

Research paper

Knowledge redundancy in supply chains: a framework

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Supply chain management, Knowledge management, Customer satisfaction

Abstract

Knowledge redundancy is a powerful concept in understanding supply chain performance including supply chain value creation and competitive advantage. This paper argues that knowledge redundancy is not about "redundancy" that might suggest a waste or duplication of knowledge. In contrast, knowledge redundancy between adjacent members of the supply chain is critical to superior supply chain performance. The paper examines the tacit and explicit nature of knowledge and knowledge redundancy in supply chains. It develops a conceptual model and a series of propositions that argue that managing knowledge redundancy in the context of supplier-related factors, firm-related factors, and interface-related factors can bring positive supply chain performance outcomes.

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1. Introduction

For many years, academic researchers and practitioners have focused on knowledge management in general (Leonard-Barton, 1995; Nonaka and Takeuchi, 1995) and, more specifically, knowledge management in the interface of organizations (Grant and Badden-Fuller, 1995). Inter-firm knowledge has been considered an important antecedent for a number of organizational performance dimensions such as productivity, effectiveness, efficiency, and so on (Dyer and Singh, 1998). One influential construct in this domain is *knowledge redundancy* (Rindfleisch and Moorman, 2001). By definition, the word "redundancy" conjures up images of duplication and waste created in the pursuit and mastery of knowledge by intra- or inter-firm team members (Leonard-Barton, 1995). Although such an assessment may be true in some contexts, in the context of supply chain management, nothing is farther from the truth. Unless supply chain members have a great deal of knowledge redundancy with the next link in the chain, businesses cannot operate effectively. Therefore, management of knowledge redundancy is essential to the activities in and superior performance of supply chains.

Although researchers and practitioners have examined constructs such as knowledge (Nonaka and Takeuchi, 1995), knowledge redundancy (Rindfleisch and Moorman, 2001), and supply chain performance (Cachon and Fisher, 2000), they have neglected to combine these ideas into a single framework. The literature is silent on what knowledge redundancy can do for buyer-seller relationships in supply chains. This is surprising given that understanding and managing knowledge redundancy can significantly improve supply chain performance, customer value, and competitive position for the members of the supply chain. In addition, there have been growing calls for introducing more rigor in research related to supply chains (Mentzer *et al.*, 2001) and for more studies on learning perspectives on supply chains (Hult *et al.*, 2000).

To alleviate these important gaps in the literature, we offer a conceptual framework that delineates the various manifestations and implications of knowledge redundancy in supply chains. Our research aims to contribute to academic research as well as management practice. By providing a comprehensive look at the manifestation of knowledge redundancy, we advance the understanding of inter-organizational

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dynamics and improve managerial understanding of knowledge management in the inter-organizational space. Examining our framework will allow businesses to set guidelines for optimal configuration of knowledge to achieve superior results in supply chains. In addition, our research answers the call for greater conceptual rigor in supply chain research (Mentzer *et al.*, 2001).

The rest of the paper is organized as follows. In Section 2, we introduce and define the elements that constitute our research domain (the nature of knowledge and technology, knowledge redundancy, and the role of knowledge redundancy in supply chains) and propose a framework for considering the role of knowledge redundancy in supply chains. In Section 3, we present research propositions concerning the antecedents and consequences of knowledge redundancy in supply chains. In Section 4, we conclude the paper by delineating the implications of our work for managerial practice and academic research.

2. Conceptual background

2.1 Nature of knowledge and technology

A firm's "know-how", or the knowledge it requires to conduct its business successfully, is made up of a complex package of manufacturing, technological, marketing, and management competencies (Madhok, 1996). According to Gardner *et al.* (2000), technology is simply a way of doing something; according to this view, technology is the "know-how" or information required to produce and sell a product or service. In a similar vein, Capon and Glazer (1987) treat technology as a subset of know-how, defining it as the information needed to produce and market a product or service. According to some researchers, technology includes all forms of knowledge, skills, and information (Dunning, 1988); others treat "knowledge" and "technology" as synonyms (Millman, 1983). In our discussion, we will use the two terms synonymously.

