

SUPPLY-CHAIN EVOLUTION: KNOWLEDGE-BASED PERSPECTIVES

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Abstract

This paper aims to go some way to answering the question: “Where are we now in the evolution of supply chains and what has to occur to advance along the continuum?” (Bowersox et al., 2000), by undertaking a conceptual synthesis of relevant literatures relating to the increasing importance of managing knowledge in supply chains. These issues are developed through a synthesis of the supply chain literature, and analyzed through adopting perspectives from knowledge management research streams. A consensus is emerging from the supply chain literature that to advance along the evolutionary continuum supply chains must become more integrated, and with increased levels of collaboration between upstream and downstream partners. Yet, the majority of existing supply chain literature still focuses on asset, alphanumeric data and information (in the form of documents and files) elements of exchange between supply chain partners. This is despite the fact that increased integration and collaboration clearly require the exchange of more complex elements at the expertise and knowledge levels. Within supply chain contexts the exchange and management of knowledge dimensions is not so well understood despite their increasing importance as more complex business dynamics shift towards competing supply chains. This paper proposes that several knowledge management concepts and frameworks are relevant and useful to supply chain academics and practitioners. It contributes to a gap in the literature relating to the exchange and development of knowledge in supply chains, which has been identified as an important area relating to the continued evolution of supply chain theory and practice.

Keywords: Knowledge Management, Supply Chains, Integration, Collaboration.

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1. Introduction

“Business practices of the future will be defined in a new unit of analysis: the supply chain (not the individual organisation) [...] 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; Burgess et al., 2006). In particular, a steady evolution of literature and practice has been taking place on supply chain issues over the last 15 years or so. This impact of supply chain management on the operations management research community has not been surprising, given that its wider impact on modern society as a whole has been profound.

The original moves into supply chain research came as a result of realizing 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 modelers working on the very real problems experienced by business managers (Christopher, 1992; Lamming, 1996; Saunders, 1998; Hines, 2000; Ketchen Jr. and Hult, 2007). 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 and Wheelwright, 1984).

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 and Towill, 2001). Nevertheless, at the beginning of the 21st century, many organizations still find that the competitive benefits of developments in supply chain management remain elusive (Davenport, 1998; Bowersox et al., 2000; Fawcett and Maignan, 2002). This indicates a failure to fully get to grips with the complexities of managing modern real-world supply chains. At the very least, it would appear that there are still

fundamental gaps in academic and practitioner understanding that need to be investigated (Frohlich and 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 it clear that organizations have to break down inter-organizational 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. Data is usually transferred in alphanumeric form, and information as a collation of such data into forms such as documents and files. Yet, academics and practitioners alike feel that it is the more complex mechanisms underlying supply chain integration and collaboration, such as the exchange of expertise and knowledge, that hold the key to better understanding and improvements in supply chain management. After all, true collaboration needs more complex forms of communication that go beyond simply sharing numbers and words- but requiring shared thinking, planning and working together towards a common goal.

Bowersox et al. ask “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 purpose of this conceptual paper is to explore this fundamental question from relevant perspectives and proposes that fresh knowledge could be obtained through consideration of appropriate concepts and frameworks from the Organizational Learning and in particular the Knowledge Management streams of strategic management literature.

Important supply chain 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 and Westbrook, 2001). Yet, managing such ‘soft’ dimensions as opinions and expertise might incur a step-change in terms of theory development, and practice implementation and development.

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 (Bessant et al., 2003). It seems common sense that to achieve true collaboration between supply chain partners requires the development of 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 still 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; Miles and Snow, 2007), this conceptual study transfers 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, yet states that there is still “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-organizational knowledge creation and transfer (Ingram and Baum, 1997), knowledge adoption and development (Cohen and Levinthal, 1990), and knowledge evolution (March, 1991; Levinthal and March, 1993; Miller and Chen, 1994).

2. Conceptual Perspectives and Definitions Adopted

Whilst recognizing that the study of supply chains can take several alternative perspectives, this study primarily adopts viewpoints, theories and frameworks from the operations management (OM) and logistics literatures. 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.

