal of Operations Management,* 16, 4, 341-59.

ANAND, K. S. (1998), "Information Systems for Coordination Under Demand Uncertainty," *PhD Thesis. Stanford University. Adviser: Haim Mendelson* .

ANDERSON, J. C. AND D. W. GERBING (1988), "Structural Equation Modelling in Practice: A Review and Recommended Two-Step Approach," *Psychological Bulletin,* 103, 3, 411-23.

ANDERSON, M. G. AND P. B. KATZ (1998), "Strategic Sourcing," *International Journal of Logistics Management,* 9, 1, 1-13.

ANKLESARIA, J. AND D. N. BURT (1987), "Personal Factors in the Purchasing/ Engineering Interface," *Journal of Purchasing and Materials Management,* 23, 4, 9-16.

ANSARI, A. AND B. MODARESS, (1990), *Just in time purchasing,* Free Press, New York.

ARGOTE, L., (1999), *Organizational learning; Creating, retaining and transferring knowledge,* Kluwer Academic, London.

ARGOTE, L., B. MCEVILY, AND R. REAGANS (2003), "Managing Knowledge in Organizations: An Integrative Framework and Review of Emerging Themes," *Management Science,* 49, 4, 571-82.

ARGYLE, N. (2002), "Supplier Relations and Communications Strategy," *National Health Service Purchasing and Supply Agency Report.*

ARGYRIS, C. AND D. SCHON, (1978), *Organizational learning; a theory of action perspective,* Addison-Wesley, Reading, MA.

ARMISTEAD, C. G. AND J. MAPES (1993), "The Impact of Supply Chain Integration on Operating Performance," *Logistics Information Management,* 6, 4, 9-14.

BABBAR, S. AND S. PRASAD (1998), "International Purchasing, Inventory Management and Logistics Research: An Assessment and Agenda," *International Journal of Operations and Productions Management,* 18, 1, 6-36.

BABBIE, E., (1990), *Survey research methods. 2nd Ed.,* Wadsworth Publishing Co., Belmont, CA.

BAILEY, P., D. J. D. FARMER, AND D. JONES, (1994), *Purchasing Principles and Management,* Pitman, London.

BARWISE, P. (1995), *Good Empirical Generalisations,* 14, 3, 29-35.

BENTLER, P. M. (1990), "Comparative Fit Indexes in Structural Models," *Psychological Bulletin,* 107, 238-46.

BENTLER, P. M. AND D. G. BONNET (1980), "Significance Tests and Goodness-of-Fit in the Analysis of Covariance Structure," *Psychological Bulletin,* 88, 3, 588-606.

BENTLER, P. M. AND C. P. CHOU (1987), "Practical Issues in Structural Modelling," *Sociological Methods and Research,* 16, 78-117.

BERTRAND, J. W. M. AND J. C. FRANSOO (2002), "Operations Management Research Methodologies Using Quantitative Modeling," *International Journal of Operations & Production Management,* 22, 2, 241-64.

BESSANT, J. AND G. TSEKOURAS (2001), "Developing Learning Networks," *AI and Society,* 15, 82-98.

BESSANT, J., R. KAPLINSKY, AND R. LAMMING (2003), "Putting Supply Chain Learning into Practice," *International Journal of Operations and Production Management,* 23, 2, 167-84.

BLACKHURST, J. J. (2002), "A Network Based Methodology to Model Supply Chain Systems ," *PhD Thesis. The University of Iowa. Supervisor: Peter J. O'Grady.*

BLACKBURN, J. D., (1991), "The quick response movement in the apparel industry: a case study in time-compressing supply chains", *Time-based competition: The next battleground in American manufacturing.*, J. D. Ed. Blackburn, Irwin, Homewood, IL, 249-50

BOBROW, D. G. AND A. COLLINS, (1975), *Representation and understanding: Studies in cognitive science,* Academic Press, New York.

BOLLEN, K., (1989), *Structural Equations with Latent Variables,* John Wiley & Sons, New York.

BOOMSMA, A. (1985), "Nonconvergence, Improper Solutions, and Starting Values in LISREL Maximum Likelihood Estimation," *Psychometrica,* 50, 2, 229-42.

BOONE, T. AND R. GANESHAN (2001), "The Effect of Information Technology on Learning in Professional Service Organizations," *Journal of Operations Management,* 19, 4, 485-95.

BOWEN, D. E. AND W. E. YOUNGDAHL (1998), ""Lean" Service: in Defense of a Production Line Approach," *International Journal of Service Industry Management,* 9, 3, 207-25.

BOWEN, H., K. CLARK, C. HOLLOWAY, D. LEONARD-BARTON, AND S. WHEELWRIGHT (1994), "Regaining the Lead in Manufacturing," *Harvard Business Review,* 72, 5, 108-44.

BOWERSOX, D. J., P. J. DAUGHERTY, C. L. DROGE, D. S. ROGERS, AND D. L. WARDLOW (1989), "Leading Edge Logistics: Competitive Positioning for the 1990's," Council of Logistics Management. IL: Oak Brook.

BOWERSOX, D. J. AND P. J. DAUGHERTY (1995), "Logistics Paradigms; The Impact of IT," *Journal of Business Logistics,* 16, 1, 17-28.

BOWERSOX, D. J., D. J. CLOSS, AND T. P. STANK (2000), "Ten Mega Trends That Will Revolutionize Supply Chain Logistics," *Journal of Business Logistics,* 21, 2, 1-16.

BOZDOGAN, K., J. DEYST, D. HOULT, AND M. LUCAS (1998), "Architectural Innovation in Product Development Through Early Supplier Integration," *R & D Management,* 28, 3, 163-73.

BROWN, J. S. AND P. DUGUID (1991), "Organizational Learning and Communities-of-Practice: Toward a Unified View of Working, Learning and Innovation," *Organization Science,* 2, February, 40-57.

BRUNER, J. S., (1973), *Beyond the Information Given,* J. M. Ed. Anglin, Norton, New York.

BRYMAN, A., (1988), *Doing Research in Organisations,* Routledge, London.

BURT, D., (1984), *Proactive Procurement,* Prentice-Hall, Englewood Cliffs.

BURT, D. N. AND M. F. DOYLE. (1992). *The American Keiretsu.* Homewood, IL: Business One; Irwin.

BURTON, T. T. (1988), "JIT/ Repetitive Sourcing Strategies: Tying the Knot With Your Suppliers," *Production and Inventory Management Journal,* 4th Quarter, 38-41.

BYRNE, B. M., (2001), *Structural equation modelling with Amos,* Lawrence Erlbaum Associates, New Jersey.

CACHON, G. P. AND M. FISHER (2000), "Supply Chain Inventory Management and the Value of Shared Information," *Management Science,* 46, 8, 1032-48.

CAMMISH, R. AND M. KEOUGH (1991), "A Strategic Role for Purchasing," *The McKinsey Quarterly,* 3, 22-39.

CAMPBELL, D. T. AND D. W. FISKE (1959), "Convergent and Discriminant Validity by the Multitrait-Multimethod Matrix," *Psychological Bulletin,* 56, March, 81-105.

CARLILE, P. R. AND E. S. REBENTISCH (2003), "Into the Black Box: The Knowledge Transformation Cycle," *Management Science,* 49, 9, 1180-95.

CARR, A. S. AND J. N. PEARSON (1999), "Strategically Managed Buyer-Supplier Relationships and Performance Outcomes," *Journal of Operations Management,* 17, 5, 497-519.

CARTER, J. R. AND R. NARASIMHAN (1996), "Is Purchasing Really Strategic?", *International Journal of Purchasing and Materials Management,* 32, 1, 20-8.

CATTELL, R. B. (1966), "The Scree Test for the Number of Factors," *Multivariate Behavioural Research,* 1 (April), 245-76.

CAVINATO, J. L. (1992), "A Total Cost/ Value Model for Supply Chain Competitiveness," *Journal of Business Logistics,* 13, 2, 285-301.

CHAO, C.H. (2001), "Formulation of an E-Business Inter-Enterprise Collaboration for the Construction Industry", *PhD Thesis. Northwestern University. Adviser: Raymond J. Krizek.*

CHAO, C., E. E. SCHEUING, AND W. A. RUCH (1993), "Purchasing Performance Evaluation: An Investigation of Different Perspectives," *International Journal of Purchasing and Materials Management,* 33-9.

CHAPMAN, S. N. AND P. CARTER (1990), "Supplier-Customer Inventory Relationships Under Just-in-Time," *Decision Sciences,* 21, 1, 35-51.

CHASE, R. B. AND D. A. TANSIK (1983), "A Customer Contact Model for Organisational Design," *Management Science,* 29, 1037-50.

CHASE, R. B., N. J. AQUILANO, AND F. B. JACOBS (2001). *Operations for Competitive Advantage.* 9th Ed. New York: McGraw-Hill.