2.2 Tacit and explicit knowledge

Polanyi (1967) first articulated the distinction between "tacit" and "explicit" knowledge. Tacit knowledge is personal, context specific, and difficult to communicate (Nonaka and Takeuchi, 1995), while explicit knowledge can be codified and transmitted easily. For instance, explicit knowledge for cathedral building would include the templates and practical geometric notions that masons and artisans would use to explain, plan, and execute the task (Turnbull, 1993). The tacit knowledge of cathedral building would include

skills such as the artisan's knowledge of exactly how hard to hit a stone without cracking it (Turnbull, 1993). While objectivity is the hallmark of explicit knowledge, tacit knowledge is characterized by subjectivity.

2.3 Knowledge redundancy

Discussions of knowledge redundancy by researchers such as Granovetter (1973) and Rindfleisch and Moorman (2001) have taken the "strength of ties" perspective. The simple notion that strong ties will promote high knowledge redundancy and weak ties will promote low redundancy has been at the core of our understanding of knowledge redundancy and its implications. Rindfleisch and Moorman (2001) were the first to measure knowledge redundancy in the context of competitor alliances. We take a more direct and broader approach to understanding knowledge redundancy, descending to the locale of work at adjacent points of supply chains. We argue that knowledge redundancy should not be avoided, but indeed managed, as supply chains cannot function effectively without knowledge redundancy.

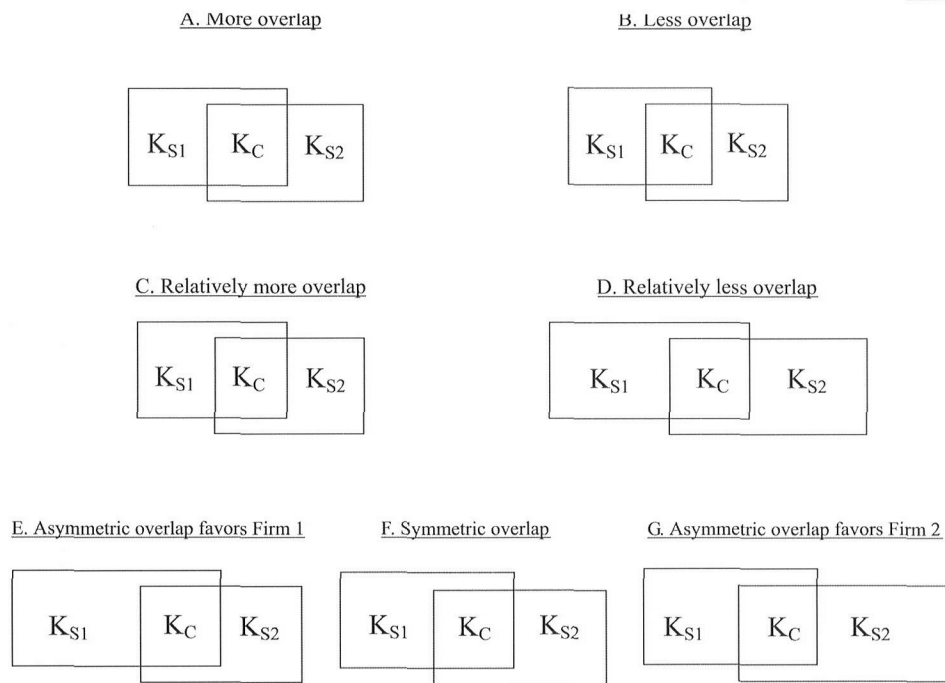
Given that no extant research examines in detail the manifestation and measurement of knowledge redundancy in the supply chain context, we offer an approach for visualizing of the concept. To better delineate the manifestations of knowledge redundancy, let us consider two adjacent firms in a supply chain. The knowledge of these firms can be manifested in several ways as shown in Figure 1. We can visualize three specific kinds of knowledge: knowledge that is common between firms, or knowledge redundancy, denoted K_C ; knowledge that is specific to firm 1 (but not possessed by firm 2), denoted by K_{S1} ; and knowledge that is specific to firm 2 (but not possessed by firm 1), denoted by K_{S2} . Our understanding of knowledge redundancy must incorporate several alternative manifestations, which are shown in Figure 1. We argue that the manifestation of knowledge redundancy between firms must be looked at from three interrelated but different perspectives:

- (1) the amount of knowledge overlap;
- (2) the amount of knowledge overlap relative to the total knowledge base; and
- (3) the nature of asymmetry in the specific knowledge of the firm.