Nevertheless, supply chain researchers also note limitations to the OM/logistics perspective that potentially restrict further theory development in this field. In this respect, this paper 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 organizational learning from the field of knowledge management are considered.

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 characterize cooperation, coordination and collaboration as the supply chain relationship types, stating that increasing levels of commitment and trust as relationships move towards collaboration are linked to success. The broader supply chain literature also relates the term “coordination” to upstream and downstream information exchange (Lee et al., 1997a; Frohlich and Westbrook, 2001). 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, according to Harrison and van Hoek (2002, p. 225), the term “coordination” is considered 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 study 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.

3. Supply Chain Management Current Literature

The Scope of Supply Chain Management Research

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 of the huge challenges it presents to managers. They state that complexity and lack of understanding present considerable challenges to the academic research community.

In his review of the scope of supply chain management research, New (1997) recognizes 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.”

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 than the sum of the parts) (Cavinato, 1992). This can be summarized by the observation that the behavior of a complex system cannot be completely understood 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, one of the key themes is 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 supply chains, rather than single firms, 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 et al., 1997; Babbar and Prasad, 1998; Saunders, 1998; Storey et al., 2006). Nevertheless, the scientific development of a coherent supply chain management discipline does require that advances be made in the development of common theoretical models to inform our understanding of supply chain phenomena.

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

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.

Bodies of Literature Associated With Supply Chain Management

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 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 and 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, but a significant challenge for supply chain scholars is the diverse and growing bodies of literature on the topic, not only in the specialized supply chain journals but also in general popular management journals (Giannakis and 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 “externalization” 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 organization, institutional and production economics (transaction costs), inter-organizational relationships and systems theory.

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-organization issues (Cox, 1997), some to discuss an alternative organizational form to vertical integration (Thorelli, 1986), while others have used it to identify and describe the relationship a company develops with its suppliers (Sako, 1992; Lamming, 1993; Hines, 1995).

The Historical Challenge of Coordinating the Supply Chain

Womack et al. (1990, p.140) stressed that 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., share 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), characterizing such cooperative supply relationships as “beyond partnership”.

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. Lamming (1996) states that one of the goals in modern supply chain management is to exploit expertise wherever it lies in the chain and to recognize the impacts in one part of the chain, of decisions made in another.

Lean to "Leagile"

The evolution of theory and practice for the development of supply chain management 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 to the consumer at the right price and at the right time 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, new supply chain paradigms of "lean" and "agile" have emerged (Christopher and Towill, 2001).

As Lamming (1996) had brought the lean paradigm into the realms of supply chain management, so Harrison (1999) broadened the agile manufacturing debate into the supply chain management literature. Naylor et al. (1999) provide useful summarized 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 on these definitions, in the light of Hill's (1993) manufacturing strategy "order winners and qualifiers". 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 also an appropriate holistic supply chain strategy. 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.

Van Hoek 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. 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.

Based on the notion that there are operating environments that favor lean and others that favor 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.

Naylor et al. (1999) illustrate the "leagility" concept with case studies, such as Hewlett Packard, emphasizing 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".

Christopher and Towill (2001) incorporate the previous issues, and outline the evolution of supply chain management from the 1980s in terms of lean and agile characteristics, leading to a customized hybrid "leagile" supply chain.

In addition to emphasizing 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”.

The concept of the supply chain as an “integrated whole” is central to the lean philosophy (Womack et al., 1990; Lamming, 1996). Lamming (1996) characterizes such integration as “customers and suppliers being ‘in the same boat’, or perhaps, by the concept of ‘mutual destiny’ recognized by neighbors in the supply chain.” This understanding of “mutual destiny” leads to the “beyond partnership” type relationships between customers and suppliers, and realizes 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).

Integration to Collaboration

One thing that most of the supply chain related literature streams agree on is that, with challenging economic climates and ever-heightened competitive pressures, companies are being driven to constantly change their business operating strategies. Furthermore, and for some time now, organizations throughout the world have been taking bold steps to break down both intra- and inter-organizational 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 organizations to encompass channel participants (Stank et al., 2001).