CHI, Y.-L. (1999), "An Integration Architecture for Large Scale Web Applications Involving Workflow, Data Exchange, and Knowledge Bases", *PhD Thesis. Arizona State University. Adviser: Philip M. Wolfe.*

CHRISTENSEN, W. J. (2000), "Supply Chain Management Knowledge and Organizational Structure", *PhD Thesis. Oklahoma State University. Adviser: Richard Germain.*

CHRISTOPHER, M., (1992), *Logistics and Supply Chain Management,* Pitman Publishing, London.

CHRISTOPHER, M. AND D. TOWILL (2001), "An Integrated Model for the Design of Agile Supply Chains," *International Journal of Physical Distribution & Logistics Management,* 31, 4, 235-46.

CHURCHILL, G. A. (1979), "A Paradigm for Developing Better Measures of Marketing Constructs," *Journal of Marketing Research,* 16 (February), 64-73.

CHURCHMAN, C. W. (1971), *The Design of Inquiring Systems: Basic Concepts of Systems and Organization.* New York: Basic Books.

CIPS, (2003), *Website,* Chartered Institute of Purchasing and Supply, http://www.cips.org/.

CLARK, K. (1996), "Competing Through Manufacturing and the New Manufacturing Paradigm: Is Manufacturing Strategy Passé," *Production and Operations Management,* 5, 1, 42-58.

CLIFF, N. a. H. C. D. (1967), "The Study of Sampling Errors in Factor Analysis by Means of Artificial Experiments," *Psychological Bulletin,* 68, 430-45.

CLINTON, S. R. AND D. J. CLOSS (1997), "Logistics Strategy: Does It Exist?", *Journal of Business Logistics,* 18, 19-44.

COHEN, J. 1988. *Statistical Power Analysis for the Behavioral Sciences.* Hillsdale, NJ: Lawrence Erlbaum Associates.

COHEN, W. M. AND D. A. LEVINTHAL (1990), "Absorptive Capacity: A New Perspective on Learning and Innovation", *Administrative Science Quarterly,* 35, 128-52.

COHEN, J., P. COHEN, S. G. WEST, AND L. S. AIKEN, (2003), *Applied Multiple Regression/Correlation Analysis for the Behavioral Cciences (3rd Ed.),* Erlbaum, Mahwah, NJ.

COOK, T. D. AND D. T. CAMPBELL, (1979), *Quasi-Experimentation: Design and analysis issues for field settings,* Houghton Mifflin, Boston.

COOPER, M. C., D. M. LAMBERT, AND J. D. PAGH (1997), "Supply Chain Management: More Than a New Name for Logistics," *The International Journal of Logistics Management,* 8, 1, 1-13.

CORBETT, C. AND L. VAN WASSENHOVE (1993), "Trade-Offs? What Trade-Offs? Competence and Competitiveness in Manufacturing Strategy," *California Management Review,* 35, 4, 107-22.

COTE, J. A. AND R. M. BUCKLEY (1988), "Measurement Error and Theory Testing in Consumer Research: an Illustration of the Importance of Construct Validation," *Consumer Research,* 14, 579-82.

COUGHLAN, P. AND D. COGHLAN (2002), "Action Research for Operations Management," *International Journal of Operations & Production Management,* 22, 2, 220-40.

COX, A. (1996), "Relational Competence and Strategic Procurement Management: Towards an Entrepreneurial and Contractual Theory of the Firm," *European Journal of Purchasing and Supply Management,* 2, 1, 57-70.

COX, A. W., (1997), *Business Success a Way of Thinking About Strategy, Critical Supply Chain Assets and Operational Best Practice,* Earlsgate, Boston, Lincolnshire.

CROOM, S. (2002), "Research in Operations Management: Rationale, Options, and Issues in Research Design," *Working Paper- Presented at European Institute for Advanced Studies in Management (EIASM) Workshop on Research Methodology.*

CROOM, S. (1996), "The Management of Dyadic Capability in New Product Development: A Qualitative Analysis of Customer-Supplier Relationships During the Jaguar X300 Vehicle Development Programme," *PhD Dissertation, University of Warwick.*

CROOM, S., P. ROMANO, AND M. GIANNAKIS (2000), "Supply Chain Management: an Analytical Framework for Critical Literature Review," *European Journal of Purchasing & Supply Management,* 6, 67-83.

CUSUMANO, M., (1985), *The Japanese automobile industry: Technology and management at Nissan and Toyota,* Harvard University Press, Cambridge, MA.

DAS, A. AND R. NARASIMHAN (2000), "Purchasing Competence and Its Relationship With Manufacturing Performance," *The Journal of Supply Chain Management,* Spring, 17-28.

DAUGHERTY, P. J., M. B. MYERS, AND C. W. AUTRY (1999), "Automatic Replenishment Programs: An Empirical Examination," *Journal of Business Logistics,* 20, 2, 63-82.

DAVENPORT, T., S. JARVENPAA, AND M. BEERS (1996), "Improving Knowledge Work Processes," *Sloan Management Review,* 37, Summer , 53-66.

DAVENPORT, T. H. (1998), "Putting the Enterprise into the Enterprise System," *Harvard Business Review,* July-August, 121-31.

DAVIS (1983), "Management Models for the Future," *New Management,* 1, 12-5.

DAVIS, T. (1993), "Effective Supply Chain Management," *Sloan Management Review,* Summer, 35-45.

DE BONTRIDDER, K. M. J. (2001), "Integrating Purchase and Production Planning: Using Local Search in Supply Chain Optimization ," *PhD Thesis. Technische Universiteit Eindhoven, The Netherlands.*

DENT, R., (2001), *Collective Knowledge Development, Organisational Learning and Learning Networks; An Integrated Framework,* Economic and Social Research Council, Swindon, UK.

DEWEY, J., (1938), *The Theory Of Inquiry,* Holt, New York.

DIETRICH, M., (1994), *Transaction Cost Economics And Beyond,* Routledge, London.

DILLMAN, D. A., (1977), *Mail And Telephone Surveys: The Total Design Method,* Wiley, New York.

DILLMAN, D. A. (1991), "The Design and Administration of Mail Surveys," *Annual Review of Sociology,* 17, 225-49.

DILLMAN, D. A., (2000), *Mail and Internet Surveys: The Tailored Design Method. 2nd Ed,* Wiley, New York.

DISNEY, S., M. NAIM, AND A. POTTER (2004), "Assessing the Impact of E-Business on Supply Chain Dynamics," *International Journal of Production Economics,* 89, 2, 109.

DOLL, W. J., A. HENDRICKSON, AND X. DENG (1998), "Using Davis's Perceived Usefulness and Ease-of-Use Instruments for Decision Making: A Confirmatory and Multigroup Invariance Analysis," *Decision Sciences,* 29, 4, 839-69.

DRETSKE, F. I., (1981), *Knowledge And The Flow Of Information,* MIT Press, Cambridge, Massachusetts.

DREYFUS, H. L. AND S. E. DREYFUS, (1986), *Mind Over Machine,* Basil Blackwell, London.

DRUCKER, P. F. (November 1991), "The New Productivity Challenge," *Harvard Business Review,* 69, 69-76.

DTI, (2000), *Learning Across Business Networks,* Department of Trade and Industry, London.

DUBIN, R., (1978), *Theory Building,* Free Press, New York.

DUSSUAGE, P., B. GARRETTE, AND W. MITCHELL (2000), "Learning From Competing Partners: Outcomes and Durations of Scale and Link Alliances in Europe, North America, and Asia," *Strategic Management Journal,* 21, 99-126.

DYER, J. AND K. NOBEOKA (2000), "Creating and Managing a High-Performance Knowledge-Sharing Network: The Toyota Case," *Strategic Management Journal,* 21, 3, 345-67.

DYER, J. H., D. S. CHO, AND W. CHU (1998), "Strategic Supplier Segmentation: The Next Best Practice in Supply Chain Management," *California Management Review,* 40, 2, 57-77.

EASTERBY-SMITH, M., R. THORPE, AND A. LOWE, (1991), *Management Research; An Introduction,* Sage, London.

EDMONDSON, A. (1999), "Psychological Safety and Learning Behaviour in Work Teams," *Administrative Science Quarterly,* 44, 350-83.

EDMONDSON, A. C., A. B. WINSLOW, R. M. BOHMER, AND G. P. PISANO (2003), "Learning How and Learning What; Effects of Tacit and Codified Knowledge on Performance Improvement Following Technology Adoption," *Decision Sciences,* 34, 2, 197-224.

ELLRAM, L. M. (1991), "Supply Chain Management: The Industrial Organisation Perspective," *International Journal of Physical Distribution & Logistics Management,* 21, 1, 13-22.

ELLRAM, L. M. AND J. N. PEARSON (1993), "The Role of the Purchasing Function: Toward Team Participation," *International Journal of Purchasing and Materials Management,* 29, 3, 2-9.

EDWARDS, P., M. PETERS, AND G. SHARMAN (2001), "The Effectiveness of Information Systems in Supporting the Extended Supply Chain," *Journal of Business Logistics,* 22, 1, 1-27.