We now describe these ideas, using Figure 1 as a guide.

The figures in the top row delineate the amount of knowledge overlap: knowledge redundancy is greater in scenario A than in scenario B, while the specific knowledge of the firms is the same in both cases. The two figures in the middle row (scenarios C and D) illustrate the notion of relative

Figure 1 Manifestations of knowledge redundancy in supply chains



Note: 1 denotes firm 1; 2 denotes firm 2; C denotes knowledge common to both firms; S denotes knowledge specific to a given firm

knowledge redundancy. Although the amount of knowledge redundancy is the same in C and D (denoted by the area represented by K_C), scenario C represents relatively more knowledge redundancy than scenario D. In other words, $K_C/(K_{S1} + K_{S2})$ is greater in scenario C than in scenario D; alternatively, $K_C/(K_{S1} + K_C + K_{S2})$ is greater in scenario C than in scenario D. Such relative overlap can have important implications for the performance of supply chains.

Finally, the three figures in the bottom row (scenarios E, F, and G) represent the asymmetry that can manifest itself in knowledge between firms. Although the absolute amount of knowledge overlap and even the relative knowledge overlap may be the same in all three scenarios (i.e. the size of K_C is the same for scenarios E, F, and G; similarly, $K_C/[K_{S1} + K_{S2}]$ and $K_C/[K_{S1} + K_C + K_{S2}]$ may also be the same for the three scenarios), the nature of firm-specific knowledge is different. For example, in scenario F, the specific knowledge is the same across the two firms. This represents a symmetric distribution of knowledge. However, comparing scenarios E and G, firm 1 has more specific knowledge than firm 2 in scenario E; the situation is reversed in scenario G. In scenario E, the asymmetry in knowledge favors firm 1 while it favors firm 2 in scenario G. Therefore, to understand inter-firm dynamics in supply chains,

knowledge redundancy must be considered and its manifestations understood via all these dimensions.

2.4 Role of knowledge redundancy in supply chains

Although “redundancy” may suggest knowledge that is superfluous, such redundancy is, in fact, a crucial asset in the context of supply chains. Unless knowledge held by buyer and seller overlaps, they are incapable of working together. At an operational level, unless a supplier has some knowledge redundancy with the buyer, the buyer is unlikely to enlist the supplier in the first place. Thus, suppliers are enlisted only when there is knowledge redundancy with the business-market buyer (Jackson and Pride, 1986).

When we view buyers and suppliers as members of a value chain, it becomes clear that the end consumer (the last point in the supply chain) can have knowledge redundancy with the retailer. For example, retailers have some knowledge of consumer preferences to plan marketing activities such as special promotions, placing products on particular shelves, and having a well-articulated return policy. In turn, the customer may have some knowledge and trust in the retailer to buy a new or existing product. At the last point (B-to-C) of the supply chain, the nature of knowledge redundancy

is relatively superficial. The consumer, for example, does not know how the retailer's reordering system works, how many other suppliers might supply similar products not currently on the shelf, and so on. In this paper, we focus on knowledge redundancy in business-to-business interfaces, *excluding* the interface with the end consumer.

2.5 A model of knowledge redundancy in supply chains

As knowledge redundancy is a *sine qua non* of supply chain relationships, managing supplier knowledge redundancy becomes a major task of proactive supply chain managers. For example, managers need answers to the following questions:

- (1) "What are the factors that influence the extent and nature of knowledge redundancy?"
- (2) "How can organizations foster the appropriate knowledge redundancy in buyer-seller relationships?" and
- (3) "What are the consequences of knowledge redundancy for organizations?"

Given that knowledge redundancy has not been examined previously in the context of supply chains, our objective is to offer an exploratory description of the topic through research propositions that link knowledge redundancy and supply chain characteristics. Figure 2 presents a conceptual model of knowledge redundancy in supply chains and will function as an organizing framework for the propositions that follow. The framework recognizes the central role of knowledge redundancy in supply chain relationships. However, knowledge redundancy is neither the ultimate performance outcome nor an exogenously determined starting point in supply

chains. That is, organizations will be able to proactively create and sustain knowledge redundancy and such knowledge redundancy, in fact, can help to achieve the desired organizational performance. Thus, our framework, for the first time in the literature, puts knowledge redundancy in the overall context of supply chains and makes a contribution to the domains of supply chain research and knowledge management research.