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, which assumes that all businesses should include sourcing, making, and delivering processes to strategically link suppliers and customers to manufacturers.

The case for improving supply chain integration through asset, data and information coordination has consistently found support in the increasing wealth of mathematical modeling and empirical analysis based supply chain literature (Narasimhan and Jayaram, 1998; Johnson and Scudder, 1999; Krause, 1999; Zhou and Benton Jr., 2007).

From a modeling standpoint, Lee et al. (1997a) investigated the root causes of the “bullwhip effect”, recognized to have catastrophic ramifications on coordination amongst supply chain partners. 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.

Cachon and Fisher (2000) investigate the value of shared information in inventory management. Their simulation finds 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 reductions in inventory and cost, especially when the demands are significantly correlated over time.

However, mathematical modeling 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. 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. Their analysis supports the notion that an integrated supply chain involves aligning sourcing decisions to achieve manufacturing goals that are set to respond favorably to customers' needs.

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." They find empirical support for the view that integration of data and information is beneficial for operational performance; basically, the greater the level of this data and information integration the better. Yet Frohlich and Westbrook (2001) go further in their concluding discussion, enhancing the pure data and information sharing view of integration to include collaboration.

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 organizations that are capable of managing the complex processes of transferring and sharing data and information between supply chain partners (Magretta, 1998; Zhou and Benton Jr., 2007). 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 data and 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 the 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 organizations. 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 decisions. Thus collaboration will go beyond integrated information systems towards a collaborative state.

An important distinction emerges between the concepts of integration and collaboration. 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) 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 there is still some uncertainty and inconsistency, and 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 organizational competitiveness.

Fisher (1997) makes it clear that a devotion to data and information integration alone is not a supply chain magic wand. Fisher’s work on product-oriented responsive and efficient supply chains is closely paralleled by the emerging literature in the lean and agile manufacturing paradigms. 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.

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 it goes way beyond just exchanging data and information. 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.

The above discussion indicates that supply chain integration needs to move to supply chain collaboration going beyond assets, data and information. First, by understanding and applying supply chain management concepts in the real world, and second, by exploring knowledge base concepts from knowledge management literature.

Most supply chain integration research stops at the data and information levels of exchange. 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. Whilst the literature recognizes 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.

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 and Magnan, 2002). This clearly opens up important new opportunities and challenges both for academics and practitioners.

4. Continuing Development of the Supply Chain

The Future of Supply Chain Management

Bowersox et al. (2000) build on 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, management needs to be aware of the changing environment in and around the firm in order not to 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 practices between supply chain partners as they struggle to establish efficient, effective, and relevant product/service solutions for end-customers.”

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 realization levels of the mega-trends gives a simplistic “maturity” scale for each, showing how developed or advanced organizations 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 of 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 section summarizes the relevant parts of Bowersox et al.’s (2000) mega-trends: “Adversarial to Collaborative”; “Information Hoarding to Sharing”; and “Towards Knowledge-Based Learning”.

Adversarial to Collaborative

It is clear, however, that collaboration is talked about much more than it is actually practiced. This mega-trend receives a score of only 2 to 3 on the ten-point maturity scale, and, given its

widely recognized importance, the move towards collaboration constitutes a major step in the future evolution of supply chains.

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

Towards Knowledge-Based Learning

Bowersox et al. (2000) argue the importance of knowledge and learning to the future evolution of supply chain logistics. 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 organizational learning represents a significant step in the evolution of supply chains. 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 organization". 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 evolve their supply chains fastest, 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.

Conceptual Gaps in Supply Chain Research

The need for further research involving knowledge-based dimensions is made clearer by Croom et al.'s (2000) comprehensive critical literature review. Croom et al. (2000) set out to define a framework for classifying and critically analyzing 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. 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: the Dyadic level, considering the single two party relationship between supplier and manufacturer or manufacturer and distributor/retailer; the Chain level, which encompasses a set of dyadic relationships, including a supplier, a supplier's supplier, a customer and a customer's customer; and the Network level, concerning a network of upstream, downstream or total operations.