ELORANTA, E. AND A.-P. HAMERI (1991), "Experiences of Different Approaches to Logistics," *Engineering Cost and Production Economics,* 21, 155-69.

EPPLE, D., L. ARGOTE, AND R. DEVADAS (1991), "Organizational Learning Curves: A Method for Investigating Intra-Plant Transfer of Knowledge Acquired Through Learning by Doing", *Organization Science,* 2, Special Issue, 58-70.

ETTLIE, J. E. (1998), "R&D and Global Manufacturing Performance," *Management Science*, 44, 1, 1-11.

FARMER, D. (1996), "Creating World Class Suppliers", *International Journal of Purchasing and Materials Management,* 32, 3, 52.

FAWCETT, S. E. AND G. M. MAGNAN (2002), "The Rhetoric and Reality of Supply Chain Integration", *International Journal of Physical Distribution and Logistics Management,* 32, 5, 339-61.

FERDOWS, K. AND A. DE MEYER (1990), "Lasting Improvements in Manufacturing Performance: In Search of a New Theory", *Journal of Operations Management,* 9, 2, 168-84.

FINARELLI, H. AND T. JOHNSON (2004), "Effective Demand Forecasting in 9 Steps", *Healthcare Financial Management,* 58, 11, 52-8.

FISHER, M. L., J. H. HAMMOND, W. R. OBERMEYER, AND A. RAMAN (1994), "Making Supply Meet Demand in an Uncertain World", *Harvard Business Review,* May-June, 83-93.

FISHER, M. L. (1997), "What Is the Right Supply Chain for Your Product?", *Harvard Business Review,* 30, March-April , 105-16.

FITZGERALD, J. A., R. JOHNSTON, S. BRIGNALL, R. SIVESTRO, AND C. VOSS, (1992), *Performance Measurement In Service Businesses,* CIMA,

FITZIMMONS, J. A. AND M. J. FITZIMMONS, (1997), *Service Management: Operations, Strategy and Information Technology,* McGraw-Hill, Boston.

FITZIMMONS, J. A., J. NOH, AND E. THIES (1998), "Purchasing Business Services", *Journal of Business & Industrial Marketing,* 13, 4/5, 370-80.

FLYNN, B. B., S. SAKAKIBARA, R. G. SCHROEDER, K. A. BATES, AND E. J. FLYNN (1990), "Empirical Research Methods in Operations Management", *Journal of Operations Management,* 9, 2, 250-84.

FLYNN, B. B., S. SAKAKIBARA, AND R. G. SCHROEDER (1995), "Relationship Between JIT and TQM: Practices and Performance", *Academy of Management Journal,* 38, 5, 1325-60.

FORRESTER, J., (1961), *Industrial dynamics,* Wiley, New York.

FORZA, C. (2002), "Survey Research in Operations Management: A Process-Based Perspective", *International Journal of Operations & Production Management,* 22, 2, 152-94.

FREELAND, J. R. (1991), "A Survey of Just-in-Time Purchasing Practices in the United States", *Production and Inventory Management Journal,* 32, 2, 43-9.

FREEMAN, V. T. AND J. L. CAVINATO (1990), "Fitting Purchasing to the Strategic Firm; Framework, Processes, and Values", *Journal of Purchasing and Materials Management,* Winter, 6-10.

FROEHLE, C. M., A. V. ROTH, R. B. CHASE, AND C. A. VOSS (2000), "Antecedents of New Service Development Effectiveness: An Exploratory Examination of Strategic Operations Choices," *Journal Of Service Research,* 3, 1, 3-17.

FROHLICH, M. T. AND R. WESTBROOK (2001), "Arcs of Integration: an International Study of Supply Chain Strategies", *Journal of Operations Management,* 19, 2, 185-200.

FROHLICH, M. T. (2002a), "E-Integration in the Supply Chain: Barriers and Performance", *Decision Sciences,* 33, 4, 537-56.

FROHLICH, M. T. (2002b), "Techniques for Improving Response Rates in OM Survey Research", *Journal of Operations Management,* 20, 1, 53-62.

FROHLICH, M. T. AND R. WESTBROOK (2002c), "Demand Chain Management in Manufacturing and Services: Web-Based Integration, Drivers and Performance", *Journal of Operations Management,* 20, 729-45.

FROHLICH, M. AND A. DONE (2004), "E-Excellence in Online OM Survey Research", *London Business School Working Paper.*

FYNES, B. AND A. AINAMO (1998), "Organisational Learning and Lean Supply Relationships: The Case of Apple Ireland", *Supply Chain Management,* 3, 2 , 96-107.

GADREY, J. AND F. GALLOUJ (1998), "The Provider-Customer Interface in Business and Professional Services", *The Service Industries Journal,* 18, 2, 1-15.

GALLOUJ, C. (1997), "Asymmetry of Information and the Service Relationship: Selection and Evaluation of the Service Provider", *International Journal of the Service Industry,* 8, 1, 42-64.

GAMMELGAARD, B. AND P. D. LARSON (2001), "Logistics Skills and Competencies for Supply Chain Management", *Journal of Business Logistics,* 22, 2, 27-48.

GARVIN, D. (1993), "Building a Learning Organisation", *Harvard Business Review,* July/ August, 78-91.

GATTY, R. (1966), "Multivariate Analysis for the Behavioural Sciences", *Applied Statistics,* 15, November, 157-72.

GERBING, D. W. AND J. G. HAMILTON (1996), "Viability of Exploratory Factor Analysis As a Precursor to Confirmatory Factor Analysis", *Structural Equation Modelling,* 3, 1, 62-72.

GIANNAKIS, M. (2001), "Supply Chain Management and the Role of Inter-Organisational Relationships in Service Organisations", *Proceedings of the 12th Annual Conference of the Production and Operations Management Society, Orlando, Florida,* March-April.

GIANNAKIS, M. AND S. R. CROOM (2004), "Toward the Development of a Supply Chain Management Paradigm: A Conceptual Framework", *Journal of Supply Chain Management,* 40, 2, 27-37.

GILL, J. AND P. JOHNSON, (1991), *Research Methods For Managers,* Paul Chapman Publishing, London.

GREEN, S. B., T. M. AKEY, K. K. FLEMING, S. L. HERSHBERGER, AND J. G. MARQUIS (1997), *Structural Equation Modelling: A Multidisciplinary Journal,* 4, 108-20.

GROONOS, C., (1990), *Service Management And Marketing: Managing The Moments Of Truth In Service Competition,* Maxwell Macmillan International Editions, Singapore.

GUIMARAES, T., D. COOK, AND N. NATARAJAN (2002), "Exploring the Importance of Business Clockspeed As a Moderator for Determinants of Supplier Network Performance", *Decision Sciences,* 33, 4, 629-45.

GUINIPERO, L. C. AND J. F. VOGT (1997), "Empowering the Purchasing Function: Moving to Team Decisions", *International Journal of Purchasing and Materials Management,* 33, 1, 8-15.

GUPTA, A. K. AND V. GOVINDARAJAN (2000), "Knowledge Flows Within Multinational Corporations", *Strategic Management Journal,* 21, 473-96.

GUY, S. P. AND B. G. DALE (1993), "The Role of Purchasing in Design", *International Journal of Purchasing and Materials Management,* 29, 3, 26-31.

HAGEDOORN, J. AND J. SCHEKENRAAD (1994), "The Effect of Strategic Technology Alliances on Company Performance", *Strategic Management Journal,* 15, 291-309.

HAIR, J. F., R. E. ANDERSON, R. L. TATHAM AND W. C. BLACK (1998). *Multivariate Data Analysis.* 5th ed. Upper Saddle River, New Jersey: Prentice-Hall Inc.

HAKANSSON, H., (1982), *International Marketing And Purchasing Of Industrial Goods- An Interaction Approach,* Wiley, New York.

HANDFIELD, R. B. (1993), "A Resource Dependence Perspective of Just-in-Time Purchasing", *Journal of Operations Management,* 11, 289-311.

HANDFIELD, R. (2002), *Writing the Ideal Paper for JOM: a New Editor's Perspective,* 20, 1-18.

HANDFIELD, R. AND S. MELNYK (1998), "The Scientific Theory-Building Process; a Primer Using the Case of TQM", *Journal of Operations Management,* 16, 4 (Special Issue on Theory Building in OM), 320-39.

HANDFIELD, R. B. AND E. L. JR. NICHOLS, (1999), *Introduction to Supply Chain Management,* Prentice Hall. Upper Saddle River, NJ.

HANSEN, M. T. (1999). "The search-transfer problem: The role of weak ties in sharing knowledge across organizational subunits", *Administrative Science Quarterly* 44, 82-111.

HARDYCK, C. D. AND L. F. PETRINOVICH (1976). *Introduction To Statistics For The Behavioural Sciences.* 2nd ed. Philadelphia: Saunders.