The model proposes that a number of antecedent factors shape the amount and type of knowledge redundancy. These antecedent factors include factors related to suppliers, factors related to both the buyer and the supplier, and factors related to the buyer-seller interface. The model also recognizes that knowledge redundancy does not exist in a vacuum but with the specific objective of the desired consequences viz. improved performance, superior customer value, and competitive advantage. Although the importance of factors included in this framework to the firm have been well established in the literature, we believe that this is the first research that tries to link the notion of knowledge redundancy with supply chain issues.

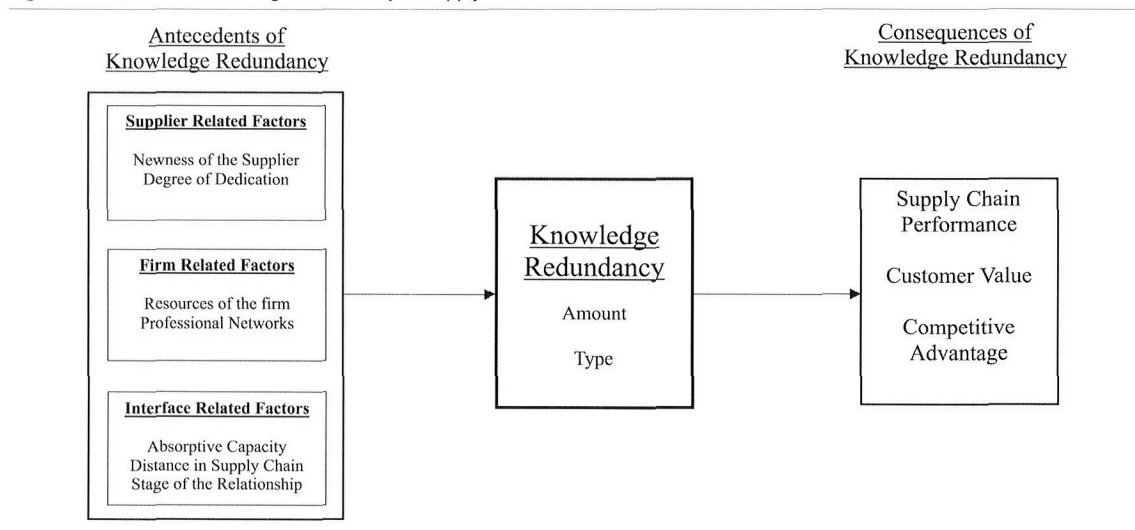
3. Research propositions

3.1 Supplier-related factors

3.1.1 Newness of suppliers

A new supplier can be expected to have lower total knowledge redundancy with a firm compared to the knowledge redundancy between existing suppliers and the firm. We might expect that existing suppliers, through their lengthy business relationships, would have developed a large knowledge redundancy, particularly of a tacit kind.

Figure 2 A model of knowledge redundancy in supply chains



It thus becomes necessary for a new supplier with the same technology to offer price discounts (Wathne *et al.*, 2001) to gain entry as a supplier, as there is no other differentiator in the realm of explicit knowledge redundancy. Entrenched suppliers may continue to be dominant even with higher prices, simply because their tacit knowledge redundancy is perceived by the buyer to have substantial value.

New suppliers competing with similar product offerings have difficulty entering business markets. Such products involve low customization, low tacit knowledge content, and are amenable to bidding at "reverse auction" Web sites (Grewal *et al.*, 2001). In other words, such products are not candidates for a coordinated supply chain approach. In contrast, a product or service that is part of an evolved supply chain is difficult to dislodge simply because the links in the chain are those of tacit knowledge redundancy, and have taken several years to develop and fine-tune. The competitive advantage of the entrenched supplier is thus one of tacit knowledge redundancy, which cannot be easily replicated by a new supplier.

- P1. Knowledge redundancy is greater for existing suppliers than for new suppliers.
 P2. The difference between a firm's knowledge redundancy with existing supplier and the firm's knowledge redundancy with new suppliers will be greater for tacit knowledge than for explicit knowledge.