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. 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. They point out that, while a very rich literature does exist on the links between organizational

competence and corporate strategy, they found only one piece of work that highlights the links between organizational competence and individual competence (1998), and none relating to the individual and organizational competence required for good supply chain management.

The Need for New Cross-Functional Conceptual Perspectives

In addition to the apparent conceptual gaps in the supply chain literature, there have been calls from distinguished researchers in the field for new perspectives. For example, Stock (1997) suggests that researchers in the supply chain field might 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 phenomena and issues through a different cognitive lens.

Croom et al. (2000) also recognize 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-organizational theory has been recognized 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” so that “the subject is [...] explored from a multiplicity of perspectives.”

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

Returning to Bowersox et al.’s (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 onto these specific 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.”

Under the “umbrella” (Argote, 1999) field of Organizational 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 organizational evolution, learning and knowledge are inextricably linked (March, 1991).

5. Relevant Conceptual Perspectives from Knowledge Management

Knowledge Management is a rapidly expanding body of literature seeking to apply a knowledge-based perspective to business issues, and focusing on knowledge as a key competitive asset (Miles and Snow, 2007). 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 but primarily organizational learning. This emerging field can be broadly divided into two thematic research areas:

1. That literature that deals with the question “what is knowledge?”; investigating the dimensions of knowledge and learning.

2. A growing body of literature that seeks to apply the “knowledge lens” in researching the effect of knowledge on performance within the context of organizations.

There are many developing lines of research dealing with major knowledge-based issues in organizations 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. 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.

Organizational Knowledge

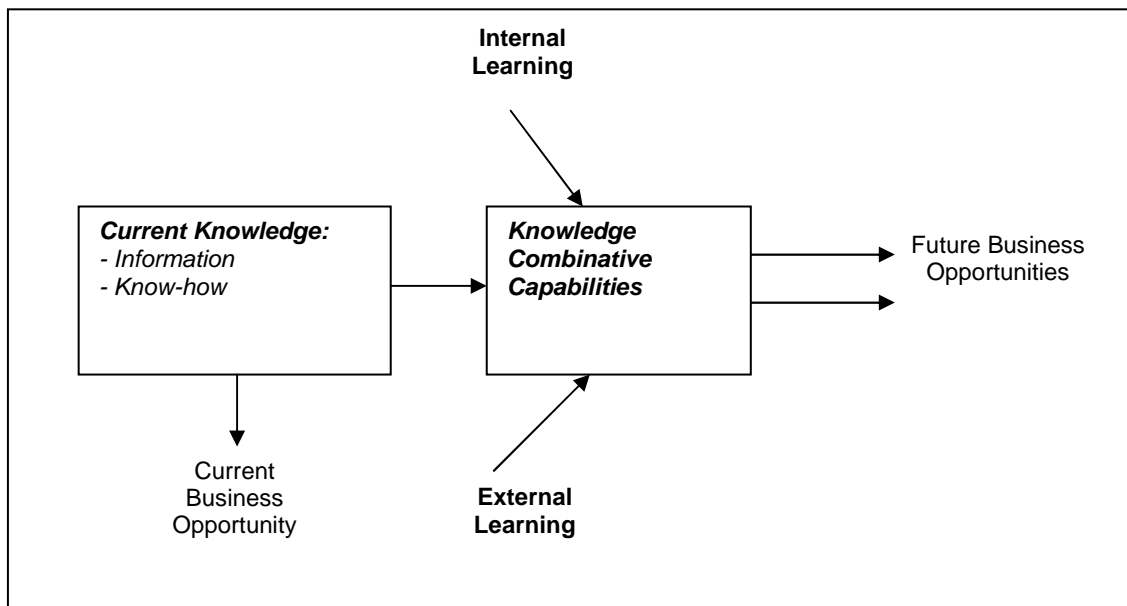
The seminal work of Kogut and Zander (1992) considers knowledge in an organizational context and, regarding the question “what is knowledge?”, they identify two knowledge categories:

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.”

