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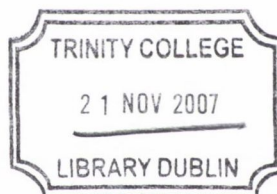
A TYPOLOGY FOR STRATEGIC SUPPLY-CHAIN MANAGEMENT:
BRIDGING THE GAP BETWEEN OPERATIONS AND STRATEGY

KATE PHILLIPS CONNOLLY

Submitted in fulfilment of the requirements for the degree of

DOCTOR IN PHILOSOPHY

School of Business
University of Dublin
Trinity College
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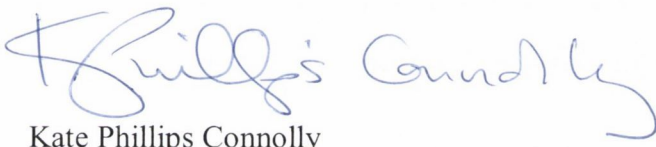


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Kate Phillips Connolly

THESIS SUMMARY

Research Problem

Over the last decade, supply-chain management (SCM), a field that emerged from the operational areas of purchasing and logistics, has become a focal area in business studies. However, efforts to move SCM from an operational to a more strategic perspective typically stop at the design, or operations strategy level, and it has proven difficult to move SCM to a strategic perspective. Led by operations and operations strategy researchers and practitioners, tremendous efforts have been made to develop management tools for the strategic adoption of SCM. However, despite findings of substantial benefits accruing to those firms that do develop their SCM capabilities, researchers report very low take-up of strategic SCM. This research explores the apparent paradox of the poor take-up of a strategic tool that has had high-profile success, and attempts to further the evolution of SCM theory.

Methods and Procedures

The research problem is essentially a paradox in a relatively new field, with a nascent level of theory. A grounded-theory approach, encompassing an extensive literature review, industry study, focus group, expert interviews, case studies and follow up with the original focus group, was used.

The broad literature review led to the identification of the theory groups of knowledge, power, and governance as key concepts for understanding and explaining SCM. Next, an inductive, multi-level, empirical research process across the focal industry (the high-technology medical device industry) yielded a portrait of SCM in practice. Finally, integrating a model of industry trajectories with SC models of knowledge, power and governance, a typology of SC types was developed and applied to the device industry.

Findings

The key findings of the research can be summarised as:

- A SCM typology (Integration, Mediation, Reactive Segmentation, and Efficient Segmentation) based on industry characteristics, that integrates both operational and strategic elements into a theoretically sound and functionally practical basis for strategic SCM;
- Development of a theoretical framework, based on the theory groups of knowledge, power and governance, for the understanding of SCM;
- Identification of the importance of industry factors in developing a SCM strategy;
- Further evidence of the limitations of the paradigm of maximum integration in SCM.

Conclusions

This research bridges the gap between the operationally-focused view of SCM and a strategic perspective, through a new typology that brings together several strands of nascent SC theory, with a particular focus on knowledge, power, and governance, and then brings in strategic theory through the industry perspective. The integration and extension of these works into a new typology not only extends the current level of SC theory, but also has immediate and powerful practical applications.

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- Fabian Armendariz, a natural teacher, whose formidable understanding of the research process has materially improved my own; and
- Mr. Aidan Connolly, who never once doubted.

DEDICATION

*To Deirdre Lyons Connolly,
who has led by example in her own work,
with respect and great affection.*

And

*To Katherine Dillon Connolly and Aine Boyer Connolly,
who have been in the trenches with me every step of the way.
You're simply the best...*

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CHAPTER 1:

INTRODUCTION

1.1 Introduction

Supply chain management (SCM) is the system-wide coordination of the flows of material, information, and money between firms in a value chain. It has been touted as the “coming thing” for more than a decade (Davenport, 2003). Instead of the standard value chain typically described in linear terms, SCM is supposed to connect the participants of a value chain in an efficient network of relationships and transactions that can reduce costs, improve customer service, develop the organization’s knowledge base, develop efficiency within the organization, and create barriers to entry for competing organizations (Fisher & Simchi-Levi, 2001; Simchi-Levi & Simchi-Levi, 2003). The business press regularly lionizes the handful of iconic names whose business strategy is fundamentally built on their SCM strategy (e.g., Dell, Ikea), or whose SCM practices are leading edge (e.g., Wal-Mart, Hewlett-Packard). The academic press has dissected various aspects of the SCM practices of the automotive, defence, and semiconductor industries. There is a tremendous range of “how-to” literature on implementing SCM, supported by studies that demonstrate the benefits of successful implementation. Both academics and industry agree on the need for and benefits of good SCM, and this agreement has taken the form of a number of integrated initiatives and partnerships [such as the supply chain (SC) groups at MIT, Stanford and Cambridge]. At the Stanford Global Supply Chain Management Forum, for example, participants from the School of Engineering and the School of Business come together with a group of approximately 30 companies, drawn from a range of industries and the Stanford Alliance for Innovative Manufacturing come together to identify, research, and disseminate best practices in

SCM. The business and academic sectors come together to develop theoretically sound and operationally practical approaches to SCM: surely the *ne plus ultra* of putting theory to work for business. The phrase that “the nature of competition is no longer firm against firm, but supply chain against supply chain” is widely quoted as either already true, or about to be true.

1.2 Research Concept

Given the consensus on the value of strategic SCM and the efforts to facilitate adoption of SCM practices, there is a surprising lack of strategic SCM in practice. Researchers and some practitioners are frustrated that despite good evidence of benefits and substantial support mechanisms, successful adoption of strategic SCM is in fact rare (Cook & Hagey, 2003; Deloitte Touche Tohmatsu, 2003; Poirier & Quinn, 2004; Simchi-Levi & Simchi-Levi, 2003). A recent study found that just 7% of firms were actually using SCM effectively (Simchi-Levi, Kaminsky, & Simchi-Levi, 2004); the inference is that 93% are either not doing it, or are not doing it very well. Another study noted that only 9% of the participating firms had made a full commitment to SCM—though these had realized a substantial benefit (Frohlich & Westbrook, 2001). Even in the leading joint initiatives, despite massive efforts and great individual success stories, both sides are finding it difficult to achieve the potential benefits of strategic SCM.

Why then, has SCM not spread more widely, more successfully, more strategically? There are many possible answers. The prevailing wisdom could be wrong: strategic SCM may not in fact be suitable for widespread application, because it is too difficult to be generally adopted, because it does not suit the structure of many industries, or even simply because the level of strategic planning implicit in SCM is not sufficiently prevalent in business. Or, the research could be wrong, and

strategic SCM is actually more widespread than reported. It has been noted that the language of SCM is so variable that multiple interpretations are not just possible but likely (Fawcett & Magnan, 2002): such different interpretations may result in inaccurate findings. Or, the research may be incomplete, with too much focus on the firm level, or within particular industries and thus not representative of what is happening at the industry level. Finally, there is the possibility that the gap between operations and strategy is hindering the development of strategic SCM: perhaps myopia is keeping executive-level management from seeing beyond the operational function to the strategic potential, as happened in the early stages of information technologies; or keeping SCM practitioners from seeing beyond the operational realities to the strategic level (Stock, 2002).

This research examines the disparity between what theory recommends and the (apparent) practice of SCM: in short, if strategic SCM is such a good idea, why aren't firms adopting it? Thus, the objective of the research is to explore the apparent disparity between SC orthodoxy and SC practice, and by doing so contribute to SC theory development and SCM practice.

1.3 Contribution

This research makes significant contributions to both theory and practice on several fronts. First, within the field of SCM there is a shortage of work integrating the practice of SCM with established business theory (Handfield, 2005; Ketchen & Hult, 2006). This work is unprecedented in its integration of multiple theory elements. It also brings together previously isolated models from three important theory groups: knowledge, power, and governance. This integration and embedding of theory is an important step in nascent theory development.

The work takes a further step in theory development by making an original and meaningful link between two fields of interest, strategic management and operations management. This is the “break away from the dominance of single disciplines” that has been called for in SCM theory development (Burgess, Singh, & Koroglu, 2006, p. 719), and contributes materially toward the evolution of SC theory from a nascent level to an intermediate level.

Finally, the work develops a typology of strategic SCs that provide a clear and constructive tool that is immediately available for practitioners to use to evaluate strategic SC options. This achieves the “goal” of theory creating “structured information that is readily accessible” (Melnik & Handfield, 1998, p. 311).

1.4 Scope

This research explores the dichotomy between theory and practice in the strategic use of SCM, with a specific objective of adding to the theoretical understanding of SCM. This requires an initially broad theoretical review, followed by more focused work. Therefore, the delimitation of the scope must paradoxically be both broad and narrow.

The area of interest is strategic SCM, which draws on elements of the fields of strategic management, operations strategy, and operations management, but is not fully contained within any of them. The distinction between operational and strategic levels of SCM is particularly salient.

The unit of analysis is the high-technology device industry. This industry provides a defined environment in which to explore the role of SCM and the competitive circumstances that may affect the use of SCM.

1.5 Definitions

Although the field of SCM is considered to be at a nascent level of theory (Harland et al., 2006, hereafter Harland), it has been more than a decade since New and Payne (New & Payne, 1995) lamented the lack of a good definition of SCs; 10 years later Gibson and Mentzer were still in “pursuit of a consensus definition” (Gibson, Mentzer, & Cook, 2005). Numerous efforts have been made to explicate and defend definitive SC terminology (as above; see also Tan 1998 and 2000 for good summaries on the efforts to create a unifying definition). For the purposes of this thesis, the following definitions that characterize the who, what, how and why of SCM will be used:

1.5.1 Supply Chain

The supply chain (SC) is the composite network of entities through which material flows as it moves along the value chain (Lummus, 1998; Harland 2001; Stannack, 1996).

1.5.2 Supply Chain Management

Supply Chain Management (SCM) is the management of the processes necessary for the operation of the supply chain (Tan 2001).

1.5.3 Strategic Supply Chain Management:

Strategic supply chain management combines the operational function of supply chain management with business strategy formulation in order to gain competitive advantage through the co-ordination and synchronization of actions (SODHI), (Chandra & Kumar 2000)

1.5.4 Supply Networks:

“Supply networks encompass the mess and complexity of networks, with lateral links, reverse links, two-way exchanges, and include a broad, strategic view...”. (Harland, 2001, p. 22; see also Mills, Schmitz and Frizelle 2004).

1.6 Structure of Thesis

This research used a grounded-theory process, which presents some challenges in the organization of the work. A strictly linear presentation does not reflect the reality of the process, yet a purely chronological presentation can be disjointed. The present work attempts to reconcile these two elements, and is presented in six stages that correspond to the evolution of the work.

Chapter 2 introduces the field of SCM, beginning with an overview of the evolution of the field, followed by a look at the levels of SCM, with particular emphasis on the operational and strategic levels. At the operational level the core types of SCs are introduced, while relevant theory groups for understanding SCM are introduced at the strategic level.

In chapter 3, the methodology of the research is developed, starting with a discussion of the use of grounded theory methodology, then outlining the five phases of the research. The findings from the primary data collection are presented in chapter 4, including the industry study, focus-group meeting, interviews, and case studies.

Analysis of these findings is presented in chapter 5, beginning with a cross-source review of the findings. Models applying the themes that emerge from the findings are then discussed in terms of their contribution to a theoretical and strategic understanding of SCM.

Building on the findings and analysis, a typology of SC types reflecting both an operational and a strategic level is developed in chapter 6. Chapter 7 applies the

SC type relevant in the focal industry to practice, providing validation of the findings. Finally, chapter 8 concludes the work, summarizing the findings of the research, and looking ahead to future work.

CHAPTER 2:

LITERATURE REVIEW

2.1 Introduction

A literature review typically serves to identify and integrate the extant literature in the focal field (Hart, 1998), providing a basis for understanding the research question and shaping the actual research to be undertaken (Bruce, 1994). However, there are particular challenges in reviewing the literature in a field that is at a *nascent* level of theory development: by definition the theory base is not well developed. There are further challenges in defining the scope of a literature review for an exploratory study, balancing the risk of overlooking a relevant vein of literature against the risk of a level of diffusion that will make it difficult to discern what is genuinely germane.