3.1.2 Degree of dedication of the supplier

A dedicated supplier, as in the case of the auto industry, has maximum knowledge redundancy with the firm. Thus, an exclusive, ancillary steering-wheel supplier might supply only to a particular Ford Motor Company plant. Clearly, such a supplier can be expected to be efficient and to be almost as internalized and domesticated as a company department (Arndt, 1979); knowledge redundancy will be at a maximum between the supplier and Ford. Dedicated suppliers have the advantage of protecting knowledge but suffer from the lack of variety in what that they can bring to the relationship (March, 1996). Lower knowledge redundancy brings variety and is promoted when the supplier supplies to other firms in the same industry. Knowledge redundancy reduces when suppliers supply to other industries and are able to bring in the learning and knowledge of those industries to the buyer (Hargadon, 1998).

- P3. Knowledge redundancy between the firm and the supplier will be *highest* when the supplier is a dedicated supplier to the firm, *moderate* when the supplier supplies to several companies in the same industry, and *lowest* when the supplier supplies to firms in different industries.

3.2 Factors related to buyer and seller firms

3.2.1 Resources of the firms

Organizations such as large consulting companies have been called "knowledge brokers" (Hargadon, 1998). These organizations are able to develop and maintain large databases of explicit knowledge on particular issues relating to individual industries. For example, Hargadon (1998) studied multi-divisional firms like Hewlett-Packard and Boeing and big consultancy firms such as McKinsey and found that these organizations have systems in place to access, learn, link, and implement knowledge solutions from across previous experiences. The experience of capturing and retrieving explicit knowledge turned out to be much more "humbling" than originally envisioned. Respondents considered such databases as a kind of "yellow pages", simply because the searchers did not know what they were looking for (Hargadon, 1998, p. 221). The ability to identify, retrieve and re-deploy a prior solution in a different context required human contact, interaction, and networking. However, large and resourceful organizations are able to carry out this networking effectively (Hargadon, 1998).

- P4. The larger the resources of the partner firms in a supply chain, the more effective the management of knowledge redundancy will be.

3.2.2 Commonality of professional networks

Professional networks, such as a business-to-business "vertical-net" network (Narayandas, 2000), allow members of an industry to share information with each other and to keep industry practices current at the company level (e.g. clothing manufacturers). Industry networks also thrive in contexts that are industry specific, such as trade shows and skill-based groupings (e.g. Product Development and Management Association, American Marketing Association) that promote particular skills (such as new product management and marketing, respectively). When buyers and sellers are members of similar networks, knowledge redundancy increases in their practice; as a result, benefits of enhanced knowledge redundancy, such as improvements in quality and cost reduction, become possible (Cannon and Homburg, 2001).

- P5. The greater the common membership in professional networks, the greater the knowledge redundancy.

3.3 Factors related to buyer-seller interface

3.3.1 Knowledge redundancy and initial supply chain relationships

Business buying theory suggests that a supplier must have specific technological capabilities to

qualify for consideration as an exchange partner (Robinson *et al.*, 1967). Industries differ in the rigor of supplier qualification processes in place. The purpose of screening is to enhance the fit between the buying organization and supplying organization. Once approved, the supplier commences supplies and is monitored by the buyer for performance on cost, quality, timeliness, technology, and so on. Coterminous with supplier selection is the process of relationship building through phases (Dwyer *et al.*, 1987). We argue that because relationship awareness sets in at the supplier selection stage of the business process, a minimum amount of knowledge redundancy between buyer and seller is required. Thus, in the auto industry, a prospective seller of electronic components must be able to show the seller some evidence of existing business of an allied product line. In this case, both buyer and seller view prior seller experience as a knowledge redundancy platform from which to commence a relationship. However, both also realize that in the absence of an established relationship, the buyer's expectation of tacit knowledge redundancy is less than its expectations of explicit knowledge redundancy. Initially, at the selection and start of the relationship, the supplier goes through a "honeymoon" period in which the expectation of tacit knowledge redundancy is low. The supplier is given time to get used to dealing with the supplier and to systems, procedures, equipment and technical people at the buyer's factory. Until such a familiarity develops, tacit knowledge redundancy will be low.