HARLAND, C. M. (1996), "Supply Chain Management: Relationships, Chains and Networks", *British Journal of Management,* 7, Special Issue, 63-80.

HARLAND, C. M., R. C. LAMMING, AND P. D. COUSINS (1999), "Developing the Concept of Supply Strategy", *International Journal of Operations & Production Management,* 19, 7, 650-66.

HARRIS, G. L. (2003), "The Value of Integration, Measurement Systems, and Application of Knowledge in Supply Management to Organization Performance", *DBA Thesis, Nova Southeastern University,* AADAA-I3105571 .

HARRISON, A., M. CHRISTOPHER, AND R. I. VAN HOEK (1999), "Creating the Agile Supply Chain", *The UK Institute of Logistics and Transportation.*

HARRISON, A. AND C. NEW (2002), "The Role of a Coherent Supply Chain Strategy and Performance Management in Achieving Competitive Advantage: An International Survey", *Journal of the Operational Research Society,* 53, 263-71.

HARRISON, A. AND R. VAN HOEK, (2002), *Logistics Management And Strategy,* Prentice Hall, Harlow, England.

HART, S. AND G. HOGG (1998), "Relationship Marketing in Corporate Legal Services", *The Service Industries Journal,* 18, 3, 55-69.

HAYDUK, L. A., (1987), *Structural Equation Modelling With LISREL: Essentials And Advances,* John Hopkins University Press, Baltimore, MD.

HAYES, R. H. AND S. C. WHEELWRIGHT, (1984), *Restoring Our Competitive Edge: Competing Through Manufacturing,* John Wiley & Sons, Ltd, New York.

HAYES, R. W. AND G. P. PISANO (1996), "Manufacturing Strategy: At the Intersection of Two Paradigm Shifts", *Production and Operations Management,* 5, 1, 25-41.

HBR SPOTLIGHT (2004), "The 21st Century Supply Chain", *Harvard Business Review,* October, 100.

HEBERLEIN, T. A. AND R. BAUMGARTNER (1978), "Factors Affecting Response Rates to Mailed Questionnaires; A Quantitative Analysis of the Published Literature", *American Sociological Review,* 43, 447-62.

HECKERT, J. B. AND R. B. MINER, (1940), *Distribution Costs,* The Ronald Press Company, New York.

HEIBELER, R. J. (1996), "Benchmarking Knowledge Management", *Strategy & Leadership,* 30, 24 (March-April), 22-9.

HENDERSON, R. M., (1996), "Technological Change And The Management Of Architectural Knowledge", in *Organizational learning,* Sproull Cohen, (Eds.), Sage Publications, Thousand Oaks, CA, 359-75

HESKETT, J. L., (1986), *Managing In The Service Economy,* Harvard Business School Press, Boston.

HILL. T., (1993), *Manufacturing Strategy: Text and Cases,* Macmillan Press, London.

HILL, T., (2000), *Operations Management. Strategic Context And Managerial Analysis,* MacMillan, Basingstoke, Hampshire.

HILL, A. V. (2002), "Five Challenges for the Operations Management Research Community", *Journal of Operations and Technology Management,* 20, 1-18.

HINES, P., (1994), *Creating World Class Suppliers: Unlocking Mutual Competitive Advantage,* Pitman, London.

HINES, P., (1995), "Network Sourcing: A Hybrid Approach," *International Journal of Purchasing and Materials Management,* 31, 2, 18-25.

HINES, P. (2000). "Value Stream Management Strategy and Excellence in The Supply Chain", Harlow: Financial Times/Prentice Hall.

HINES, P., P. COUSINS, D. T. JONES, R. LAMMING, AND N. RICH, (1999), *Value Stream Management; The Development Of Lean Supply Chains,* Financial Times Management, London.

HINES, P., M. HOLWE, AND N. RICH (2004), "Learning to Evolve: A Review of Contemporary Lean Thinking", *International Journal of Operations & Production Management,* 24, 9/10, 994.

HIRSCHMAN, C. H. AND M. B. HOLBROOK, (1992), *Postmodern Consumer Research: The Study Of Consumption As Text,* Sage Publications Inc, Newbury Park.

HORVATH, L. (2001), "Collaboration: The Key to Value Creation in Supply Chain Management", *Supply Chain Management,* 6, 5, 205-7.

HOULIHAN, J. B. (1988), "International Supply Chains: A New Approach", *Management Decision,* 26, 3, 13-9.

HOYLE, R. H. ED., (1995), *Structural Equation Modelling, Concepts, Issues, And Applications,* Sage Publications, Thousand Oaks, CA.

HU, L. T. AND P. M. BENTLER, (1995), "Evaluating Model Fit", In *Structural equation modelling: Concepts, issues and applications*, R. H. Hoyle, (Ed.), Sage, Thousand Oaks, CA, 76-99

HUANG, S. H., M. UPPAL, AND J. SHI (2002), "A Product Driven Approach to Manufacturing Supply Chain Selection", *Supply Chain Management,* 7, 4, 189-99.

HUBER, G. P. (1991), "Organizational Learning: The Contributing Processes and the Literatures", *Organization Science,* 2, 1 (Feb), 88-114.

HULT, G. T. M., E. L. J. NICHOLS, L. C. GUINIPERO, AND R. F. HURLEY (1999), "Global Organizational Learning in the Supply Chain: A Low Versus High Learning Study", *Journal of International Marketing,* 8, 3, 61-83.

HULT, G. T. (2003), "An Integration of Thoughts on Knowledge Management", *Decision Sciences,* 34, 2, 189-96.

HULT, G. T. M., E. L. J. NICHOLS, L. C. GUINIPERO, AND R. F. HURLEY (2000), "Organizational Learning in Global Purchasing: A Model and Test of Internal Users and Corporate Buyers", *Decision Sciences,* 31, 2 (Spring), 293-325.

HUNTER, J. E., F. L. SCHMIDT, AND G. B. JACKSON, (1983), *Meta-Analysis: Cumulating Research Findings Across Studies,* Sage, Beverly Hills, CA.

HYLAND, P. W., C. SOOSAY, AND T. R. SLOAN (2003), "Continuous Improvement and Learning in the Supply Chain", *International Journal of Physical Distribution & Logistics Management,* 33, 4, 316-35.

i2 (2003), "Supply Chain Management Software and Services." [http://www.i2.com/].

IMAI, K., (1987), *Kaizen,* Random House, New York, NY.

INGRAM, P. AND J. A. C. BAUM (1997), "Opportunity and Constraint: Organizations Learning From the Operating and Competitive Experience of Industries", *Strategic Management Journal,* 18, 75-98.

JAYARAM, J., C. DROGE, AND S. K. VICKERY (1999), "The Impact of Human Resource Management Practices on Manufacturing Performance", *Journal of Operations Management,* 18, 1, 1-20.

JD EDWARDS/ PEOPLESOFT (2003), "The JD Edwards EnterpriseOne Supply Chain Management Products", [http://www.peoplesoft.com/corp/en/products/ent_one/all_ent_one_products.jsp].

JENKINS, C. AND D. A. DILLMAN (1995), "The Language of Self-Administered Questionnaires As Seen Through the Eyes of Respondents", *Statistical Policy Working Paper 23: New Directions in Statistical Methodology,* 3, 470-516.

JENKINS, C. AND D. A. DILLMAN (1997), "Towards A Theory Of Self-Administered Questionnaire Design", In *Survey Measurement And Process Quality,* L. Lyberg and others, (Eds.), Wiley-Interscience, New York, 165-96.

JOGLEKAR, N. R. AND S. R. ROSENTHAL (2003), "Coordination of Design Supply Chains for Bundling Physical and Software Products", *The Journal of Product Innovation Management,* 20, 5, 374.

JOHNSON, M. E. AND G. SCUDDER (1999), "Supporting Quick Response Through Scheduling of Make-to-Stock Production/ Inventory Systems", *Decision Sciences*, 30, 2 (Spring), 441-67.

JONES, C., W. HESTERLY, AND S. BORGATTI (1997), "A General Theory of Network Governance; Exchange Conditions and Social Mechanisms", *Academy of Management Review*, 22, 4, 911-45.

JORESKOG, K. G. (1971b), "Simultaneous Factor Analysis in Several Populations", *Psychometrika*, 36, 409-26.

JORESKOG, K. G. AND D. SORBOM, (1989), *Lisrel 7: A Guide To The Program And Applications*, SPSS Inc., The Netherlands.

KELLOGG, D. L. AND W. NIE (1995), "A Framework for Strategic Service Management", *Journal of Operations Management*, 13, 4, 323-37.

KERLINGER, F. N., (1986), *Foundations Of Behavioural Research*, Holt, Rinehart & Winston. New York.

KNIGHT, L. (2002), "Network Learning: Exploring Learning by Interorganizational Networks", *Human Relations*, 55, 4, 427-54.