This review approaches the SC literature from three perspectives. It begins with an overview of the evolution of the SCM field, because the past is very much prologue in understanding current SCM theory and practice. Next, following a brief summary of extant work on SCM, major approaches to framing SCM are outlined. Third, existing linkages between SCM practice and theory, an area perceived as significantly underdeveloped (Burgess et al., 2006; Chen & Pauraj, 2004; Lambert & Cooper, 2000; Melnyk & Handfield, 1998; Meredith, 1998; Mills, Schmitz, & Firizelle, 2004; New, 1996; Storey, Emberson, Godsell, & Harrison, 2006), are considered. Finally, theoretical elements for understanding SCM are identified and summarized.

2.2 Evolution of SCM

SCM is the result of the fusion and evolution of two fields: distribution, which evolved into logistics, and purchasing, which grew into SCM, (Tan, 2002). The beginnings of what we now call SCM can be traced to the 1950s and early 1960s, through systems integration as well as the management of interorganizational operations through channels research (M. C. Cooper, Lambert, & Pagh, 1997). Coming out of World War II there was a suppliers market, and process control efficiencies were used to increase volume and reduce costs (Stonebraker & Afifi, 2004). Purchasing was essentially a service to facilitate production, and, along with distribution, was not seen as an area of strategic planning (Farmer, 1998). Management practices were still the rigid and top-down hierarchies of the 19th century (Stonebraker & Afifi, 2004). Trading relationships were win-lose, and there was little sharing of technology or expertise with customers or suppliers (Chandra & Kumar, 2000). Vertical integration was strong: ownership gave a level of control of the SC that allowed firms to obtain efficiencies and responsiveness without relying on other parties (Chandra & Kumar, 2000; LaLonde & Masters, 1994). In academic research the focus was largely on internal operations (Mills et al., 2004).

In the 1960s, as Europe and Asia recovered from World War II, Japanese and German firms broadened their market coverage, exposing the uneven quality and poor distribution systems in the United States and western Europe (Stonebraker & Afifi, 2004). This led to a shift from the internal focus of the 1950s and 1960s to a more dyadic view in the 1970s (Mills et al., 2004). The oil crisis of 1973 provoked a significant materials shortage (Farmer, 1998), which gave a new importance to sourcing and supplier relationships. Simultaneously, deregulation of the transportation industry (Ballou, Gielbert, & Mukherjee, 2000) made the coordination of product

movement more complex. Together these factors created a shift in the economics of transportation: some costs went up dramatically (particularly fuel) while the range of transport options broadened as new entrants came into the marketplace. Both the size and the suddenness of the changes brought the purchasing and logistics functions to a higher level of management focus, just as the Japanese approach to SCM began to enter western economies (Stonebraker & Afifi, 2004; Tan, 2002) and there was a reevaluation of operations practices. Basic materials-management concepts (such as material requirements planning) evolved, with the integration of functions (especially product design and manufacturing). Attention shifted to reducing work-in-process inventories and improving quality, product development, and delivery lead-time (Tan, 2000). Both the purchasing (upstream) and logistics (downstream) functions emerged as important cost-control centres, and the fields were increasingly professionalized (M. C. Cooper et al., 1997; Tan, 2000).

In the 1980s, driven by increasingly global operations, increasing customer demands, the deregulation of the telecommunications industry and the dramatic growth in information-technology (IT) capabilities (Tan, 2002), SCM began to move from a functional role to one that incorporated some planning or design of the SC. This evolution was accompanied by a change in nomenclature, with distribution and purchasing evolving into logistics and materials management. The close trading relationships found in Japanese manufacturing were also noted, and the potential benefits of strategic and cooperative buyer–supplier relationships were considered (Tan, 2000). The SC concept now extended into an external chain (Harland, 1996) and research broadened to include second-tier suppliers and the larger external chain (Mills et al., 2004).

By the 1990s SCM was recognizable in its current form. There was an emphasis on processes to improve efficiency and effectiveness, greater alignment of organizational structures with operational processes and more integration across interfirm boundaries (Chandra & Kumar, 2000; Tan, 2002). Operational approaches, such as enterprise resource planning, e-commerce, lean processes, and total cost of ownership became part of the parlance. Many of the iconic SC leaders—Wal-Mart, Ikea, Dell—emerged during this period. Simultaneously, the research focus broadened from the flow of material and information to product development and collaboration (Mills et al., 2004). Organizational relationships extended up and down the chain (Tan, 2000), with an increasing emphasis on strategic alliances (Chandra & Kumar, 2000) and partnerships (Harland, 1999): SCs were now supply networks (Harland, 1996).

Although SCM has evolved from a low-profile support function into a field with its own name and with aspirations of being a discipline in its own right, the integration of its antecedent elements—purchasing and logistics—is still in the early stages. Rather like the Rio Blanco and the Rio Negro that together form the Amazon, upriver they are still flowing side by side, even though the traders in the busy commercial town of Manaus see only one mixed river. These parallel tracks are evident in the SCM literature: a significant proportion of the work can be clearly identified as deriving from a purchasing/supply perspective, while a similar proportion come from a logistics/distribution perspective; virtually no studies are done that cover both ends (Samiee & Walters, 2006). The divide is clear enough that one literature review was written in a specific attempt to integrate the two perspectives (Tan, 2000). Moreover, because the divide extends back to some of the academic institutions that are leaders in SCM research (for example, the University of

Michigan has a strong logistics focus, whereas the University of Arizona has a strong supply focus), and farther back to SCM textbooks that uniformly emphasize one end of the SC or the other (e.g., Purchasing and SC Management, Logistics and SC Management), movement toward a more integrated approach is hindered. This divide in turn hinders the development of the theoretical understanding that ideally should contribute to the development of the field into the strategic discipline that it aspires to be (Burgess et al., 2006): a recognized strategic component with a tangible, positive impact on the firm's bottom line (Lancioni, Schau, & Smith, 2003).

2.3 Literature Base

In addition to the divide between the logistics and supply perspectives, there is a divide between the operational and strategic SCM literature. SCM theory has not evolved much beyond its roots: it is still seen largely as the domain of the operations management field. Although SCM is well covered in the operations-management literature there is a minimal presence in the management or strategy literature. For example, the *Journal of Operations Management* lists more than 100 articles on SCM over the last 10 years, including a dedicated issue in 2006. In contrast, the *Strategic Management Journal* has published five SCM articles over the last 15 years; even a special issue on strategic networks (2000) did not reference SCM despite a range of articles addressing issues that SCM practitioners consider to be elements of strategic SCM. This disparity goes beyond nomenclature and into perspective: the authors of the articles in *Strategic Management Journal* did not see their work as being of or for SCM, underscoring the narrow way in which SCM is still perceived.

The progression of characterizations of SCM from a functional activity within an organization to “a middle ground” between markets and hierarchies (Ketchen & Giunipero, 2004) and a “core competence” (Fine, 1998) reflects an evolution in

perspective from operational tool to strategic asset. This entails applying strategic decision processes and an integrated approach to SC systems (Houlihan, 1988): seeing SCM as an integral part of the strategic process, rather than as a collection of discrete operational functions, but this perception is still largely found in operations-management quarters.

There are a number of excellent SC literature reviews (Ballou et al., 2000; Burgess et al., 2006; M. C. Cooper et al., 1997; Croom, Romano, & Giannakis, 2000; Gibson et al., 2005; Harland, 1996; Mills et al., 2004; Tan, 2000) in which SCM is viewed from a variety of perspectives. These works examine SCM in terms of (a) SC “schools” that reflect the origins or process aspects of the discipline—i.e., logistics and process design—(Cigolini, Cozzi, & Perona, 2001); (b) who or what is being studied, or the methodology of the research (Croom et al., 2000); (c), the benefits associated with integrated SCs (Frohlich & Westbrook, 2001), or (d) specific SCM practices, tools and techniques (Ballou et al., 2000; Frohlich & Westbrook, 2001; Haugel & Jackson, 2001; Tan, 2002). The overwhelming focus of these works is on operational aspects of SCM at the firm or interfirm level: there is little work addressing SCM at the macro, or strategic level.

Work done at the industry level is most frequently done within a handful of focal industries (notably fashion retailing, automotive, aerospace, and consumer goods). The impact of the automotive sector on the development of SCM theory and concepts has been particularly notable. The complexity of the automotive industry (a typical car can have 10,000 parts) and the competitiveness of the market provide an incentive to optimize operations, from management (Sloan at GM) to SCM. Many familiar SCM concepts were either developed by, or applied in novel ways to, the automotive industry. Concepts such as design for manufacturing, component

engineering, interchangeability of parts, and reduction of the total number of parts came into widespread use during the early decades of the automotive industry (c. 1900-1930); just in time, total quality management, integrated product development and design and lean production all emerged from the industry in post-war Japan (c1950–1980; Lamming, 1993).

2.4 SC Frameworks

As evident from the summary of literature reviews of SC research (Section 2.3), much of the theoretical work that has been done on SCM reflects efforts to codify the field, an appropriate task for fields at a nascent level of theory development (Edmondson & McManus, 2005). Most of the efforts to codify SCM are by the level of SCM within an organization, or the type of SC recommended for different circumstances; a third approach is the integration paradigm, which though less structured, reflects an effort to link operational elements with a strategic focus.

2.4.1 Levels of Supply Chain Management

A range of work has identified different levels of SCM in an effort to codify the different ways in which SCM operates within an organization. Examples include: Behavioural, Planning & Control, and Operational (Closs & Mollenkopf, 2004); Strategic, Tactical and Operational (Narasimhan & Mahapatra, 2004); Strategic, Coordination and Operations (Johnston, 2004); Strategic, Design and Operational (Huan, Sheoran, & Wang, 2004), and Tools, Techniques and Strategy (Cigolini, 2004). Consistent with this language, Phillips Connolly et al. (2005b) created a framework of three levels of SCM:

Operational: SC tools—the means of implementation, support, or enablement of SC techniques.

Design: SC tactics—the SC framework and control systems for operationalizing SC strategies. For example, the SC tactic of continuous replenishment can be implemented through the SC tool of electronic data interchange (EDI).

Strategic: aligning the SC with the overarching objectives of the organization, reflecting both the dynamics of the organization's SC and the industry SC as a whole.

The operational level is the best known, the most applied, and the most studied: it is the practical application of SCM to the daily operations of the organization, including inventory management, production, planning, and scheduling, as well as improved manufacturing methods (Huan et al., 2004). This level comes under the aegis of operations management. Examples of Operational SC tools can be found in Appendix 1.

The role of the design level is to create an SC that will balance and optimize the organization's strategic objectives with its operating realities, providing the critical processes for organizing the chain that are the manifestation of strategy (Denison, 1997) and that reflect "a provider's execution capabilities and the design of its...processes" (Fine, 1998). It is in the domain of operations strategy. Examples of SC techniques for designing the SC can be found in Appendix 1.

Finally, the strategic level reflects business strategy formulation by the organization, in order to identify and reach its objectives. It thus encompasses Fine's (1998) and Denison's (1997) concept of supply/value-chain design and management as a core competency of the firm. Demonstrating the presence or absence of a strategy directly is difficult, but Cigolini et al. (2004) make the case that strategy can be inferred from the combination of SC tools and techniques used. As has been noted, there are recurrent calls for a more strategic approach to SCM.