- P6. For a business-to-business relationship in a supply chain to start, a minimum level of knowledge redundancy must exist between adjacent members of the supply chain.
- P7. For a business-to-business relationship to start, the minimum level of knowledge redundancy required is greater for explicit knowledge than for tacit knowledge.

3.3.2 Stage of the relationship

Once a buyer-seller relationship commences, knowledge redundancy increases, as buyer and seller representatives interact, and as operations are streamlined and business processes are aligned. For instance, installation of supply chain software calls for a deep understanding and knowledge redundancy between supplier and buyer processes; computer programs must recognize that the same machine part has different codes at the buyer and seller factories. Increases in knowledge redundancy between the buyer and seller organization occur as both parties "develop" their relationship (Dwyer *et al.*, 1987). Increasing knowledge redundancy translates into more

aligned business processes, thereby enhancing productivity in the supply chain. Thus, for example, a buyer will no longer have to send a series of faxes to inform the seller of a change in production planning. Instead, it is possible for the supplier to view the buyer's production plan and make changes accordingly.

If a task is routine, then explicit knowledge redundancy is strongly related to efficiency in the supply chain. Routine tasks tend to be well documented, equipped with clear procedures to deal with possible deviations. These documentations, such as computer codes and similar systems, allow for a major increase in efficiency. However, a complex, non-routine task is difficult to codify; thus, knowledge redundancy assumes a more tacit nature. A complex, non-routine task might be a new problem at the next point in the supply chain. To deal with such a problem, tacit knowledge redundancy becomes increasingly necessary. Extending this situation to supply chains, tacit knowledge redundancy between supply chains' adjacent members can help to solve problems between adjacent supply chain members and those at more distant points.

- P8. As the relationship between supply chain members becomes more mature, the amount of knowledge redundancy increases.
- P9. The greater the knowledge redundancy between adjacent supply chain members, the greater the efficiency of operations.

At the pre-relationship and awareness stages of a buyer-seller relationship, a capability assessment is made, in part, on the basis of written explicit documents (Cannon and Perreault, 1999). For example, the buyer may publish a tender document listing detailed technical specifications required for an industrial product or service. The seller, new to the relationship, would respond to items on the tender document that typically ask for explicit evidence of knowledge (e.g. software purchase). At initial tender meetings, the seller might produce written references from other customers to establish its knowledge redundancy, at least at the explicit level. At the initial stages of the business relationship, clearly explicit knowledge and its redundancy will be more in evidence (Slater, 1992).

- P10. The earlier the stage of inter-firm relationship in a supply chain, the higher the redundancy in explicit knowledge (relative to tacit knowledge).

In later stages of the relationship, when both buyer and seller have experience working with each other, knowledge redundancy will begin to assume a more tacit nature. Employees will frequently

resolve technical problems at the operational levels; many problems might not be even documented. Such a phenomenon is highlighted by Orr (1990), who found that Xerox technicians had to deal with unknown computer codes generated by faulty machines in customer premises. The technicians learned to resolve such problems based on their prior experience of taking feedback from both the customer and their own community of practice (Brown and Duguid, 1991). A similar phenomenon is noted in the Japanese automobile industry where supplier relationships are long-term and more well coordinated (Takeishi, 2001).

P11. The later the stage of inter-firm relationship in a supply chain, the greater the redundancy in tacit knowledge (relative to explicit knowledge).

3.3.3 Absorptive capacity

Absorptive capacity refers to the ability of the firm to absorb new knowledge (Cohen and Levinthal, 1990). Absorptive capacity applies to both the upstream supplier and the downstream buyer. Both must have a core level of knowledge redundancy crucial to the absorptive capacity of each other. This includes an understanding of the knowledge processing routines of each other and an awareness of technical developments in the environments surrounding each member. If the absorptive capacity is high in the relationship, following Lane and Lubatkin (1998), one would expect supply chain members to bring fast-developing but new technology to the relationship. Such awareness will lead to competitive advantage for the entire supply chain. In fact, new knowledge redundancies will develop as both parties gain a deeper understanding of the dimensions of the new technology.