KNIGHT, L. A. (1998), "A Competence-Based Approach to Supply Strategy Implementation", *Seventh International IPSERA Conference, London*, 288-98.

KIM, J. AND C. W. MUELLER, (1978), *Factor Analysis: Statistical Methods And Practical Issues*, Sage Publications, Newbury Park CA.

KOGUT , B. AND U. ZANDER (1992), "Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology", *Organization Science*, 3, August , 383-97.

KRAJEWSKI, L. (2002), "Reflections on Operations Management Research", *Journal of Operations and Technology Management*, 20, 1-18 .

KRAUSE, D. R. (1999), "The Antecedents of Buying Firms' Efforts to Improve Suppliers", *Journal of Operations Management*, 17, 205-24.

KRAUSE, D. R., R. B. HANDFIELD, AND T. V. SCANNELL (1998), "An Empirical Investigation of Supplier Development; Reactive and Strategic Processes", *Journal of Operations and Technology Management*, 17, 39-58.

KVIZ, F. J. (1977), "Toward a Standard Definition of Response Rate", *Public Opinion Quarterly*, 41, 265-7 .

LAMMING, R. C., (1993), *Beyond Partnership: Strategies For Innovation And Lean Supply*, Prentice-Hall, Hemel Hempstead.

LAMMING, R. C., (1996), "Squaring Lean Supply With Supply Chain Management: Lean Production and Work Organisation", *International Journal of Operations and Production Management*, 16, 2, 183-97.

LAMMING, R., T. JOHNSEN, J. ZHENG, AND C. HARLAND (2000), "An Initial Classification of Supply Networks", *International Journal of Operations and Production Management*, 20, 6, 675.

LAMMING, R. C., N. D. CALDWELL, D. A. HARRISON, AND W. PHILLIPS (2001), "Transparency in Supply Relationships: Concept and Practice", *The Journal of Supply Chain Management*, 37, 4, 4-10.

LAWRENCE, J. J. AND M. P. HOTTENSTEIN (1995), "The Relationship Between JIT Manufacturing and Performance in Mexican Plants Affiliated With US Companies", *Journal of Operations Management*, 13, 3-18.

LEE, H. L. AND C. BILLINGTON (1992), "Managing Supply Chain Inventory: Pitfalls and Opportunities", *Sloan Management Review*, Spring, 65-73.

LEE, H. L. AND C. BILLINGTON (1996), "The Evolution of Supply Chain Management and Practice at Hewlett Packard", *Interfaces*, 25, 5, 42-63.

LEE, H. L., PADMANABHAN V., AND S. WHANG (1997a), "Information Distortion in a Supply Chain: The Bullwhip Effect", *Management Science*, 43, 4 (April), 546-58.

LEE, H. L., V. PADMANABHAN, AND S. WHANG (1997b), "The Bullwhip Effect in Supply Chains", *Sloan Management Review*, Spring , 93-114.

LEE, R. G. AND B. G. DALE (1998), "Business Process Management: A Review and Evaluation", *Business Process Management Journal*, 4, 3, 214-25.

LEE, H. L., K. C. SO, AND C. S. TANG (2000), "The Value of Information Sharing in a Two-Level Supply Chain", *Management Science*, 46, 5, 626-43.

LEE, H. L. (2004), "The Triple-A Supply Chain", *Harvard Business Review*, October, 102-12.

LEENDER, M. R. AND D. L. BLENCKHORN, (1988), *Reverse Marketing*, The Free Press, New York.

LEONARD-BARTON, D. (1992), "Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development", *Strategic Management Journal*, 13, 111-28.

LEONARD-BARTON, D. (1995), *Wellsprings Of Knowledge: Building And Sustaining The Sources Of Innovation*, Harvard Business School Press, Boston, MA.

LEVINTHAL, D. A. AND J. G. MARCH (1993), "The Myopia of Learning", *Strategic Management Journal*, 14, 95-112.

LEVITT, B. AND J. G. MARCH (1988), "Organizational Learning", *Annual Review of Sociology*, 14, 319-40.

LEVITT, T. (1976), "The Industrialization of Service", *Harvard Business Review*, 54, 5, 32-43.

LEWIS, H. T., (1956), *The Role Of Air Freight In Physical Distribution*, Harvard University, Boston, Graduate School of Business Administration, Division of Research.

LEWIS, J. C., M. M. NAIM, AND D. R. TOWILL (1997), "An Integrated Approach to Re-Engineering Material and Logistics Control", *International Journal of Physical Distribution and Logistics Management*, 27, 3, 197-209.

LOVELACE, K., D. L. SHAPIRO, AND L. R. WEINGART (2001), "Maximising Cross-Functional New Product Teams' Innovativeness and Constraint Adherence: A Conflict Communications Perspective", *Academy of Management Journal*, 44, 4, 779-93.

LOVELOCK (1983), "Classifying Services to Gain Strategic Marketing Insights", *Journal of Marketing*, 47 , Summer, 9-20.

LUMMUS, R. R., R. J. VOKURKA, AND K. L. ALBER (1998), "Strategic Supply Chain Planning", *Production and Inventory Management Journal*, 39, 3, 49-58.

MACBETH, D. K., N. FERGUSON, AND G. NEIL (1992), "Developing Customer-Supplier Relationships", *First PSERG Conference, Glasgow.*

MACCALLUM, R. C., M. ROZNOWSKI, AND L. B. NECOWITZ (1992), "Model Modifications in Covariance Structure Analysis: The Problem of Capitalization on Chance", *Psychological Bulletin*, 111, 3, 490-504.

MACKAY, D. M., (1969), *Information, Mechanism And Meaning*, MIT Press, Cambridge, Massachusetts.

MAGRETTA, J. (1998a), "Fast, Global, and Entrepreneurial: Supply Chain Management, Hong Kong Style- An Interview With Victor Fung", *Harvard Business Review.*

MAGRETTA, J. (1998b), "The Power of Virtual Integration: An Interview With Dell Computer's Michael Dell", *Harvard Business Review*, March- April, 73-84.

MALHOTRA, M. K. AND V. GROVER (1998), "An Assessment of Survey Research in POM: From Constructs to Theory", *Journal of Operations Management*, 16, 4, 407-25.

MALHOTRA, A. (2000), "Transforming Supply-Chains: Infrastructures for Collaborative Knowledge Creation", *PhD Thesis. University of Southern California. Adviser: Omar A. El Sawy*.

MANUGISTICS (2003), "Manugistics Supply Chain Management Solutions. [http://www.manugistics.com/solutions/scm.aspx].

MARCH, J. G. (1991), "Exploration and Exploitation in Organizational Learning", *Organization Science*, 2, 1- Special Issue, 71-87.

MARCH, J. G., (1994), "The Evolution Of Evolution", in *Evolutionary Dynamics of Organizations*, J. A. C. Baum and J. V. Singh, (Eds.), Oxford University Press, New York,

MARCH, J. G. AND H. A. SIMON, (1958), *Organizations*, Wiley, New York.

MARCOULIDES, G. A. AND R. E. SCHUMACKER, (1996), *Advanced Structural Equation Modelling*, Lawrence Erlbaum Associates, Mahwah, NJ.

MARSH, H. W. (1987), "The Factorial Invariance of Responses by Males and Females to a Multidimensional Self-Concept Instrument: Substantive and Methodological Issues", *Multivariate Behavioural Research*, 22, 457-80.

MARSH, H. W. (1994), "Confirmatory Factor Analysis Models of Factorial Invariance: A Multifaceted Approach", *Structural Equation Modelling*, 1, 1, 5-34.

MASON-JONES, R., J. B. NAYLOR, AND D. TOWILL (2000), "Engineering the Leagile Supply Chain", *International Journal of Agile Management Systems*.

MATCHLUP, F., (1980), *Knowledge: It's Creation, Distribution And Economic Significance. Volume 1: Knowledge And Knowledge Production*, Princeton University Press, Princeton, New Jersey.

MCCOLGAN, E. A. (1997), "How Fidelity Invests in Service Professionals", *Harvard Business Review*, 75, 1, 137-43.

MCGILL, I. AND S. WARNER-WEILL, (1989), *Making Sense Of Experiential Learning*, Open University Press, London.

MCGINNIS, M. A. AND J. W. KOHN (1990), "A Factor Analytic Study of Logistics Strategy", *Journal of Business Logistics*, 11, 1, 41-63.

MCGINNIS, M. A., (1993), "Logistics Strategy, Organizational Environment, and Time Competitiveness", *Journal of Business Logistics*, 14, 1, 1-23.

MCGRATH, J. E., (1982), "Dilemmatics: The Study Of Research Choices And Dilemmas", In *Judgment Calls in Research*, J. Martin and R. Kula J.E. McGrath, (Eds.), Sage Publications, Beverly Hills, CA, p. 69-102.

MCGRATH, R. G. (2001), "Exploratory Learning, Innovative Capacity, and Managerial Oversight", *Academy of Management Journal*, 44, 118-33.