2.4.2 Types of Supply Chains

Fisher (1997), noting that despite innovations in both the tools and techniques of SCM and that SC performance has “never been worse” (Fisher, 1997, p. 105), argued that understanding the nature of the demand for a product would enable better alignment of SC practices. This view is consistent with the view that SCs should be designed around the characteristics of the product in question (Cigolini et al., 2001; Fisher, 1997; Payne & Peters, 2004). Working on the basis that SCs have a physical function and a market-mediation function, Fisher characterized two basic types of SCs: the (physically) efficient, and the (market) responsive. Subsequent work has elaborated on these two types, notably lean (Lamming, 1996) or routinized (Lamming, 2000) (which broadly align with efficient) and agile (Lee, 2002; Christopher, 2000), quick (Cigolini, 2004) or dynamic (Harland, 2001) (which broadly align with responsive), along with a range of hybrids (Vonderembse, Uppal, Huang, & Dismukes, 2006). The downstream focus of Fisher’s typology was balanced and extended by Lee’s (2002) typology of supply chain strategies, which addressed the question of supply uncertainty (Lee, 2002). In addition to Efficient and Responsive strategies (which essentially parallel Fisher), and an Agile model (which essentially parallels Vonderembse, et al), Lee added a Risk-Hedging strategy, in which firms reduce their risk of supply disruption by pooling safety stocks. Although the Risk-Hedging strategy is focused on inventory management, it introduces the concept of ‘de-coupling’ the supply chain for strategic purposes.

Although Fisher’s two basic types have become broadly accepted as ideal types and is the nomenclature that will be used for this work, the following sketches also draw on the works cited above and reflect their general use within the SC field (see also Table 1, below, for more detailed characteristics of these SC types).

Efficient Supply Chain

An efficient SC is associated with products for which there is relative stable demand. This is typically found in commodity-type products that satisfy basic needs, are sold in high volumes, and have long product life cycles. This stable environment facilitates the market-mediation function of SCM, but also leads to high levels of competition, which in turn limits profit margins. Therefore, an efficient SC for “functional” products will focus on the physical function of the SC, particularly operational and process improvements such as cost containment, high-utilization rates, high inventory turns, and low inventory levels. Because of the ability to forecast demand, a build-to-stock (BTS) model is generally associated with efficient SCs.

Table 1 Basic Supply Chain Types (continued)

Table 1
Basic Supply Chain Types

	Efficient (Fisher)	Lean (Vonder- embse)	Risk-Hedging (Lee)	Routinized (Harland)	Responsive (Fisher)	Agile (Lee; Vonderembse)	Quick (Cigolini)	Dynamic (Harland)
Definition		Continuous improvement to reduce costs, time and waste	Shared inventory			Dynamic response to changing market		
Purpose	Continuous improvement	Cost-cutting, flexibility, incremental improvement	Pool resources to reduce risk	Process improvement important	Investment in SC responsiveness is greater than from investments in efficiency	Understand & meet customer requirements; customized/niche products in short time; Hedge risks	Priority is to improve effectiveness of SC coordination in product development and logistics	HR integration and knowledge capture key
Operations								
Manufacturing implications	Elimination of waste/manufacturing steps	Lean manufacturing techniques		Cost minimization		Agile manufacturing		
Production planning	High-use rates	Confirmed orders and reliable forecasts			Flow of information in from market is critical	Use IS & IT to move information		
PLC	High-inventory turns	Long (> 2 years)						Motivating trading partner relations key

Table 1 Basic Supply Chain Types (continued)

	Efficient (Fisher)	Lean (Vonder- embse)	Risk-Hedging (Lee)	Routinized (Harland)	Responsive (Fisher)	Agile (Lee; Vonderembse)	Quick (Cigolini)	Dynamic (Harland)
Knowledge								
Integration	Minimization of inventory levels	Manufacturing, purchasing, quality, suppliers	Real-time sharing of information on inventory and safety stocks	Minimization of inventory	Unpredictable demand	Marketing, engineering, distribution, information systems	Difficult to forecast demand	Uncertain demand
Governance								
Alliances	Emphasis on efficiency	Traditional partnerships/JV @ operations level						
Markets	Improvement focus is on operations	Current market segments					High commitment needed	Low volume or low profile: buyer power is higher
Organizational structure	Emphasis on information flows/communication	Static; hierarchy		Resource integration and information key				
Power								
Supplier selection	Shorter lead times	Choose for low cost/high quality	Have more than one source					
Demand	Integration of manufacturing, purchasing, quality, and suppliers	Can be accurately forecast (error rate ~ 10%)		Operations management and SCM important		Unpredictable change, demand		

Table 1 Basic Supply Chain Types (continued)

	Efficient (Fisher)	Lean (Vonder- embse)	Risk-Hedging (Lee)	Routinized (Harland)	Responsive (Fisher)	Agile (Lee; Vonderembse)	Quick (Cigolini)	Dynamic (Harland)
Inventory	“	High turns; minimization key				Hedge risk by pooling inventory		
Manufactur- ing focus	“	High-use rate	Increase safety stocks		Use buffers to ensure product availability	Use buffers to ensure product availability		
Product Design	“	Maximize performance at minimal cost			Select suppliers for speed, flexibility, and quality			
Devolution of decision making	Supplier selection based on low cost and quality	Teams in functional departments			Maintain flexibility in SC	External flexibility	Flexibility important	
	Alliances through partnerships and joint ventures					Collaborative product design Alliances often specific to a project/product		Networking activities important
Lead time		Minimize				Shorten lead times aggressively	Reduce lead times to avoid lost sales & obsolescence	
Competitive Environment								
	Stable markets			Stable markets				
	Long life cycle				Short PLC	Short PLC Constant renewal of		

Table 1 Basic Supply Chain Types (continued)

Efficient (Fisher)	Lean (Vonder- embse)	Risk-Hedging (Lee)	Routinized (Harland)	Responsive (Fisher)	Agile (Lee; Vonderembse)	Quick (Cigolini)	Dynamic (Harland)
					products & competencies		
Low profit margins			Low profit margins				Frequent new products
Stability feeds competition							
High volumes			High volumes	Innovation to differentiate			
Price/demand elasticity is high				High profit margins			
Product design for ↓cost / ↑perf.			Product design for ↓cost / ↑perf.			Compete on product not price	Compete on innovation not price
Demand can be forecast /is stable			Demand can be forecast/is stable			Often limited use of SCM	
			Power balance can be low or high				
Example Industries							
PCs		Grocery stores					
Automobiles		Service car parts	Automobiles assemblers (high power)				
Pharmaceutic als							

Table 1 Basic Supply Chain Types (continued)

	Efficient (Fisher)	Lean (Vonder- embse)	Risk-Hedging (Lee)	Routinized (Harland)	Responsive (Fisher)	Agile (Lee; Vonderembse)	Quick (Cigolini)	Dynamic (Harland)
als								
Grocery								
Classical books								
Basic apparel								
Packaged goods							Fashion apparel	

Responsive Supply Chain

When products compete more on product innovation than price, demand tends to be unpredictable and the focus shifts from leanness to responsiveness. These products have a significantly shorter product life cycle, but higher margins and greater variety. Responsive SCs allow for buffer stocks to better meet demand, use modular designs to increase flexibility, postponement to mitigate unreliable forecasts, and work to reduce lead times. The need to accommodate variable demand means that responsive SCs are more associated with a build-to-order (BTO) production model, though a hybrid approach uses BTS for components with long lead times, or bottleneck materials, and BTO for components with short lead times.

2.4.3 SC Paradigm

Ironically, given the divide between upstream and downstream approaches to research in SCM noted above, the dominant paradigm in SCM, crudely put, is that integration is good, and more integration is better (Chen, 2004; Choi, 2001; Cooper, 1997; Frohlich, 2001; Lancioni, 2003; Min, 2004; Min, 2001; New, 1995; Stevens, 1989; Tan, 2000; Trent, 1998; Christopher, 2000). Although it is acknowledged that integration is hard, even risky (Fawcett & Magnan, 2002; Tan, 2000), there are demonstrable benefits (Cigolini et al., 2001; Frohlich & Westbrook, 2001). For example, in one study of 600 manufacturers, only 7% of the firms had integrated their SCs, yet those firms were 73% more profitable than those that had not (Deloitte Touche Tohmatsu, 2003). In another study the top SCM performers were twice as efficient as the average, while spending less than half as much of their revenue on their SCs (Cook & Hagey, 2003). Yet another study found that firms with integrated SCM showed more than twice the improvement in a broad range of performance measures than the average (Frohlich & Westbrook, 2001).

Integrated SCM entails seeing the SC as an integrated whole or as a single process rather than as discrete functions, and as applying strategic decision processes and an integrated approach to systems (Houlihan, 1987). It focuses on the integration of the functional activities (i.e., marketing, logistics, production, procurement) performed by different organizations within an entire international supply chain, all with the goal of delivering superior customer value while sharing risks and resources to combat competition (Overby & Min, 2001). Indeed, once the principle of integration is accepted, the strategic focus becomes simply the direction and extent of the integration to be sought (Frohlich & Westbrook, 2001).

An integrated approach to SCM may be the theory, but there are many studies that indicate it is not the practice (Akkermans, Boggerd, & Vos, 1999; Deloitte Touche Tohmatsu, 2003, 2004; Fawcett & Magnan, 2002; Thomas, 1999; Whipple, Frankel, & Anselmi, 1999). Moreover, although the integrated SC model has become the dominant paradigm, it has been argued that this “orthodoxy” is misplaced, because the nature of the integration process is inherently limited in applicability (Cox & Watson, 2004; Stonebraker & Afifi, 2004).

The first argument is that the integrated SCM paradigm is derived largely from the Japanese experience and the automobile industry. However, the Japanese approach is not as trust and equity based as some have portrayed it: it is based on buyer dominance and a culture of compliant suppliers (Cox, Sanderson, & Watson, 2000; Shimizu, 1996). Further, this form of SCM has been characterized as working best when buyers have dominance over suppliers (Cox & Watson, 2004). And finally, the automobile industry, with its well-defined tiers of suppliers, high volumes, and standardized demand and supply, is an atypical industry (Cox & Watson, 2004).

The second argument is that integration is inherently limited in applicability. It has been argued that few companies can or will be able to develop an integrated SC, in part because it is very resource intensive: the transaction costs of supplier selection and relationship development, as well as the dedicated investment required are all very high. Further, the “lean” approaches that are associated with integrated SCs are not appropriate where there is uncertainty or variability of demand: more agile approaches are better (Bensaou, 1990; Christopher, 2000; Fisher, 1997; Mason-Jones, Naylor, & Towill, 2000). One study (Joshi, Kashlak, & Shermand, 1998) found that companies that had succeeded in building integrated SCs tended to have high volumes, competitive suppliers, relatively low switching costs and regular demand patterns, which are characteristic of efficient SCs, but not SCs in which market mediation (e.g., responsiveness) is a core function.

The integration paradigm is so ubiquitous that some writers use it to define SCM (Min & Mentzer, 2004). Even writers who argue that it is not always the most appropriate approach implicitly accept the paradigm. For example, Lee (1998) who recognized early on that different approaches to upstream and downstream SCM might be necessary, and introduced the notion strategic ‘decoupling’ of the supply chain in his Risk-Hedging supply chain type, still seeks to maximize the level of integration and efficiency of the SC. The other approaches are essentially ways of off-setting trading circumstances that hinder the effectiveness of the ideal, integrated model. Stonebraker and Afifi, (2004) , despite repeated assertions that integration is both risky and not always appropriate, ask practitioners to identify their position on a continuum in which all the attractive options are firmly in Phase IV—full SC integration with external trading partners. In effect, their conclusion is that integration is always appropriate, once there is a suitable level of readiness within the firm.

2.5 Theory Links

Despite the impressive successes of a small number of high-profile firms, the few studies that have been completed suggest that successful adoption of integrated SCM is in fact rare (Cook & Hagey, 2003; Deloitte Touche Tohmatsu, 2003; Poirier & Quinn, 2004; Simchi-Levi & Simchi-Levi, 2003). Understanding the theoretical underpinnings of SCM may help to identify the nature of the gap between potential and reality and perhaps point to solutions or alternative approaches. However, it has been argued that SCM cannot be considered a discipline because there is a lack of developed theory (Harland, 2006). This lack of theoretical constructs for developing a strategic approach to SCM ensures that SCM remains an operational issue, which limits understanding as to how supply management interacts with other management and business phenomenon, as well as the potential for integration at a more strategic level.