Thus “organizations ‘know’ something”, and this knowledge has “persisting effects” on 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 1.

Figure 1

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 and Duguid, 1991; Nonaka, 1994; Romer, 1995). The underlying feature behind tacit knowledge is that individuals and organizations appear to know more than they can explain. Tacit forms of knowledge, usually related 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).

Szulanski (1996) relates the above organizational knowledge issues to the development of distinct competences and the dissemination of best practices (i.e., organizational capabilities). He states that: “Practice refers to the organization’s routine use of knowledge and often has a tacit component, embedded partly in individual skills and partly in collaborative social arrangements.”

Knowledge Creation

This body of literature deals with how knowledge is formed in organizations, and brings together research from areas of learning behavior, innovation and teamwork. For example, Edmondson (1999) investigates learning behavior in work teams within manufacturing companies. She discusses the fact that the organizational 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 conceptualization of learning as a process and using the term “learning behavior” to avoid confusion with learning outcomes such as greater understanding. 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 organizational learning literature and identifies five main learning processes through which

knowledge is acquired by organizations. The first three of these learning processes are particularly relevant to the supply chain context:

1. Congenital learning: “Organizations do not begin their lives with clean slates [...] An organization’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 organization’s “starting knowledge”.
2. Experiential learning: “After their birth, organizations acquire some of their knowledge through direct experience”. Such “learning by doing” leads to the development of higher levels of individual and organizational competence (Levitt and March, 1988). Also related to experiential learning are issues of appraisal and feedback and “single-loop” and “double-loop” learning (Argyris and 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 [by] borrowing from other organizations is one form of organizational 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, although vicarious learning by imitation is perhaps less so.

Another potentially useful example from the knowledge creation and acquisition literature is McGrath (2001), who argues that exploratory learning behavior results in the creation of new organizational knowledge which 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 organizational “slack” in the creation of innovative knowledge. Their central research focus is: “if slack is a form of inefficiency but also essential for innovation, organizations 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 on how organizations adopt knowledge that is developed outside their own realms. The work of Cohen and Levinthal (1990) is widely cited in this area; they argue that the “ability of a firm to recognize 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.

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, and 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”. Dussuage et al. (2000) note that organizational theorists “have long recognized 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

The inter-firm knowledge transfer literature, which is often closely linked to that of knowledge adoption, considers how knowledge is transferred between companies. Ingram and Baum (1997) investigate the relative competitive benefits an organization 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 on the risk of organizational failure of hotel chains, and finds that internally-focused organizational learning is beneficial up to a point, but beyond that it can be detrimental and further knowledge needs to be sought from outside the organization.

On the other hand, organizations 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 on organizational outcomes and the effectiveness of knowledge flows through such networks. He considers the influence on 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) find empirical support for the knowledge flows associated with both direct and indirect ties having positive impact on performance, but they find that “structural holes” have a negative effect on collaborative performance. This is analogous to the empirical evidence in favor of supply chain collaboration.

Mowery et al. (1996) empirically examine inter-firm collaborative knowledge transfers within strategic alliances. They reflect on a “capabilities acquisition” view of firm strategy that focuses on the acquisition of new capabilities through organizational 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.