MENDEZ, E. G. AND J. N. PEARSON (1994), "Purchasing's Role in Product Development: The Case for Time-Based Strategies", *International Journal of Purchasing and Materials Management*, 30, 1, 3-12.

MENTZER, J. AND M. MOON (2004), "Understanding DEMAND", *Supply Chain Management Review*, 8, 4, 38-5.

MEREDITH, J. R., A. RATURI, K. A. GYAMPAH, AND B. KAPLAN (1989), "Alternative Research Paradigms in Operations", *Journal of Operations Management*, 8, 4, 297-326.

MEREDITH. J. R. (1998), "Building Operations Management Theory Through Case and Field Research", *Journal of Operations Management*, 16, 4, 441-54.

MEREDITH, J. R. (2001), "Hopes for the Future of Operations Management", *Journal of Operations and Technology Management*, 19, 397-402.

MEREDITH, J. R. (2002), "Introduction: 20th Anniversary of JOM: An Editorial Retrospective and Prospective", *Journal of Operations and Technology Management,* 20, 1-18.
MILLER, D. AND M. J. CHEN (1994), "Sources and Consequences of Competitive Inertia: A Study of the U.S. Airline Industry", *Administrative Science Quarterly,* 39, 1-23.
MILLER, R., M. HOBDAY, X. OLLEROS, AND S. LEROUX-DEMERS (1995), "Innovation in Complex Systems Industries: the Case of Flight Simulation", *Industrial and Corporate Change,* 4, 2, 363-400.
MORRIS, M. H. AND R. J. CALANTONE (1991), "Redefining the Purchasing Function: an Entrepreneurial Perspective", *International Journal of Purchasing and Materials Management,* Fall, 2-9.
MORTON, R. (2003), "Return to Sender", *Logistics Today,* 44, 11, 33.
MOWERY, D. C., J. E. OXLEY, AND B. S. SILVERMAN (1996), "Strategic Alliances and Interfirm Knowledge Transfer", *Strategic Management Journal,* 17, Winter Special Issue, 77-91.
NARASIMHAN, R. AND J. JAYARAM (1998), "Causal Linkages in Supply Chain Management: An Exploratory Study of North American Manufacturing Firms", *Decision Sciences,* 29, 3 (Summer), 579-605.
NARASIMHAN, R. AND A. DAS (1999), "An Empirical Investigation of the Contribution of Strategic Sourcing to Manufacturing Flexibilities and Performance", *Decision Sciences,* 30, 3, 683-718.
NARASIMHAN, R., J. JAYARAM, AND J. R. CARTER (2001), "An Empirical Examination of the Underlying Dimensions of Purchasing Competence", *Production and Operations Management,* 10, 1, 1-15.
NARASIMHAN, R. AND S. W. KIM (2002), "Effect of Supply Chain Integration on the Relationship Between Diversification and Performance: Evidence From Japanese and Korean Firms", *Journal of Operations Management,* 20, 303-23.
NASSIMBENI, G. (1998), "Network Structures and Co-Ordination Mechanisms: A Taxonomy", *International Journal of Operations and Production Management,* 18, 6, 538-54.
NATIONAL HEALTH SERVICE, Purchasing and Supply Agency (2002), "Modernising Supply in the NHS", *Published Report.*
NAYLOR, J. B., M. M. NAIM, AND D. BERRY (1999), "Leagility: Integrating the Lean and Agile Manufacturing Paradigms in the Total Supply Chain", *International Journal of Production Economics,* 62, 107-18.
NELSON, R. R. AND S. G. WINTER, (1982), *An Evolutionary Theory Of Economic Change,* Harvard University Press, Cambridge, MA.
NEW, S. J. (1995), "Supply Chain Integration: Results From a Mixed Method Pilot Study", *Fourth International IPSERA Conference, Birmingham.*
NEW, S. J. (1997), "The Scope of Supply Chain Management Research", *Supply Chain Management,* 2, 1, 15-22.
NEW, S. (2003), "There May Be Troubles Ahead", *Supply Management,* 8, 1, 16-9.
NEW, S. J. AND J. RAMSAY (1995), "Supply Chains- Corporate Path to Economic Disaster?", *Fourth International IPSERA Conference, Birmingham.*
NIE, W. AND D. L. KELLOGG (1999), "How Process of Operations Management View Service Operations", *Production and Operations Management,* 8, 3, 339-55.
NISHIGUCHI, T., (1994), *Strategic Industrial Sourcing: The Japanese Advantage,* Oxford University Press, Oxford.
NOHRIA, N. AND R. GULATI (1996), "Is Slack Good or Bad for Innovation?", *Academy of Management Journal,* 39, 1245-65.

NONAKA, I. A. (1994), "A Dynamic Theory of Organizational Knowledge Creation", *Organization Science,* 5, February , 14-37.

NORMANN, R., (1991), *Services Management: Strategy And Leadership In Service Business- 2nd. Ed.,* John Wiley & Sons, Chichester, England.

NUNNALLY, J. C., (1979), *Psychometric Theory,* McGraw-Hill, New York.

OLIVER, R. K. AND M. D. WEBER, (1982), "Supply-Chain Management; Logistics Catches Up With Strategy", In *Logistics: The Strategic Issues*, M. L. Christopher, (Ed.), Chapman & Hall, London, 63-75.

ORACLE (2003), "The Oracle E-Business Suite- Supply Chain Management." [http://www.oracle.com/applications/scm/index.html].

PANNIRSELVAM, G. P., L. A. FERGUSON, R. C. ASH, AND S. SIFERD (1999), "Operations Management Research: An Update for the 1990s", *Journal of Operations Management,* 18, 95-112.

PARASURAMAN, A., V. A. ZEITHAML, AND BERRY. L (1988), "SERQUAL: a Multi-Item Scale for Measuring Consumer Perceptions of Service Quality", *Journal of Marketing,* 64, 12-40.

PARKER, G. G. (1998), "Contracting for Employee and Supplier Capability Development", *PhD Thesis. Massachusetts Institute of Technology. Supervisor: Charles H. Fine.*

PAULIN, M., J. PERRIEN, AND R. FERGUSON (1997), "Relational Contract Norms and the Effectiveness of Commercial Banking Relationships", *International Journal of Service Industry Management,* 8, 5, 435-52.

PAYNE, L. W. (1996), "Unlocking An Organization's Ultimate Potential Through Knowledge Management", *Knowledge Management in Practice, American Productivity & Quality Center* 31, April-May : 1.

PETERSEN, K. J., R. B. HANDFIELD, AND G. L. RAGATZ (2003), "A Model of Supplier Integration into New Product Development", *The Journal of Product Innovation Management,* 20, 4, 284.

PODSAKOFF, P. M. AND D. W. ORGAN (1986), "Self Reports in Organizational Research: Problems and Prospects", *Journal of Management,* 12, 4, 531-44.

POLYANI, M., (1966), *The Tacit Dimension,* Doubleday, Garden City, New York.

POSTREL, S. AND R. P. RUMELT (1992), "Incentive, Routines, and Self-Command", *Industrial and Corporate Change,* 1, 3, 397-425.

PRAHALAD, C. AND G. HAMEL, (1994), *Competing for the Future,* Harvard University Press, Boston, MA.

PRTM (2003), "A Process-Centred Approach to Supply Chain Management." [http://www.prtm.com/services/one.asp?service_id=1].

QUINN, J. B. AND C. E. GAGNON (1986), "Will Service Follow Manufacturing into Decline?", *Harvard Business Review,* 64, 6, 95-105.

QUINN, J. B., P. ANDERSON, AND S. FINKELSTEIN (1996), "Managing Professional Intellect: Making the Most of the Best," *Harvard Business Review,* 74, March , 71-82.

QUINTEN, A. AND M. RAAIJMAKERS (1999), "Effectiveness of Different Missing Data Treatments in Surveys With Likert-Type Data: Introducing the Relative Mean Substitution Approach", *Educational and Psychological Measurement,* 59, 5, 725-48.

RABINOVICH, E. (2001), "Supply Chain Management and the Internet: Transaction and Product Distribution Efficiencies", *PhD Thesis. University of Maryland College Park. Co-Directors: J. P. Bailey, P. T. Evers.*

RAGATZ, G. L., R. B. HANDFIELD, AND T. V. SCANNELL (1997), "Success Factors for Integrating Suppliers into New Product Development", *Journal of Product Innovation Management,* 14, 190-202.

RAO, C. R., (1975), *Linear Statistical Inference And Its Applications*, Wiley, New York.

RECK, R. F. AND B. G. LONG (1988), "Purchasing: a Competitive Weapon", *Journal of Purchasing and Materials Management*, Fall, 2-8.

REMENYI, D., B. WILLIAMS, A. MONEY, AND E. SWARTZ, (1998), *Doing Research In Business And Management: An Introduction To Process And Management*, Sage, London.

REVANS, R., (1980), *Action Learning*, Blond and Briggs, London.