This is evident in what theory work has been done, which tends to be too narrow to embed SCM in the “wider context” that will allow for the necessary links to a broader understanding of SCM (Mattson, 2003, p. 424) and thus to a “coherent” evolution of the discipline (Croom et al., 2000). This limits otherwise useful models for characterizing certain aspects of SCs (Cigolini et al., 2001; Frohlich & Westbrook, 2001) as well as some attempts to ground SCM by identifying a particular theory, such as transaction costs (Grover & Malhotra, 1998), complex adaptive systems (Choi et al., 2001), or contingency theory (Stonebraker & Afifi, 2004). Other theoretical bases that have been referenced for understanding SCM include organizational behaviour, industrial organization, institutional sociology, system engineering, network theory, game theory, and role theory (Croom et al., 2000; Harland, 2006).

The evident limitations to using a single-theory approach to a boundary-crossing field such as SCM has led to the recognition of a need to “break from the dominance of single disciplines such as Operations Management” (Burgess et al., 2006, p. 79), so a novel approach integrating concepts from three theory groups was proposed (Phillips Connolly et al., 2005b). In this work, SCM was approached from the broadest possible perspective, so as not to overlook or prematurely exclude theories that might have something significant to contribute.

The initial theoretical evaluation took the approach of the Saxe fable, in which several blind men try to understand the beast in front of them by describing the part that they can feel. By walking around the elephant of SCM, and describing it from several theoretical vantage points, the most relevant theoretical constructs for understanding SCM could be discerned. A list of 20 major theory groups was identified and each reviewed for possible applicability to SCM. This list was then reduced and refined through an iterative, discursive process. (Table X summarizes the evolution of the list of theory groups). Finally, there were three theory groups that represented an irreducible minimum, each covering essential aspects of SCM: knowledge, power, and governance. These are each substantial fields in their own right, and it is neither germane nor within the scope of this paper to provide a comprehensive review of them. Rather, elements of each were identified that enhance the understanding of SCM at a strategic level (Phillips Connolly et al., 2005b). In looking at the role of each of the theory groups with respect to the application of SCM it becomes clear that they address different aspects of SCM:

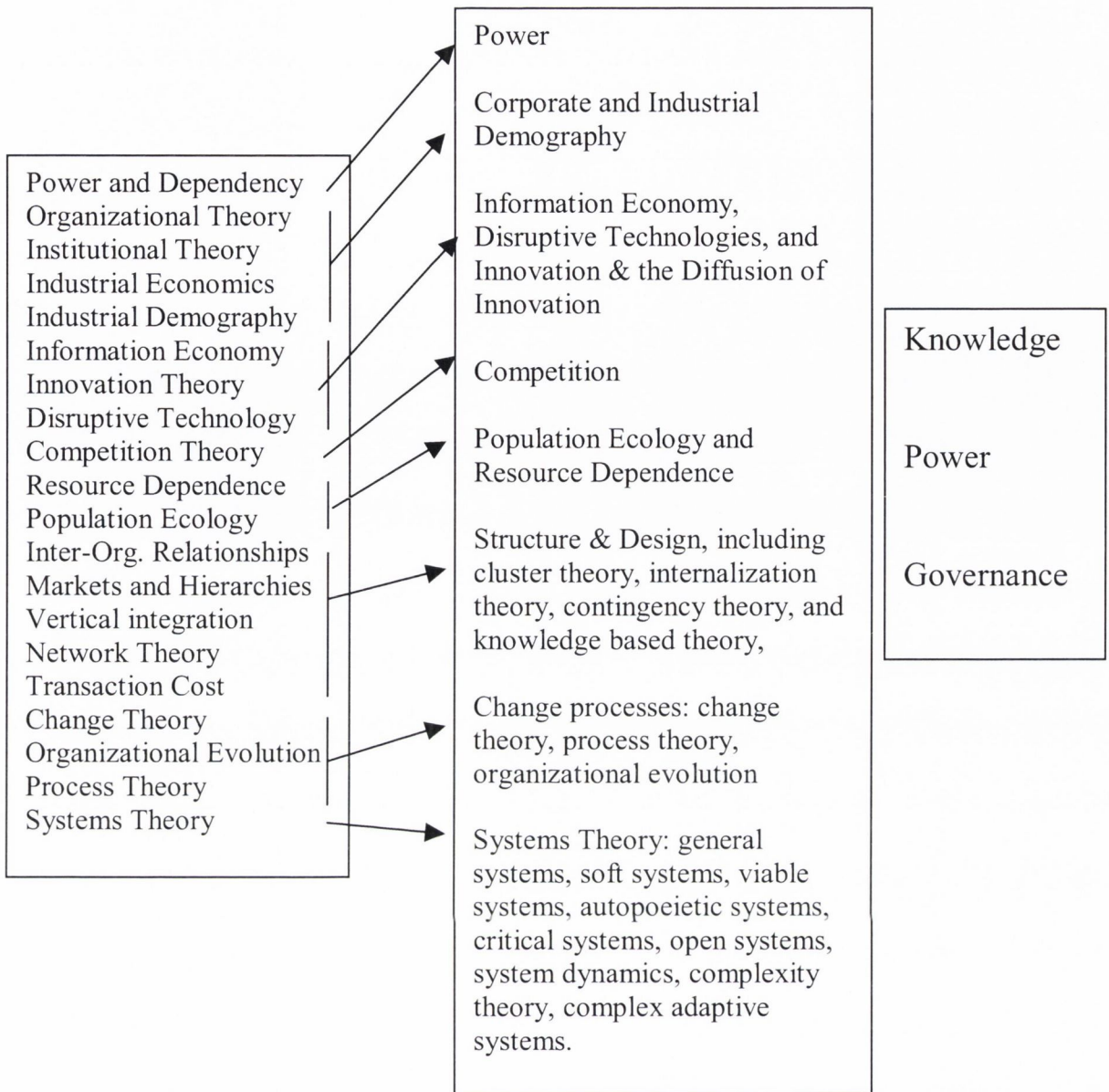


Figure 1. Knowledge, power, and governance: Different aspects of supply-chain management.

1. Governance addresses the ‘how’ of SCM: the ways in which trading relationships are arranged to accommodate or maximize the SC.
2. Power addresses the ‘who’ of SCM: the relative power between the SC partners. This is a dynamic function, as relative power can be based on a variety of factors, and can shift between trading partners.
3. Knowledge is the ‘why’ of SCM: the significant benefit of strategic SCM is better knowledge at lower cost.

These three theory groups, as they relate to understanding SCM, are reviewed in the following sections.

2.5.1 Knowledge

It has been noted that the global competitive environment has led to “inputs” becoming “ubiquities”: that is, many of the traditional sources of competitive advantage in international business, such as proximity to markets, organizational design, and sales and marketing strategies, are no longer unique: they are widely available at essentially similar costs and thus ubiquitous (Maskell, 2001). However, an organization’s ability to create and leverage knowledge remains unique. In knowledge-based theory an organization’s strength is based on its ability to create, store, and apply knowledge; knowledge is seen as the organization’s most important resource (Grant, 1999; Grant & Baden-Fuller, 1995). It is taken for granted that knowledge is increasingly distributed and that knowledge workers are increasingly important in terms of value added (Foss, 2002a). Knowledge-based theory has been so persuasive that contingency theorists have characterized knowledge—both tacit and explicit—as a contingency variable (Birkinshaw, Nobel, & Ridderstrale, 2002).

For the purposes of this thesis, knowledge is “...defined as credible information that is of potential value to an organization” (Hult, 2003 p. 189). The importance of structured, formalized or codified knowledge transfer systems in SCM has been recognized (Edmondson, Winslow et al 2003), but the operational emphasis of much SC work has led to an over-emphasis on the IT aspects of knowledge management (Styhre, 2001). From a strategic SCM perspective, however, the central challenge for the organization is to know what information it has, where that information is, and what information it needs. This includes knowledge of governance

options (what is available, what is most appropriate for the competitive circumstances), as well as the power implications (see also section 2.5.2, Power, and 2.5.3, Governance, below). There is an element of resource dependency here: without the necessary knowledge the organization cannot successfully compete. There is also an element of transaction costs theory, as there are costs to identifying, finding, accessing, and using knowledge.

Knowledge-based theory brings many useful concepts to the understanding of SCM. If an organization can create value through knowledge transfers with customers or suppliers, the linear value chain is fundamentally changed, becoming more like the SCM model (Sveiby, 2000). This value chain can lower the costs of transferring tacit knowledge and problem-solving abilities (Heiman & Nickerson, 2002). The benefit of greater access to knowledge at a lower cost helps to explain why organizations might pursue SCM. Moreover, shared knowledge may be less expensive but is no less valuable or powerful. Where the old saying was “knowledge is power” the newer version could be “shared knowledge is power.” SCM may be operationalized through technology, but it is knowledge and the application of that knowledge across the SC that holds it all together.

It has been noted that efforts to apply knowledge theory as a tool can be too linear and limited and that “in the future, ‘knowledge theory’ will be quite simply and directly about the state of knowing. It will have less and less to do with control, systems, production, processes, mechanics or methodologies” (Maloney, 2000). This parallels evolving thinking about SCM, traditionally seen in terms of controls and processes, but as it evolves becoming more conceptual and strategic.

2.5.2 Power

Supply chain power has been defined as “the capacity to optimize the behaviour of suppliers and subcontractors in accordance with desired performance objectives” (Stannack, 1996, p. 51). The balance of power within a competitive environment underpins most aspects of an organization’s operations. The balance of power can tilt in favour of the customer or the producer, and is not immutable (Gereffi, 2001). One force that is changing power balances is communication technologies and systems (such as the internet, EDI, and intranets), which can deconstruct both producer-driven and buyer-driven global commodity chains through their ability to create efficient markets on a scale not previously possible (E. Sullivan, 2004). Another force is the blurring of organizational boundaries through interorganizational relationships, which can shift the location or distribution of power (Pettigrew, 2003).

The question of power balance has been specifically linked to SCM, through the concept of global commodity chains (Gereffi, 2001). This model places any given SC on a continuum between producer-driven and customer-driven SCs, and facilitates the tracking of movement or change in the power balance. However power is not necessarily the only driver in a supply chain: the chain may be driven by an organization that has a stronger vision or stronger leadership. Personal influence, rather than financial or market power can drive a supply chain (Simchi-Levi et al., 2004), which means that the locus of power in a supply chain is not necessarily the biggest or market-dominant participant in the chain. Whatever the source of power, however, the presence of a driver firm has been shown to lead to faster development and adoption of SC initiatives (Simchi-Levi & Simchi-Levi, 2003).

The use of knowledge is a key determinant of power for both strong and weak members of the supply chain (Munson, Rosenblatt, & Rosenblatt, 1999). This has been well documented in the retail sector, where the increasing availability of and access to knowledge of the market and consumer behaviour is tilting the balance of power to retailers (Borghesani, de la Cruz, & Berry, 1997; Munson et al., 1999). One way of keeping power balanced through supply chain interorganizational relationships is by ensuring that none of the participants is excessively dependent on another, for example, by limiting the relative share of business between them, which also has the benefit of maintaining the flow of new ideas from other sources (Landry, 1998). Regulators and/or market forces can—and often do—correct power imbalances. Importantly for SCM, however, power *balances* can also lead to problems. That is, when the relationship between two or more organizations is such that they operate in mutual self-interest, that self-interest can lead (or appear to lead) to collusion, price-fixing, and anticompetitive practices. These can be corrected, but it is a critical challenge for SCM that the interorganizational relationships that are a central part of an effective SC can also become, or be seen as, anticompetitive. Managing the balance between constructive but not anticompetitive trust relationships is a central challenge for SCM.

2.5.3 Governance

Governance is used here in the broad sense of ‘the action or manner of governing’ (OED), and is more specifically defined for this work as the structure or type of relationships between trading partners in a SC (Grover, 2003).