Absorptive capacity is knowledge domain specific and "path or history-dependent" (Cohen and Levinthal, 1990, p. 136). Unless the parties take a sustained interest in remaining current, they can be "locked-out" from recognizing a new opportunity. In addition, to quote Reich (1987) "... each new generation of technology builds on that which came before, once off the technological escalator it's difficult to get on" (Cohen and Levinthal, 1990, pp. 136-7).

P12. The greater the absorptive capacity in the supply chain relationship, greater the knowledge redundancy and greater the openness to new information, and greater the competitive advantage.

3.3.4 Distance in the supply chain

Business marketing research suggests that, in practice, most industrial firms have only a sparse

knowledge of how their product or service is used downstream (Cannon and Homburg, 2001). For example, a typical hardware item manufacturer, such as a wood-screw maker, might not have a precise knowledge of all the screw's applications nor its exact requirements for the same. This is typical of low-value items that find their way to supply chains via retailers (e.g. Home Depot and its sales to contractors).

P13. As the distance between the supply chain members increases, knowledge redundancy decreases.

Adjacent members of the supply chain interact and learn from each other and, in the process, increase their tacit knowledge redundancy. They transact orders, supplies, and payments with each other and have many mundane reasons to interact. These interactions result in increasing knowledge redundancy between them. With experience and greater involvement, tacit knowledge redundancy increases rapidly and becomes sticky at the buyer's site (Ogawa, 1998). In contrast, non-adjacent members have few routine reasons to interact with each other. Without such interactions, development of tacit knowledge redundancy is impaired.

If we examine network-based knowledge, we find that information sharing at the network level is explicit (such as an industry member sharing information at a Web-based business-to-business portal). To participants in such knowledge sharing, knowledge is explicit and similar to know-how shared between rivals, which are typically industries at the same point in a supply chain (von Hippel, 1987). The information shared in this manner still must be adapted and modified by adjacent supply chain members before it can become tacit knowledge.

P14. As the distance between supply chain members increases, tacit knowledge redundancy decreases.

P15. As the distance between supply chain members increases, explicit knowledge redundancy decreases.

P16. As the distance between supply chain members increases, tacit knowledge redundancy decreases at a higher rate than explicit knowledge redundancy.

4. Conclusions and discussion

Our research offers a useful framework for academicians and practitioners to think about researching and managing knowledge redundancy in supply chains. We conceptually examined the nature of knowledge redundancy, and its critical

importance for supply chain performance. We developed a conceptual model and a series of propositions that argue that managing knowledge redundancy in the context of supplier-related factors, firm-related factors, and interface-related factors can bring positive supply chain performance outcomes. There are several research and practical implications of our research.

First, given that knowledge management issues have been rarely addressed in the context of supply chains, empirical verification of our framework presents a number of challenges. Despite the frequent use of the construct of knowledge redundancy, there have been limited attempts to develop measurement scales. For example, reliable measures are yet to be developed to measure the sub-components of knowledge redundancy, such as amount of redundancy, knowledge redundancy relative to specific knowledge, and the potentially asymmetric nature of knowledge redundancy. The next challenge is to identify the unit of analysis. Clearly, the interface between two firms is the domain of our work. However, given that a supply chain is a system of such interfaces, it might be useful to note that every firm is in a multitude of supply chains which make it much more like a network; however, for conceptual clarity and empirical simplicity, the analysis may focus on a single supply chain or dyad.

The second issue that must be addressed is how the role of knowledge redundancy changes are based on the context of the interface. For example, intuitively we can surmise that the role of knowledge redundancy will be different between routine activities, new product development, quality control, and so on. Also, global supply chains involving not only the supply of products but also supply of high-tech services like outsourced software and call centers, pose special research opportunities and challenges.

Third, while conceptualizing knowledge management issues in a single supply chain is accomplished rather easily, understanding and modeling knowledge redundancy in a firm's entire value chain system, spanning several countries simultaneously would be significantly more involved. While this complexity is perhaps the reason why supply chain issues have not been examined in a theoretically rigorous manner, for effective supply chain management, these issues must be resolved based on conceptual logic as well as empirical testability.

Finally, managers should not underestimate the tremendous value of the tacit knowledge redundancy that a long-standing partner brings to a supply chain relationship, particularly in a global Internet connected market. Simultaneously, managers should also encourage existing suppliers to take interest in developments occurring at different points of the supply chain.

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