ROBINSON, J. P. S. P. R. W. L. S., (1991), "Criteria For Scale Selection And Evaluation", In *Measures Of Personality And Social Psychological Attitudes*, J. P. Shaver P. R. Wrightsman L. S. Robinson, (Ed.), Academic Press, San Diego, Calif.,

ROGERS, S. AND R. S. TIBBEN-LEMBKE, (1999), *Going Backwards: Reverse Logistics Trends And Practices*, Logistics Executive Council, University of Nevada, Reno.

ROMER, P. (1995), "Beyond the Knowledge Worker", *World Link*, 28, Jan-Feb, 56-60.

ROTH, P. L. (1994), "Missing Data; A Conceptual Review for Applied Psychologists", *Personnel Psychology*, 47, 3, 537-60.

ROTH, A. V. AND W. E. JACKSON (1995), "Strategic Determinants of Service Quality and Performance: Evidence From the Banking Industry", *Management Science*, 41, 11, 1720-33.

ROTH, A. V. AND C. A. GIFFI (1995), "Winning in Global Markets; Neo-Operations Strategies in U. S. and Japanese Manufacturing", *OM Rev.*, 10, 4, 1-36.

ROTH, P. L., F. S. SWITZER, AND D. M. SWITZER (1999), "Missing Data in Multiple Item Scales; A Monte Carlo Analysis of Missing Data Techniques", *Organizational Research Methods*, 2, 3, 211-32.

ROZEBOOM, W. W. (1965), "Linear Correlations Between Sets of Variables", *Psychometrika*, 30, 57-71.

RUNGTUSANATHAM, M. J. (1998), "Let's Not Overlook Content Validity", *Decision Line*, July, 10-3.

RUNGTUSANATHAN, M. J., T. Y. CHOI, D. G. HOLLINGWORTH, AND Z. WU (2001), "Survey Research in Production/ Operations Management: Historical Analysis and Opportunities for Improvement", *Working Paper of Department of Management, Arizona State University, Tampa, AZ.*

RUNGTUSANATHAM, M. J., T. Y. CHOI, D. G. HOLLINGWORTH, Z. WU, AND C. FORZA (2003), "Survey Research in Operations Management; Historical Analyses", *Journal of Operations Management*, 21, 475-88.

SAKO, M., (1992), *Prices, Quality And Trust: Interfirm Relations In Britain And Japan*, Cambridge University Press, Cambridge.

SANDERS, N. R. AND R. PREMUS (2002), "IT Applications in Supply Chain Organizations: A Link Between Competitive Priorities and Organizational Benefits", *Journal of Business Logistics*, 23, 1, 65-83.

SAP (2003), "mySAP SCM: A Quick, Complete Solution to Connect and Empower Your Organization", [http://www.sap.com/solutions/business-suite/scm/index.epx].

SARKIS, J. AND S. TALLURI (2002), "A Model of Strategic Supplier Selection", *Journal of Supply Chain Management*, 38, 1, 18-29.

SASSER, E. W., P. R. OLSEN, AND D. D. WYCKOFF, (1979), *Management Of Service Operations: Texts, Cases And Readings*, Allyn & Bacon Inc., USA.

SAUNDERS, M. J. (1995), "Chains, Pipelines, Networks and Value Stream: The Role, Nature and Value of Such Metaphors in Forming Perceptions of the Task of Purchasing and Supply Management", *First Worldwide Research Symposium on Purchasing and Supply Chain Management. Tempe, Arizona*, 476-85.

SAUNDERS, M. J., (1998), "The Comparative Analysis of Supply Chains and Implications for the Development of Strategies", *Seventh International IPSERA Conference, London,* 469-77.

SAUNDERS, M., (1997), *Strategic Purchasing And Supply Chain Management. 2nd Ed.,* Pitman, London.

SCHONBERGER, E. H., (1990), *Building A Chain Of Customers; Linking Business Functions To Create The World Class Company,* The Free Press, New York.

SCHRAGE, E. (2004), "Supply and the Brand", *Harvard Business Review,* June, 1-3.

SCHULZ, M. (2001), "The Uncertain Relevance of Newness: Organizational Learning and Knowledge Flows", *Academy of Management Journal,* 44, 4, 661-81.

SCHUMPETER, J. A., (1942), *Capitalism, Socialism and Democracy,* Harper and Row, New York.

SCOTT, C. (1961), "Research on Mail Surveys", *Journal of the Royal Statistical Society,* 124, 143-205.

SCUDDER, G. D. AND C. A. HILL (1998), "A Review and Classification of Empirical Research in Operations Management", *Journal of Operations Management,* 16, 1, 91-101.

SENGE, P., (1999), *The Dance Of Change: Mastering The Twelve Challenges To Change In A Learning Organisation,* Doubleday, New York, NY.

SHAH, R. AND P. T. WARD (2003), "Lean Manufacturing: Context, Practice Bundles, and Performance", *Journal of Operations Management,* 21, 2, 129.

SHI, Z. (2001), "Inter-Organizational Information System Use in Supply Chain: Toward an Integration of Competence Based and Transaction Cost Based Views of the Firm", *PhD Thesis. The University of Toledo. Advisers: Anand S. Kunnathur, T. S. Ragu-Nathan.*

SHIN, M. (2003), "Developing Effective Knowledge Sharing Strategies Within Teams and Across Organisations", *PhD Thesis, Cambridge University,* 52-11544.

SIHRA AND LUTZ, (1997), "Applying group technology in services: A case study", in *Advances in services marketing and management,* T. A. Swartz, D. E. Bowen, and S. W. Brow, (Eds.), JAI Press, Greenwich, CT,

SILVESTRO, R. (1998), "The Manufacturing TQM and Service Quality Literatures: Synergistic or Conflicting Paradigms?", *International Journal of Quality and Reliability Management,* 15, 3, 62-75.

SILVESTRO, R., L. FITZGERALD, R. JOHNSTON, AND C. VOSS (1992), "Toward a Classification of Service Processes", *International Journal of Service Industry Management,* 3, 3, 62-75.

SINGLETON, R. A. AND B. C. STRAITS, (1999), *Approaches to Social Research. 3rd Ed.,* Oxford University Press, Oxford.

SKILTON, P. F. AND K. DOOLEY (2002), "Technological Knowledge Maturity, Innovation and Productivity", *International Journal of Operations & Production Management,* 22, 7/8, 887-901.

SKINNER, W. (1974), "The Focused Factory", *Harvard Business Review,* 52, 3, 113-21.

SLACK, N. AND H. BATES (1997), "What Happens When the Supply Chain Manages You? A Knowledge Based Approach", *3rd International IPSERA Conference, Naples,* T1--20.

SLACK, N., S. CHAMBERS, C. M. HARLAND, A. HARRISON, AND R. JOHNSTON, (1998), *Operations Management,* Pitman Publishing, London.

SLATER, S. F. AND J. C. NARVER (1995), "Market Orientation and the Learning Organization", *Journal of Marketing,* 59, 3, 63-74.

SLONE, R. E. (2004), "Leading a Supply Chain Turnaround", *Harvard Business Review,* October, 114-21.

SMAROS, J., J.-M. LEHTONEN, P. APPELQVIST, AND HOLMSTROM. J (2003), "The Impact of Increasing Demand Visibility on Production and Inventory Control Efficiency", *International Journal of Physical Distribution & Logistics Management,* 33, 4, 336-55.

SMITH, A., (1776), *An Inquiry Into The Nature And Causes Of The Wealth Of Nations,* Methuen and Co. Ltd., London.

SOONHONG, M. (2001), "A Market Orientation in Supply Chain Management", *PhD Thesis, The University of Tennessee. Supervisor: Mentzer, J..*

SORENSON, O. (2003), "Interdependence and Adaptability: Organizational Learning and the Long-Term Effect of Integration", *Management Science,* 49, 4, 446-63.

STANK, T. P., S. B. KELLER, AND P. J. DAUGHERTY (2001), "Supply Chain Collaboration and Logistical Service Performance", *Journal of Business Logistics,* 22, 1, 29-48.

STARBUCK, W. H. AND F. J. MILLIKEN (1988), "Challenger: Fine-Tuning the Odds Until Something Breaks", *Journal of Management Studies,* 25, 319-40.

STECKEL, J. H., S. GUPTA, AND BANERJI A. (2004), "Supply Chain Decision Making: Will Shorter Cycle Times and Shared Point-of-Sale Information Necessarily Help?", *Management Science,* 50, 4, 458-65.

STERMAN, J. D. (1989), "Modelling Managerial Behaviour: Misperceptions of Feedback in a Dynamic Decision Making Experiment", *Management Science,* 35, 3.

STEVENS, J. (1989), "Integrating the Supply Chain", *International Journal of Physical Distribution & Materials Management,* 19, 8, 3-8.

STOCK, J. R. (1997), "Applying Theories From Other Disciplines to Logistics", *International Journal of Physical Distribution and Logistics Management,* 27, 9/10, 515-35.