Governance draws to some extent on each of the theory groups examined so far: organizational structure and processes materially affect the ability of the organization to find, create, and use knowledge, and balance of power issues are

intrinsic to the decisions an organization makes about its structure and external trading relationships. It encompasses the field of organization design and how organizations structure their internal and external processes and relationships, reflecting structural issues such as “market versus hierarchy” decisions; and process issues such as transaction cost analysis and resource dependency. Because transaction cost economics (TCE) operates at the governance level, and can be a useful tool for examining most contracting problems (Williamson, 1998), it may appear that TCE would be a more appropriate theoretical lens than governance for understanding SCM. However, the unit of analysis in TCE is the transaction, whereas the focus of the present work is the industry level, and by extension, the firm level, which is where advantages from cooperative adaptation- a significant element in SCM- can be achieved (Williamson, 1998). Further, the strict application of TCE to SCM can be counter-productive. For example, TCE would support a ‘lean’ SC approach, which eliminates the waste of non-value adding activities. However, a pure adoption of such an approach may not have the flexibility to function well in real life, and the ‘costs’ of achieving that flexibility will not necessarily yield the quantifiable value. (Lamming, 1996). Still, TCE has been identified as a tool that has been underused in the Operations field, with the potential to be a useful tool for evaluating specific choices, such as the adoption of asset-specific technology (particularly process and communication technologies; Grover, 2003). Coincidentally, the industry chosen for this research- in the health care sector- turns out to be one of the fields in which many transactions can be considered ‘intractable’ from a TCE perspective (Williamson, 1998), further confirming the choice of governance- including a TCE perspective- as a theoretical basis for understanding SCM.

Effective SCM requires extensive, flexible, and responsive control and coordination mechanisms. These can be internalised through a hierarchy within the firm; externalised, through the marketplace; or “allied,” through interorganizational relationships (Landry, 1998). These relationships are changing and becoming more complex, in part because of information and communication technologies (Whipple, 1999; Rasheed, 2001).

Although SCM is most often discussed in externalized contexts, SCs work within any degree of formal operating structure (military organizations, for example, have historically been at the forefront of SC development). In highly vertically integrated organizations and industries, most SCM issues will be internal (which may be affected by internal power asymmetry). However even these industries eventually have to reach the market, and at this point the question of power becomes relevant, as the organization will have to establish its power relative to its distribution system and customer base. If the balance of power shifts from producer to buyer, the SC and hence the organizational structure, may also have to change.

For organizations in which SCM is externalized, there are challenges both *up* (to providers of inputs) and *down* (to the end user or marketplace) the SC. Up the chain there is potential for conflicts between partner requirements and the organization’s requirements. Down the chain the organization must balance central conflict between the requirements of a “physically efficient” SC with those of a “market responsive” SC. These efforts have implications for areas as diverse as production, product design, marketing, strategy, outsourcing, interorganizational relationships, and the organizational structure of the firm (Fisher & Simchi-Levi, 2001). It has been observed that the more interdependent the participants in an SC become, the more isomorphic their organizational structures will become (DiMaggio

& Powell, 1983). SC partners rely on trust rather than power, and they operate more as networks than as hierarchies (Min & Overby, 2001).

2.5.4 Supply Chain Management and Knowledge, Power, and Governance

It has been argued that due to the “information age,” globalization, and the development of the knowledge economy, new forms of organizational design are necessary. The move to flatter hierarchies and away from vertical integration, the increasingly interactive nature of market relationships, and the blurring of industry divisions have been in process for a number of years (Fenton & Pettigrew, 2000). More specifically, control mechanisms and organizational structures are changing as firms recognize the importance of managing the complex distributed knowledge that is now perceived as their core asset (Foss, 2002b).

Each of these themes draws on a resource perspective, and marks a shift toward nonmarket, nonhierarchical relationships (Fenton & Pettigrew, 2000; Powell, 1990). Where minimizing transaction costs were once seen as the primary motivation for the firm, a larger context is now inferred, including the value of relationships. It has been observed, for example, that organizations may make choices that are suboptimal in the short run, because of the greater long-term value of the customer or partner relationship (Axinn & Matthyssens, 2002).

Within the “new organizational forms” authors generally view the boundary between hierarchies and markets as blurring on both sides as both take on elements of the other, but another view is that they are simply using coordination mechanisms that were traditionally used within firms between firms (Foss, 2002b). This would suggest that instead of or in addition to new forms of organizing, new forms of managing transactions and interactions within and between firms are appropriate.

Similarly, Fenton and Pettigrew (2000) concluded that it is not so much the structural characteristics of organization design that have changed, as the internal workings and the experience of the people working within the organization. That is, the essence of the multidivisional form (M-form) is intact, but the governance structures within that framework and the connections within and between organizations are both better understood and evolving (Fenton & Pettigrew, 2000).

Ernst and Kim (2002, p. 1427) take that view further, and argue that these converging trends have fundamentally changed organizations from multinationals that “exploit labor cost differentials” to “global network flagships that ‘integrate their dispersed supply, knowledge, and customer bases into global (or regional) production networks.’” Although these structures are seen in organizational design terms as networks, they can also be seen as international SCs.

SCM requires that the organization structure itself in such a way that information, material, and financial flows are efficiently integrated into the operational units of the SC, whether those units are internal or external (Fisher & Simchi-Levi, 2001). This correlates directly with knowledge-based theory relating to the value of the transfer of knowledge. In SCM there is a clear value to lowering the costs of transferring tacit knowledge and problem solving (Heiman & Nickerson, 2002). Interorganizational relationships are particularly well suited to the integration and transfer of knowledge in support of SCs, especially when the necessary knowledge cannot be embedded within the product (Grant, 1999; Grant & Baden-Fuller, 1995). The transfer of knowledge between firms, especially in product development, is materially affected by the choice of governance mechanism. (Voordijk, de Haan, & Joosten, 2000)

The power aspects of these flows are clear, and the role of trust also comes into play. In identifying success factors for interorganizational relationships, the number of factors that are *de facto* trust builders is notable. For example, one such list cites four key factors: power balancing, cospecialization (the parties develop mutually dependent connections), target costing (the parties cooperate on setting pricing), and personal ties (Landry, 1998). The last three factors are trust-oriented. Ultimately, successful SCM relies on trust. As was noted forty years ago, “no matter how crucial a capacity or activity, the organization need not attempt to incorporate it if the organization can be certain of its availability, when needed, on reasonable terms” (Thompson, 1967).

2.5.5 Application

In preparation for the field research, the theory groups were further examined, to ensure a tight fit between the information acquired and the theoretical perspectives being developed and investigated.

The use of sourcing options and the relative presence of those options is seen as an important aspect of SC evolution (Fine, 1998), and has been explicitly linked with power (Cox, 2004; Dyer, 2000; Lamming, 1996) and knowledge (Foss & Pedersen, 2004; Voordijk et al., 2000). Further, the use of SC tools and techniques, which have been identified as a proxy for SC strategy (Cigolini et al., 2001) are also linked with changing structures or governance (Stevens, 1989) and integration with partners (Frohlich & Westbrook, 2001) and changing types of power (Stannack, 1996).

A model of the potential relationships between knowledge, power and governance theory (Figure 2, below) was created to convey the interactive, dynamic relationship between the three theory groups.

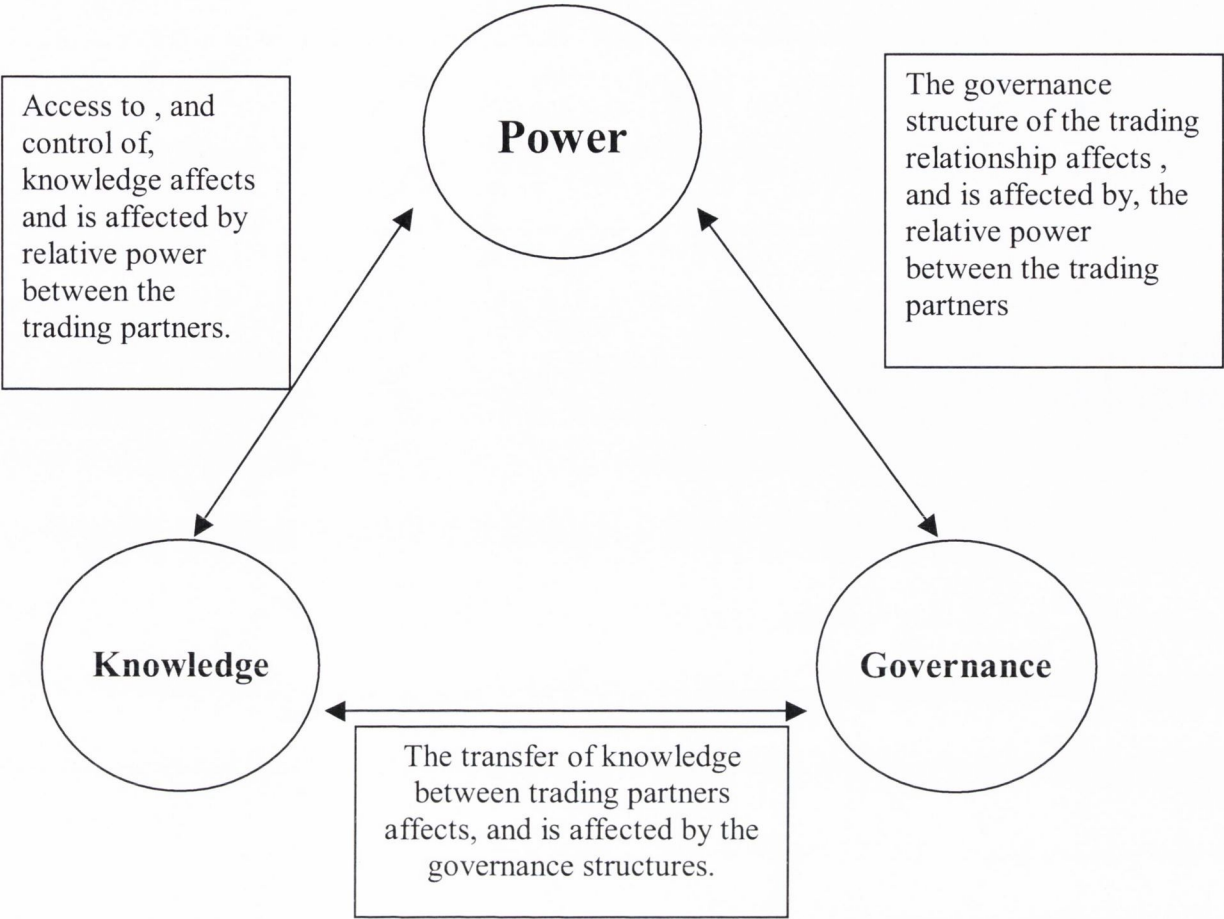


Figure 2. Relationships between knowledge, power, and governance theory in SCM.

2.5.6 Theory Summary

By taking a broad look at theory groups, and examining them for their relevance to SCM, three theory groups, in dynamic relationship to each other, have been identified as being particularly important in understanding SCM. Ketchen and Hult (2006), separately, and subsequently, took a similar approach when they identified nine theory groups as contributing to the understanding of SCM: transaction-cost economics, agency theory, resource dependence theory, institutional theory, game theory, network theory, social capital theory, strategic choice theory, and a resource based/knowledge-based view. Of these, they particularly emphasized a resource-based/knowledge-based view, strategic choice, agency theory, institutional theory, and systems theory, and especially, knowledge (Ketchen & Hult, 2006). It is

interesting to note that the elements of agency theory that were emphasized relate to power, particularly the potential for one trading partner to use their relative power at the expense of the other. Further, the focus within systems theory was on organizational activities, notably governance. Thus, the Ketchen and Hult (2006) findings are generally consistent with the Phillips Connolly findings.

2.6 Conclusion

A number of elements of SCM have been elucidated through this literature review, notably the role of the evolution of SCM, the distinction between the different levels of SCM within the firm, the general typology of SCs, the dominant integration paradigm of SCM, and links with three theory groups. It is clear from the literature review that SC theory is indeed at a nascent level of development, and that there has been very little “formal theorizing” (Edmondson & McManus, 2005). However, the tools for such theorizing are emerging.