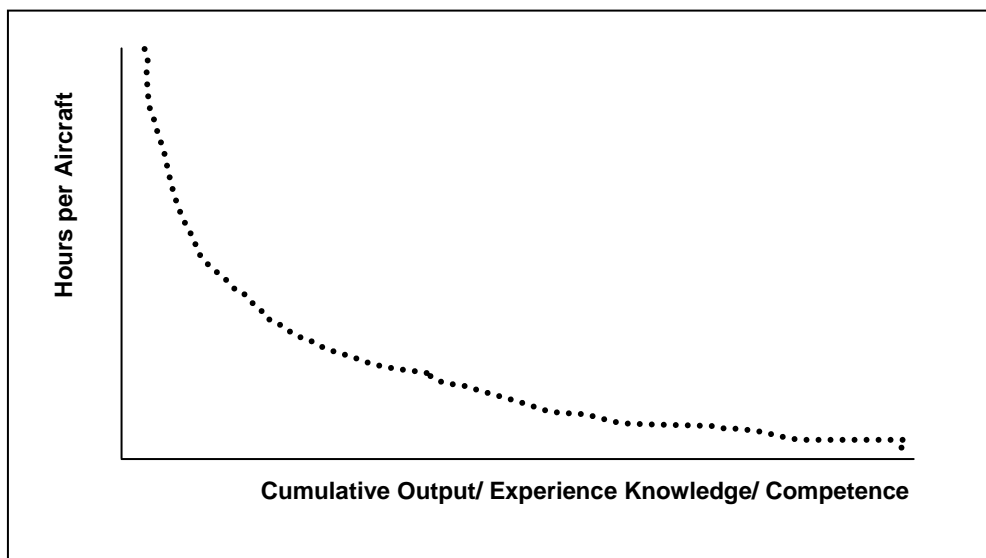
Knowledge Evolution

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 organizational learning curve or experience curve, whereby improvements in the way things are done (e.g., faster, fewer 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 labor hours required to produce each subsequent aircraft reduces as experience is gained. However, the learning rate 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 organizations, and is shown in Figure 2, although the rates of organizational learning can vary considerably between organizations.

Figure 2

The learning curve



March (1991) introduced the famous trade-off between “exploiting” existing knowledge, and “exploring” new knowledge. In other words, due to uncertainty surrounding the organizational knowledge exploration process, many companies are more inclined to opt for the apparent “sure thing” of exploiting existing internal organizational knowledge to improve relative

performance and competitive advantage. Given limited resources, mechanisms of “mutual learning” between organization 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.

Related to this need to carefully balance internal exploitation and external exploration is the research on “competitive inertia”. In essence, Miller and Chen (1994) find that good past performance contributes to competitive inertia and find limited evidence that competitive inertia is associated with short-term performance. Nevertheless, they conclude that more mature organizations could avoid such problems, because “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) recognize that, although on the one hand applying existing knowledge might make the organization better, on the other hand it might also make it “myopic” to the longer run and larger picture. Despite such negative mechanisms, Levinthal and March (1993) still believe that organizational knowledge and learning are important and can be beneficial, as long as their management maintains “an appropriate balance between exploitation and exploration”.

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.

Knowledge Management in the Supply Chain Context

Knowledge management and organizational 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 organizational learning and inter-firm knowledge management specifically between supply chain partners is apparently limited. Also, despite clear parallels, cross-fertilization between supply chain and knowledge management literatures appears to be rare.

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 who 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 limited work on knowledge and learning in supply chains falls broadly into two groups:

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

Bessant et al. (2003) combine both knowledge management and supply chain perspectives to explore knowledge and learning beyond the boundaries of the individual firm. They 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. Bessant et al. (2003) 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, focused 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. (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) emphasize the importance that knowledge management and organizational learning will have on building and sustaining future supply chain competitiveness.

6. Conclusions and Suggestions for Future Research

To address the fundamental question “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 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.

An important conceptual gap in the literature is identified as presenting potential barriers to the continued evolution of supply chain theory and practice. The review found a recognition among researchers that much of the existing literature is limited to analyzing efficiency of assets, data and information flows. Furthermore, the review identified that many organizations 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.

These findings indicate that to “advance along the evolutionary continuum”, supply chain integration needs to move to supply chain collaboration, through understanding supply chain management concepts in the real world and exploring knowledge base concepts from knowledge management literature. Concepts of integration and collaboration are fundamental to the evolution of supply chain management theory and practice.

This synthesis of literature explores the gap in supply chain understanding through the adoption of relevant theories and concepts, particularly from the knowledge management stream of literature, thus answering calls from operations management and supply chain researchers to bring new perspectives into the field. Many of the 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.

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.

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