STOCK, G. N., N. P. GREIS, AND J. D. KASARDA (2000), "Enterprise Logistics and Supply Chain Structures: The Role of Fit", *Journal of Operations Management,* 18, 531-47.

STRATMAN, J. K. (2001), "Information Integration for Supply Chain Management: An Empirical Investigation of ERP Systems in Manufacturing", *PhD Thesis. The University of North Carolina at Chapel Hill. Advisor: Aleda V. Roth* .

STRATMAN, J. K. AND A. V. ROTH (2002), "Enterprise Resource Planning (ERP) Competence Constructs: Two Stage Multi-Item Scale Development and Validation", *Decision Sciences,* 33, 4, 601-28.

STUART, I. F. (1991), "Purchasing in an R&D Environment; Effective Teamwork in Business", *International Journal of Purchasing and Materials Management,* 27, 4, 9-34.

STUART, I. F. (1993), "Supplier Partnerships: Influencing Factors and Strategic Benefits", *International Journal of Purchasing and Materials Management`,* 29, 4, 22-8.

SUAREZ, F. F., M. A. CUSUMANO, AND C. H. FINE (1996), "An Empirical Study of Manufacturing Flexibility in Printed...", *Operations Research,* 44, 1, 223-40.

SUPPLY CHAIN COUNCIL INC. (2004), *Supply Chain Operations Reference Model. Overview of SCOR Version 6.1,* Supply Chain Council (www.supply-chain.org), Pittsburgh.

SVENSSON, G. (2004), "Key Areas, Causes and Contingency Planning of Corporate Vulnerability in Supply Chains: A Qualitative Approach", *International Journal of Physical Distribution & Logistics Management,* 34, 9, 728.

SYSON, R., (1989), *Improving Purchasing Performance,* Pitman Publishing, London.

SZULANSKI, G. (1996), "Exploring Internal Stickiness: Impediments to the Transfer of Best Practice Within the Firm", *Strategic Management Journal*, 17, Winter Special Issue, 27-43.

TAN, K. C., V. R. KANNAN, AND R. B. HANDFIELD (1998), "Supply Chain Management: Supplier Performance and Firm Performance", *International Journal of Purchasing and Materials Management*, 34, 3, 2-9.

TEECE, D. (1998), "Capturing Value From Knowledge Assets: the New Economy , Markets for Know-How, and Intangible Assets", *California Management Review*, 40, 3, 55-79.

THORELLI, H. B. (1986), "Networks: Between Markets and Hierarchies", *Strategic Management Journal*, 7, 1, 37-51.

TIBBEN-LEMBKE, R. S. (2002), "Life After Death: Reverse Logistics and the Product Life Cycle", *International Journal of Physical Distribution & Logistics Management*, 32, 3/4, 223-45.

TIDD, J. (1997), "Complexity, Networks and Learning; Integrative Themes for Research on Innovation Management", *International Journal of Innovation Management*, 1, 1-22.

TOURANGEAU, R. AND K. A. RASINSKI (1988), "Cognitive Processes Underlying Context Effects in Attitude Measurement", *Psychological Bulletin*, 103, 299-314.

TOWILL, D. R. (1996), "Industrial Dynamics Modelling of Supply Chains", *International Journal of Physical Distribution and Logistics Management*, 26, 2, 23-42.

TOWILL, D. R., P. CHILDERHOUSE, AND S. M. DISNEY (2002), "Integrating the Automotive Supply Chain: Where Are We Now?", *International Journal of Physical Distribution & Logistics Management*, 32, 1/2, 79-95.

TSAI, W. (2001), "Knowledge Transfer in Intraorganizational Networks: Effects of Network Position and Absorptive Capacity on Business Unit Innovation and Performance", *Academy of Management Journal*, 44, 5, 996-1004.

TUSHMAN, M. L. AND P. ANDERSON (1986), "Technological Discontinuities and Organizational Environments", *Administrative Science Quarterly*, 31, 439-65.

TYLER, K., D. MCGIRR, AND E. STANLEY (1998), "Contextualising: Technology, Relationships and Time in a Financial Services in a Virtual Organisation", *The Services Industries Journal*, 18, 3, 70-89.

TSIKRIKTSIS, N. (2003), "A Review of Techniques for Treating Missing Data in OM Survey Research", *London Business School Working Paper*.

UPTON, D. M. (1995), "Flexibility As Process Mobility: the Management of Plant Capabilities for Quick Response Manufacturing", *Journal of Operations Management*, 13, 3-4, 205-24.

ULWICK, A. W. (2002), "Turn Customer Input into Innovation", *Harvard Business Review*, 80, 1 (Jan), 91-7 .

VAN ACKERE, A., E. R. LARSEN, AND J. D. W. MORECROFT (1993), "Systems Thinking and Business Process Redesign: An Application to the Beer Game", *European Management Journal*, 11, 4.

VAN DEN BURG, W. AND C. LEWIS (1988), "Some Properties of Two Measures of Multivariate Association", *Psychometrika*, 53, 109-122.

VAN HOEK, R. I. AND A. HARRISON (2001), "Guest Editorial", *International Journal of Physical Distribution & Logistics Management*, 31, 4, 231-4.

VAN HOEK, R. I., A. HARRISON, AND M. CHRISTOPHER (2001), "Measuring Agile Capabilities in the Supply Chain", *International Journal of Operations & Production Management*, 21, 1/2, 126-47.

VASTAG, G. AND F. MONTABON (2001), "Linkages Among Manufacturing Concepts, Inventories, Delivery Service and Competitiveness", *International Journal of Production Economics,* 71, 195-204.

VERMA, R. AND J. C. GOODALE (1995), "Statistical Power in Operations Management Research", *Journal of Operations Management,* 13, 139-52.

VICKERY, S., C. DROGE, AND R. MARKLAND (1993), "Production Competence and Business Strategy; Do They Affect Business Performance?", *Decision Sciences,* 24, 2, 435-56.

VOKURKA, R. J. AND S. W. O'LEARY-KELLY (2000), "A Review of Empirical Research on Manufacturing Flexibility", *Journal of Operations Management,* 18, 4, 485-501.

VOSS, C. A. (1995), "Alternative Paradigms for Manufacturing Strategy", *International Journal of Operations and Production Management,* 15, 4, 5-16.

VOSS, C. A. (1995), "Operations Management- From Taylor to Toyota and Beyond", *British Journal of Management,* 6, 17-29.

VOSS, C. A., K. BLACKMON, R. B. CHASE, B. ROSE, AND A. V. AND ROTH (1997), "Service Competitiveness- An Anglo- U.S. Study", *Business Strategy Review,* 8, 7-22.

VOSS, C. AND K. BLACKMON (1998), "Differences in Manufacturing Strategy Decisions Between Japanese and Western Manufacturing Plants: the Role of Strategic Time Orientation", *Journal of Operations Management,* 16, 2-3, 147-58.

VOSS, C., N. TSIKRIKTSIS, AND M. FROHLICH (2002), "Case Research in Operations Management", *International Journal of Operations and Production Management,* 22, 2, 195-219.

VOSS, C. A. (2003), "Rethinking Paradigms of Service. Service in a Virtual Environment", *International Journal of Operations and Production Management,* 23, 1, 88-104.

WALLER, M., M. E. JOHNSON, AND T. DAVIS (1999), "Vendor-Managed Inventory in the Retail Supply Chain", *Journal of Business Logistics,* 20, 1, 183-203.

WATSON, G. (2001), "Subregimes of Power and Integrated Supply Chain Management", *Journal of Supply Chain Management,* 37, 3, 36-41.

WINTER, S. G. (1984), "Schumpeterian Competition in Alternative Technological Regimes", *Journal of Economic Behaviour and Organization,* 5, 287-320.

WITT, C. E. (1999), "Needed: Skills in Warehousing", *Material Handling Engineering,* August, 39-42.

WOMACK, J. P., T. D. JONES, AND D. ROOS, (1990), *The Machine That Changed The World,* Rawson Associates; Maxwell- Macmillan, New York.

WORLD BANK, (1983), *World Development Report,* The World Bank, Washington, D.C.

WRIGHT, D. (2003), "Relationship Management in Supply Networks", *Logistics and Transport Focus,* 5, 1, 30.

YU, Z. (2002), "Modelling and Analysis of Strategic Supply Chain Management Systems", *PhD Thesis. Hong Kong Polytechnic (China). Advisers: Yan Hong, T. C Edwin Chang.*

ZACK, M. H. (1999), "Managing Codified Knowledge", *Sloan Management Review,* 40, 4 (Summer), 45-58.

ZEITHAML, V. AND M. J. BINTER, (1996), *Services Marketing,* McGraw-Hill, New York.

ZEITHAML, V. A., L. L. BERRY, AND A. PARASURAMAN (1996), "The Behavioral Consequences of Service Quality", *Journal of Marketing,* 60, 2, 31-46.