CHAPTER 3:

METHODOLOGY

3.1 Introduction

The methodological approach derived directly from the objective of the research: to explore the apparent disparity between SC orthodoxy and SC practice. The following section discusses the research approach. Next, the unit of analysis- the context in which the research was conducted is described. Finally, the research process is outlined.

3.2 Research Approach

3.2.1 Philosophy

One complaint about extant SC research is that it has been largely limited to a positivist research paradigm, and needs to move beyond that approach if it is to develop into a coherent theory (Burgess et al., 2006). The highly structured positivist approach is aligned with the philosophical approach used in the natural sciences (Saunders, Lewis, & Thornhill, 2003), in which data collection and analysis are central, and which seeks to establish natural laws that are independent of human dynamics (Benton & Craib, 2001). The engineering and operations backgrounds of many SC researchers may explain why the positivist approach has been dominant, but this approach may miss important insights in the complex field of management (Saunders et al., 2003). A more interpretivist or constructionist approach can reflect these complexities while providing a rich understanding of the reality of a given situation. However, the emphasis on a unique environment can hamper generalization to other circumstances (Saunders et al., 2003). A realist approach takes the middle ground: it tries to understand and explain a phenomenon, rather than search for

external causes or fundamental laws (Amaratunga & Baldry, 2001) or the subjective reality of the participants (Saunders et al., 2003). Realism assumes that organizations are real: they have form, structures, boundaries, purposes and goals, resources, and members whose behaviours result from structured relations among them (Dubin, 1982): these elements are germane to understanding the adoption of a strategic management tool such as SCM.

3.2.2 Qualitative v. Quantitative

As a positivist approach is aligned with quantitative research, constructionism and realism are associated with qualitative research.. A qualitative approach recognizes the role of the researcher in the creation of knowledge and uses a variety of approaches (Flick, 2002; Silverman, 2005). Identification of a specific method of qualitative research typically means choosing from methodologies such as experimentation, survey, case study, grounded theory, ethnography, action research, cross-sectional, longitudinal, exploratory, descriptive, and explanatory study (Saunders et al., 2003). However, it has been argued that many of these approaches have, in practice, blurred together and can be considered as a qualitative method with various branches that suit particular lines of inquiry (M. B. Miles & Huberman, 1994).

3.2.3 Inductive v. Deductive

The present research is exploratory in purpose, seeking to understand an apparent paradox and elucidate theoretical elements in a field that is a nascent level of theory development. Thus a deductive approach, which empirically tests general concepts or theoretical structures against particular examples (Hussey & Hussey, 1997) is less appropriate for this work than an inductive approach, which moves from original observations to theory (Arbnor & Bjerke, 1997; Saunders et al., 2003). Based

on “description” rather than “implicit and explicit prescription” (Mintzberg, 1979, p. 585), it aligns with the “digging into a paradox” of nascent theory building (Edmondson & McManus, 2005, p. 7)

3.2.4 Grounded Theory

The exploratory nature of this research required an iterative, learning approach that is flexible and open-ended, which makes a grounded theory approach appropriate (Edmondson & McManus, 2005, p. 7). Grounded theory can facilitate understanding (Martin & Turner, 1986), allow theory to evolve from the exploration and the data (D'Onofrio, 2001), and is consistent with the use of the multiple research approaches (“slices of data”) needed to understand a subject (Glaser & Strauss, 1967). As an inductive approach (Orton, 1997), it is a useful way to draw together varied, qualitative, data (Edmondson & McManus, 2005, p. 7).

However, grounded theory has fractured into several camps, with cofounders Glaser and Strauss leading the divide, so it is helpful to clarify the approach used in the present research. Glaser went on to put stronger emphasis on objectivist assumptions founded in positivism, while Strauss emphasized a more pragmatist approach to positivism. This research draws on a constructivist approach based on pragmatism, within a realist paradigm, as argued by Charmaz (2005). This approach uses grounded theory guidelines as a tool but without objectivist or positivist assumptions, and emphasizes a focus on the question at hand rather than the methods of study (Charmaz, 2005).

The contextualist approach, which has been described as mirroring grounded theory, and which has been positioned within a looser framework of Strauss and Corbin's (1998) grounded analysis, differentiates itself from grounded theory largely by renouncing the concept of explicit stages and techniques such as those that

characterized the early forms of grounded theory (Pettigrew, 1997, p. 342). It shares with grounded theory the underlying emphasis on the importance of “peripheral vision, poking around in relevant places, a good dose of creativity” (Mintzberg, 1979, p. 585) as making good research.

What all these versions of grounded theory have in common is an iterative approach that seeks to discern meaning from qualitative data. Cycling between process data and process theory (Orton, 1997) is essentially the middle position between the “no theory ideal” and the “strong a-priori explanation” (Parkhe, 1993), and a way to engage with the complexity of the real world that is needed in SCM research (New & Payne, 1995). This is the process that was followed in this work.

3.3 Unit of Analysis

3.3.1 Supply Chain

The aim of the research is to explore the gap between SC theory and practice. Exploring SCs in practice can be done either through horizontal SCs (that is, examining a firm (or firms) at a particular link in the value chain), or vertical SCs (that is, by examining the links between up- and downstream trading partners). Vertical SCs as the unit of analysis was rejected because they introduce too many variables: the reasons for strategic adoption or nonadoption of SCM might vary between levels on the SC and/or by industry. Horizontal SCs, on the other hand essentially represent an industry.

The choice of industry as the unit of analysis offers several benefits. First, industry effects have been found to play a significant role at the business-segment level (McGahan & Porter, 1997). This work (and others, such as Chang & Singh, 2000) found that the relative level of corporate, industry, and firm effects vary, depending on a variety of factors (such as level of industry aggregation and firm size),

but that industry effects are notably strong in core strategies such as technology (Mauri & Michaels, 1998). Mauri and Michaels specify that they are using Chandler's characterization of core strategies as those that involve the allocation of existing resources and the development of new ones, a clear fit with SCM (Chandler, 1962, p. 383, as cited in Mauri & Michaels, 1998).

Further, the nature of SCM is that it links firms across industry boundaries, yet substantial SCM work has been done in only a handful of industries—and most of those do not generalize to other industries (notably the automotive and aerospace industries). Thus SCM is a strategic and operational issue that by definition cannot be restricted to the firm level, but for which only limited consideration has been given in an industry context.

Using industry as the unit of analysis provides an appropriate context in which to explore the adoption of SCM, providing an opportunity to identify the characteristics of SCM in a given situations. It also allows for the consideration of other factors that could emerge as being relevant, such as the stage of the industry life cycle, relevant industry drivers, and competitive factors.

Finally, as virtually every firm in an industry is both a supplier and a customer, if up- or downstream effects are important in the adoption/nonadoption of SCM they should become apparent in an industry-based study.

3.3.2 Industry Selection

The industry level was chosen as the unit of analysis, and a further decision was made to make one industry the focus of the study. This focus allows for a depth of understanding that may allow relevant but previously unrecognized factors in understanding SCM to come to the fore. Further, given the inherent complexity of

SCM, attempting to understand the nature of SCM in more than one industry is beyond the scope of this research.

Having chosen the industry level as the unit of analysis, the next step was to select an industry, beginning with clarification of selection criteria, as outlined in Table 2 below. The expectation was that an industry that is fast cycle (has shorter product life cycles) would be more likely to have strategic reasons for being relatively advanced in their approach to SCM, if only because the threat of obsolescence would reasonably focus efforts on inventory management (one of the most adopted SCM practices). By similar logic, a technologically or innovation-oriented industry would reasonably be more likely to be comfortable with the adoption of new systems.

Table 2
Industry Selection Criteria

1. Fit With Project Profile	
SCM Potential: Does the industry have characteristics that would make it strategically more likely to be proactive in its SCM?	In considering why firms might not be using SCM as recommended, it is reasonable to start in an industry whose characteristics suggest that SCM would be particularly beneficial
Industry Characteristics: Is the industry large and/or profitable enough to be able to afford advanced SC approaches?	Many SC tools and techniques require significant investment, which may inhibit adoption in small or low-margin industries.
Industry Structure: Is the industry structure one that will allow for understanding the SC dynamics within the industry?	If the industry has a complex structure there may be too many variables to separate out in a meaningful way.
2. Practicalities	
Information	Is there enough information available and is it accessible?
Contacts	How accessible are the key players and are there good points of contact or other resources available?
Access	Are information and contacts available? How locally?

Two industries in which a tremendous amount of SC work has been done—automotive and aerospace—were eliminated because their industry structures and dynamics are so atypical (Cox, 1999). Fashion and fast-moving consumer goods, industries which have also been extensively studied, were eliminated in favour of a

business-to-business industry, as these have been relatively underresearched (Burgess et al., 2006). Computers, electronics, and telecommunications were considered as candidates, but it became clear immediately that both the computer and electronics industries were too large and diverse for the purposes of this project. At the 2-digit ISIC code level the industries cover too many disparate operational entities, so subindustries were chosen for further evaluation. For the computer industry, electronics manufacturing services (components) was chosen because it is a very fast cycle industry that has a reputation for being advanced in SCM. For electronics, high-technology medical devices was chosen, as it is fast cycle and should therefore benefit from SCM practices. Industry reviews on these three—electronics manufacturing services, medical devices, and telecommunications equipment—were developed. Each review included an overview of the industry, major products, industry structure, industry regulation, and institutional involvement, the outlook and challenges facing the industry, and an overview of its SC features.

The relative merits of using each industry were identified, and a comparative evaluation indicated that the field of high-technology medical devices provided the best fit with the selection criteria. The decision factors included:

- the size and structure of the industry: there is a relatively small top tier of firms that represents a disproportionate share of the industry, which would facilitate the research process;
- the presence of long-term relationships that are characteristic of the industry are an element of the integrated SCM paradigm;
- the short product life cycles (typically less than two years) means that active SCM should be particularly beneficial, in order to maximize revenues before obsolescence;

- the research-intensive nature of the industry lends itself to the collaborative relationships that SCM emphasizes;
- the industry is both growing and has high profit margins, so there is scope for investing in new strategies and systems; and
- the technological orientation of the industry as well as its relative youth suggest that firms in the industry might be more receptive to new technology-based approaches and/or innovative business practices.

A final crosscheck with other industry groups that would fit the above criteria was made, reviewing the reasons for including/excluding them from consideration. However, the balance between a number of important variables predisposing the industry towards SCM and the relatively small number of large firms confirmed the choice of high-technology medical devices as suitable base from which to explore the adoption of SCM.

3.4 Research Process

The research process cycled between phases of inductive and deductive work: moving from original observation to theory, then validating that theory by testing it against practice (Arbnor & Bjerke, 1997). One of the important elements in the selection of a grounded theory approach to this research was the ability to use multiple research approaches. During the research process, interviews, a focus group, case studies, and a survey questionnaire were all employed as ways of gathering and refining data while continually cycling back and checking the findings against the literature and the previous findings. Each approach contributed materially and substantially to the final work.

There were four phases or cycles of empirical data gathering using four different data-gathering methods. This is consistent with the finding that in SCM,

progress in research is more likely if a range of methodologies—including “soft data” such as management views—are used, reflecting the holistic scope of the field (New & Payne, 1995). Table 3, below, summarizes the various approaches used.

Table 3
Data Collection Methods

	Lit Review	Industry Study	Exploratory Study	Case Studies	Industry Survey
Focus	Conceptual Issues	Understand industry characteristics	Features of SC	Factors influencing SC development	Validating case findings and theory application
Data Source	Literature perspectives	Public & private published data	Semistructured focus group and expert interviews	Semistructured interviews	Survey
Sample & Respondents	-/-	- / -	Industry SC steering committee Expert Interviews	2 pure-play firms	Focus group
Findings	Deduction of contextual variables; Identification of conceptual models	Identifica-tion of industry characteris-tics, structure, challenges and preliminary SC featruess	Identification of strategy, structure and process characteristics/ variables	Difference between theory and practice; effects of product, process and environment.	Identification of fit of taxonomy of types of SC; pattern of practice

3.4.1 Phase 1: Background Data

In the first phase, background data on the medical-device industry was gathered from archival sources, including the internet, company filings, and industry publications. This material was integrated into the Industry Note (chapter 4).

3.4.2 Phase 2: Data Collection

Because of the exploratory nature of the research, four methodologies of data collection were employed sequentially: focus group, expert interviews, case study, and a survey with focus-group follow up. The broader scope of the focus group was refined by more in-depth interviews, which were followed in turn by the more

detailed information that can be obtained from case studies. Table 4, below, summarizes the data sources.

	NUMBER OF PARTICIPANTS	WHEN	FORMAT
Focus Group 1	8 + Liaison	Sept-Oct 2004	Pre-meeting w/ liaison; On-site meeting w/ group
Expert Interviews	2	May-July 2005	On-site meetings; Phone conversations and e-mail before and after meetings
Case Study Interviews	Medtronic: 3 Bard: 2	April-July 2005	Phone conversations; email before, between and after
Focus Group 2	8 + Liaison	October 2006 – January 2007	Phone & email (with liaison); Internet survey; Presentation

Focus Group

Focus groups are used to gather data—feelings and/or opinions—from a group of people involved in a common situation, and can be a useful means of gathering a range of views at an early stage of research (Hussey & Hussey, 1997). Given the broad scope and exploratory nature of this research, a focus group is an appropriate way in which to gather the information needed to further shape the direction of research.

Ireland has one of the largest medical-device clusters in the world, comparable to the clusters in Massachusetts and Minnesota (IDA Ireland), and the biggest non-U.S. (excluding Puerto Rico) cluster (Phillips Connolly, Sullivan, Brennan, & Murray, 2005a). More than half of the top 25 firms are present (of more than 100 firms overall), and a number of market-leading firms, including Abbott, Boston-

Scientific, Johnson & Johnson (JNJ), and Stryker serve global markets from Ireland. All elements of the industry, from distribution to production to research and development, are present.

The Irish Medical Devices Association (IMDA) is a representative industry association under the umbrella of the Irish Business and Employers Confederation, and represents nearly 80% of the medical-device firms in Ireland. An explicit element of their vision is to support “world class manufacturing and supply chain strategies,” and to that end one of the six working groups within the association is the Supply Chain Management Working Group (SCMWG). The group works by “sharing best practices and information, benchmarking and delivering workshops” to members (see the IMDA website). The members of the Supply Chain Steering Committee of the IMDA should therefore provide an accurate reflection of the device industry in general, and the practice of SCM within the industry in particular, and was thus selected as the focus group for this work. Prior to meeting with the group, a background meeting with the executive liaison between the SC committee and the IMDA was held. After this meeting a date for the meeting with the committee was set and an agenda for the focus group meeting was drafted. The findings from the focus group are presented in chapter section 4.2.

Expert Interviews

Expert interviews can provide a targeted focus on the subject and provide insight from knowledgeable participants (Eisenhardt, 1989; Yin, 1994). The process of “open discovery” is a particular strength of interviews (Hussey & Hussey, 1997), appropriate for an exploratory study.

Informants were selected by identifying individuals who would have a relatively high level understanding of SCM, and a senior enough position to be

involved in the development of the SCM strategy within the firm. A second but critical factor was accessibility: both the willingness of an individual to participate in the research, and the geographic location in question. The first informant is the head of the IMDA SCMWG, and the Director of Global Supply Chain (GSC) for DePuy, a major medical-device firm. The second informant is the head of SCM for Boston Scientific, another leading device firm. Both informants were selected from the pool of medical-device firms (see Case Studies, below).

The interviews themselves were semistructured using an interview guide, and aimed to explore in greater detail the dynamics of SC strategy within the industry (the interview guide can be found in Appendix 2 and the interview template can be found in Appendix 3). This is consistent with a phenomenological approach—as opposed to a positivist approach, which would have used structured, closed questions—(Hussey & Hussey, 1997). Semistructured interviews are particularly suitable when the logic of a situation is not clear (Easterby-Smith, Thorpe, & Lowe, 1991), which in turn is appropriate for the investigation of a paradox.

Because of the early stage of the research, the interviews were long (2–3 hours) and open ended, to allow as full a picture as possible to emerge. Follow-up validation interviews (see validation, below) were shorter and more focused. The findings from the interviews are presented in chapter section 4.3.

Case studies

Case Methodology. In the context of a grounded-theory methodology, one of the advantages of data collection through case study is the fluidity of the case-study construct, for which there are a plurality of definitions (Locke, 2001). Although this is sometimes seen as a negative characteristic (Locke, 2001), the notion that “case study is not a methodological choice, but a choice of object to be studied” (Stake, 1994, p.

236) fits with both the overarching use of grounded theory, as well as the focus in this work on a strategic organizational practice, which can be considered an object for case study (Post & Andrews, 1982, as cited in Locke, 2001). In this work the case studies are an additional method of understanding the phenomenon in question—another “slice of data”—rather than an end in themselves. Thus the present work is closer to the Lawrence and Lorsch approach of using a case “because of the potential it has to offer in providing insight into a substantive issue or to advance theory” (Locke, 2001, p. 16) rather than Yin’s approach, which assumes that “research ought to be theory driven and that multiple case studies should be designed around the kind of replication logic found in the design of scientific experiments” (Yin, 1998, cited in Locke, 2001, p. 16).

The aim of case studies is to understand and articulate patterns and linkages of theoretical importance (Eisenhardt, 1991; Yin, 1994): to describe a situation so that future hypotheses and applications can develop from a level of understanding (Finch, 1999). They are often used for exploratory research in areas in which theory is underdeveloped (Hussey & Hussey, 1997), as in the present case. Theory development can be done through deductive-theory testing or inductive-theory building (Eisenhardt, 1989; Perry, 1998), but at a nascent level of theory, inductive work will be dominant (Edmondson & McManus, 2005). While case-study research can involve deduction based on prior theory, inductive theory building is more prominent and more closely aligns with the aim of this research (Perry, 1998).

Case Study in the Present Research. Case-study work can bridge the gap between research and practice, which is relevant to the present study of the paradoxical gap between theory and practice. This qualitative approach is appropriate

for identifying the underlying constructs (Amaratunga & Baldry, 2001), and investigating a complex contemporary phenomenon *in situ* (Yin, 1994).

Indeed, the limited amount of existing work makes this close to the ideal of beginning a case study with “a research problem and...some potentially important variables, with some reference to extant literature” (Eisenhardt, 1989). A case-study approach as opposed to other available methodological approaches (i.e., surveys) is preferred for new areas of research and/or areas for which existing theory seems inadequate (Eisenhardt, 1989; Rowley, 2002).

Selection of Case Firms. Purposeful sampling—“the selection of cases to provide the opportunity to learn a great deal about issues central to the research” (Locke, 2001, p. 17)—is important in case-study work. Of fifteen “strategies for purposefully selecting information rich cases” (Patton, 2002, p. 230), this work is closest to “stratified” purposeful sampling designed to capture the major variations within the sample.

The “high-technology” medical-device industry is fragmented and diverse. There are large multifaceted multinationals (for example, JNJ and Abbott Labs); dominant industry firms (e.g., Medtronic, Guidant) and small firms (more than 70% of companies in the EU have fewer than 50 employees (Eucomed, 2003). Together, these small firms account for just 10% of sales. A “large” firm in the medical-device industry is defined as having over \$200 million in annual revenue. Only 20% of medical-device firms can be categorized as large; of these, the top 2% account for 50% of sales (Lewin, 2003).

These large firms are the drivers of the industry and are significant for understanding both its nature and evolution. Moreover, they have the resources (financial and organizational) to explore and adopt new strategies and technologies,

and the market influence to act as drivers of SCM adoption. Thus the decision was made to draw the case-study firms from their ranks.

The first step was to identify the leading firms. A list of the largest medical-technology firms was derived from Standard and Poor's list of comparative companies with over \$1 billion in annual sales, the Hoover list of top 10 medical-device companies, and various publications identifying leading medical-technology companies. The firms were ordered by volume of sales of medical-technology products.

In total there were 24 firms with more than \$1 billion in medical-technology sales. Eight firms were excluded on the basis that their primary products were equipment, supplies, or a combination. That is, although some of their products would be considered high-technology medical devices, the bulk of their business is not (note that in the case of Tyco it was not possible to determine the actual proportion of sales because the company does not provide segment-sales information).

Of the remaining 16 firms, Guidant and Johnson & Johnson have been combined, given their announced merger plans. Thus, 15 firms were left as case-study candidates. As can be seen in Table 4 below, the top three firms—Medtronic, Baxter, and Siemens Healthcare, with sales from \$7.4 billion to \$9 billion, are substantially bigger than any of the other firms: their sales are as much as ten times greater than those at the bottom end of the list and more than twice as great as the middle group. The middle group—Stryker, Guidant, Boston Scientific and Abbott—are clustered fairly tightly between \$3 billion and \$3.5 billion in sales. The last group includes Smith and Nephew, St. Jude Medical, Zimmer, GE Healthcare, Perkin Elmer, JNJ, Bard, and Varian Medical Systems, and range from \$1 billion to \$2 billion.

Table 4
Top Medical Technology firms

Firm	Turnover (\$m)	S&P Top 10 ¹	Hoover's Rank	Study Rank	Reason to Exclude
Medtronic	9,087	1	5	1	
Baxter	8,916	2	3	2	
Siemens Medical	7,422 ¹		6	3	
Tyco Healthcare	6,695 ²		4	4	Mixed
Becton Dickinson	4,527		7		Equipment
Stryker	3,625	3		5	
Guidant /JNJ	3,698	4	8	6	
Fisher Scientific	3,564	5			Supplies
Boston Scientific	3,476	6	10	7	
Alcon	3,400		9		Supplies
Abbott	3,040	7		8	
Smith & Nephew	2,187			9	
Hillbrand	2,103	9			Equipment
Thermo Electron	2,097	8			Equipment
St. Jude Medical	1,932	10		10	
Zimmer	1,901			11	
GE Healthcare	1,701 ¹			12	
Biomet	1,600			13	
Dentsply	1,571				Equipment
PerkinElmer	1,535			14	
JNJ Med Device	1,490		1		
Bard	1,433			15	
Invacare	1,247				Supplies
Varian Med. Systems	1,041			16	

¹Medical device/technology sales only

²Includes devices and supplies.

Number of Cases. Case studies deal with unique situations, so two case-study firms were selected. Using more than one case yields better results for making contributions to management theory or concepts (Benbasat, Goldstein, & Mead, 1987; Eisenhardt, 1989; Yin, 1994) because it increases the level of detail available and strengthens the results through replication, thereby increasing the level of confidence in the robustness of the resultant theoretical findings (Amaratunga & Baldry, 2001; Rowley, 2002). Multiple case studies also provide a higher level of detail and

robustness for analysis (Rowley, 2002). Working from a “stratified” purposeful-selection perspective, it was decided to select a firm from the top strata that would be large enough, successful enough, and powerful enough to be able to lead strategic SC adoption if it chose to, balanced by a second firm from the bottom strata—also strong and successful, but smaller and less powerful than the market leader. This might appear at first glance to be outlier sampling but it is not: the purpose is not to learn from the unusual but rather to capture the range. Nor is it typical case sampling, which would involve choosing firms from the middle strata only, an approach that would not yield as full an understanding of the overall industry picture.

The stratified approach works well with the clear segmentation of the device industry. Between the two strata represented by the case firms, any major variations in SC adoption should emerge. However, to ensure a thorough understanding of SCM within the industry, two further firms were selected to complement the case firms. These firms represented important elements of the industry (a large multinational conglomerate and a mid-range pure play firm) for which case studies were not viable. The first informant came from a large multinational conglomerate for which limited information is available (the information available is pooled at levels that make analysis unfeasible), limiting its usefulness for a case study, but with the potential to provide an important perspective on the industry. The second informant came from a pure play firm in the middle of the range, whose firm had refused to participate in a case study, but agreed to cooperate in a more limited way. Thus, between the interviews and the cases, a very representative look at the industry was achieved, meeting the sample size criterion of “supporting the study’s purpose” (Patton, 2002, p. 245) of exploring the phenomenon of the strategic adoption of SCM at the industry level.

Analysis of Case Firm Candidates. The fifteen candidate firms were evaluated against established criteria as outlined below.

- One large and one small case firm.
- “Pure play”: the extent to which the firm concentrates on the core industry.

A company in which medical devices represents a small part of the company’s overall portfolio may yield results that are less representative of the device industry, particularly as their strategic variables may differ substantially. Therefore there would be a weighting against a company that derives a substantial proportion of their revenue from other industries.

- Evidence of SC focus: a slight positive weighting to firms whose SC efforts, while not out of line with industry norms, are more transparent or explicit than their peers.

- Strategic events: the presence of strategic “events”—episodes in which the firm made clear strategic choices or showed evidence of strategic planning. A firm with a history of strategic planning would be more likely to be consider including SCM in that process than a firm with a less-developed approach to strategic management.

- Globalization: it has been argued that there is a correlation between globalization and SCM, either because improved SCM makes globalization both operationally more feasible and strategically more potentially profitable, and/or because the logistics challenges of globalization obliges an organization to focus on SCM (Brennan, Murray, Phillips Connolly, & Sullivan, 2005). Therefore a more global firm should be more likely to have evolved their SCM strategies.

- Major organizational change within the last three years: firms who have faced major changes (such as restructuring, major financial crises, or significant

mergers or acquisitions) are likely to be still in the process of digesting these changes, which may in turn make any research findings less reflective of the norm. Therefore, a negative weighting would be given in the presence of such events.

Summary tables of the evaluation of each firm can be found in Appendix 4.

Selection of Case Firms. Each firm was reviewed considering the relative weighting of the evaluation criteria as well as what particular advantages or disadvantages the firm had compared to the other candidates. Several firms were eliminated directly:

- Guidant: at the beginning of merging with JNJ
- Abbott, Siemens, GE, and JNJ: medical technology is a small piece of the larger corporation (the pure play issue), which in turn means that information is grouped with larger divisions, severely limiting access.

- Zimmer: completed a merger doubling the size of the company in 2003

Of the remaining firms, Medtronic emerged as the best option amongst the large firms. It was the only pure play firm in the large group, and there was evidence of SCM (albeit largely for distribution efficiency). The smaller firm group was more homogenous; Bard was selected on the basis that it had a broader strategic history than the others.

Data Collection. Background data was collected for each case firm from a variety of sources, including:

- publicly available data provided directly or indirectly by the firm (e.g., annual reports, government filings, website information, promotional material, and newsletters);
- publicly available data from independent organizations (e.g., business magazines and industry journals);

- proprietary data, from research institutions (e.g., Standard & Poors, Dun & Bradstreet, Hoovers) and trade associations (AdvaMed, Eucomed); and
- historical information and industry background information provided by the managers interviewed.

Interviews were held with key SC decision makers to draw on their extensive knowledge base and aid in determining how SCM functions within their firm, and more broadly, their industry (D. Cooper & Schindler, 1998; Naumes & Naumes, 1999; Yin, 1994). Semistructured interviews provided a flexible tool able to be adapted to the individual and the firm, and allowed for the unexpected paths and cues suggested by “theoretical sensitivity” (Glaser & Strauss, 1967) that developed throughout the research process.

Direct approaches were made to individuals, but both firms required a short description of the research to be sent to the corporate office before agreeing to participate, and (in one case) giving permission for the individuals to be interviewed or (in the other case) nominating individuals to be interviewed. Confidentiality concerns were a recurring theme in trying to gain the cooperation of the firms and in some cases has limited the use of individual identifiers in this work to their titles.

Interviews were done by telephone. Each individual was interviewed at least twice for approximately an hour; an individual from each case firm was interviewed a third time, and clarifying points were addressed by email.

The interviews were semistructured (see Appendix 5 for a copy of the interview agenda). The write-ups of each case were sent to the respective firms for approval; no requests for changes or corrections were made by the participants.

3.4.3 Phase 3: Analysis

The typical approach to interview and case-study analysis is to create a descriptive narrative account of the encounter, which is then analyzed in order to generate insight (Gersick, 1998; Pettigrew, 1988), assist researchers with the volume of data collected during site visits/interviews (Eisenhardt, 1989), and provide an initial method for organizing and understanding qualitative data (Bryman & Burgess, 1994). However, grounded theorists object that there is a danger of losing or overlooking insights by reducing the information into an intermediate data layer before conceptualization (Locke, 2001).

In contrast, the usual grounded-theory approach is to transcribe the interviews as nearly exactly as possible and code each word, phrase, or paragraph that might have meaning. The data-reduction process continues through an iterative cycle of coding, summarizing, and theme identification (M. B. Miles & Huberman, 1984, 1994). However, grounded theory is usually used in social science contexts in which there is more, and more complex data to interpret than is found here. The extensive coding practices that are characteristic of most writing about grounded theory were not appropriate in this case where simple coding and sorting mechanisms by standard information processing software were sufficient. Indeed, the main findings emerged clearly and organically from the research.

However, to ensure that a sufficient level of rigor was attained and to explore the potential for greater replicability, the first round of empirical data (from the focus group and the interviews) was coded twice directly from the original data, once manually and once through the qualitative software package NVivo (a tally of the findings can be found in chapter 4). The results were identical and no new

understanding or constructs emerged from the entry or manipulation of the data with the NVivo software, so its use was discontinued.

The analysis of the case data began with thematic (content) analysis in which the data was sorted by like characteristics until patterns formed, which in turn became type categories (Gall, Borg, & Gall, 2002, p. 519). These themes and concepts are grounded in the research.

Once the case data was coded in a uniform manner, the original literature review and theory work were revisited. This allowed for patterns to be compared and contrasted with constructs grounded in SCM management-theory literature. This mode of cross-case comparison aimed at forming types or families to see whether any clusters or groups that shared patterns or configurations could be discerned (M. B. Miles & Huberman, 1994). The piecing together of individual patterns can help draw a more complete theoretical picture (Eisenhardt, 1991). Because building theory from case-study research is a strikingly iterative process, the resultant theory is likely to be empirically valid, as the theory-building process is so tightly connected with evidence that should also be consistent with empirical observation (Eisenhardt, 1989).

The findings from these analyses can be found in chapter 4.

3.4.4 Phase 4: Theory Development

In keeping with the iterative nature of the grounded-theory methodology and the theory development objective of this research, the findings from the analysis were explored for their potential contribution to theory. The findings represented both strategic and operational aspects of SCM.

At the strategic level, findings linked to the theory groups of knowledge, power and governance, as well as the importance of industry context, were extended with the application of four corresponding extant models. The findings and models

were then integrated into a new typology for SCM that advances SC theory. The typology characterizes four types of SCs that are aligned with four industry trajectories, and provide a clear strategic approach to SC development.

At the operational level, the findings were linked to extant SC tactics and techniques, and applied to the four SC types. Specific suggestions for operational approaches that align with the strategic types are provided. The extant models and their links to SCM can be found in Chapter 5, while the new SC typology can be found in Chapter 6.

3.4.5 Phase 5: Validation

A preliminary attempt at validation of the SC typology was made by returning to the original focus group. The composition of the group had changed slightly (some members had retired, and new ones replaced them), but the majority of the group remained the same. Moreover, the goals and objectives of the group were the same, and the population pool from which it was drawn was the same. However, confidentiality was an even bigger issue this time, as the purpose was to test a theoretical SC type against practice at their firms. Finally, the group acceded to a two-step process. . A survey with both closed and open questions was drafted and emailed to the IMDA, who then forwarded it to each member of the group. The online survey service, Survey Monkey, was used, enabling responses to be returned with full confidentiality. The executive liaison of the group monitored responses to ensure participation. After the surveys were analyzed a presentation of the findings was given to the group. This combination of survey and expert focus group has proved to be a useful combination in other SCM work, as it addresses the problems of terminology and complexity that are inherent in the field (New & Payne, 1995). These findings can be found in chapter 7.

3.5 Summary

The methodology employed in this study involved a number of different approaches, some of which (notably case study and survey) are more often used as the primary source of data. In this instance none of the individual strands would be strong enough to support an entire piece of research: more case studies or a larger sample size for the survey would be necessary. Here, the relative value of each approach was essentially even. The process of gathering information for the identification and selection of case firms, for example, yielded both valuable data and significantly enriched the understanding of the competitive circumstances as they related to SCM. Equally, the theory review and elaboration laid what became the cornerstones of the theoretical contribution for this work. This data resulting from this cumulative exploration of the environment is reviewed in chapter 4.

CHAPTER 4:

FINDINGS

As outlined in Chapter 3, Methodology, there were five phases of research. Having chosen to explore SCs through horizontal SCs- that is, at the industry level- and chosen the high technology medical device industry in particular, the first data collected was an examination of the device-industry itself. Because the work is essentially the exploration of an apparent paradox, it was hoped that a good understanding of the industry and its competitive environment could aid in the identification of relevant factors. Building on this base, the next phase of data collection was directly from the industry in the form of a SC focus group from an industry association, which helped establish baselines and reference points within the SC context. More detailed interviews with individuals in senior supply-management positions in device firms followed. The fourth set of data derived from two case studies, which looked at the SC function within device firms. Finally, there was a validation survey and follow-up meeting with the initial industry focus group. The findings from each stage are summarized in the following sections

4.1 Industry Study

The unit of analysis chosen in Chapter 3, Methodology, was the high technology medical device industry. In keeping with the spirit of a grounded theory approach and the exploratory nature of the research, the information gathering was deliberately broad, yet mindful of Porter's admonition as to the importance of a systematic approach in generating data for an industry analysis (Porter, 1980). The following sections first characterizes the device industry (including definition, industry classification, products, structure), and then the environment in which it

operates (regulatory and legal). The outlook for the industry, and the challenges it faces are discussed, and then SCM in the device industry is considered. Finally, in summary, a Porter five-forces assessment of the industry integrates the overview of the device industry.

4.1.1 Introduction

Medical devices have been around since at least the early parts of recorded history, as trepanning tools used (successfully) by the early Mayans demonstrates. However it wasn't until the 17th century, when the development of science as a structured undertaking in tandem with discoveries in anatomy, lenses, and metal work, that more sophisticated medical devices, surgical instruments, and microscopes were developed. The search for better ways to deliver treatments or understand the inner workings of the body continues a history that goes from the development of stethoscopes and anaesthesia in the 19th century to x-rays and magnetic resonance imaging in the 20th century.

It is important to remember that as simple as some of these tools now seem, they were cutting-edge technology in their day. Then as now the goal of the medical-device industry was to find better ways to diagnose and treat disease; a third goal, prevention, emerged during the 20th century, and the goal of our age, cost effectiveness, is the newest industry driver.

Defining the Industry

The medical-device industry develops nondrug or biological products, devices, and diagnostics to prevent, diagnose, and treat disease (Eucomed, 2003). In fact, the field is changing and evolving so quickly, and is such an integral part of the overall health care industry, that category definitions can be helpful:

Bioscience: includes biotechnology, life sciences (such as agriculture or environment), medicine, bioanalytical instruments and software.

Biomedical: Bioscience applied only to human health.

Biotechnology: a set of biological methods or technologies, usually using cellular and/or molecular processes, applied to research and product development.

Pharmaceuticals: the industry of producing chemicals industrially for the preventative or therapeutic treatment of disease.

Medical Devices: any physical item used in medical treatment; sometimes specifically electromechanical systems. (King & Seline, 2000)

Industry Classification

The classification of medical devices varies between the leading systems (International Sectoral Industrial Classification, Standard Industrial Classification, Standard International Trade Classification and North American Industry Classification System; see Table A6.1 in Appendix 6 for a comparison). The basic categories are similar, but the allocation among groups takes a product-based approach in the Standard International Trade Classification scheme and an activity-based approach in the International Standard Industrial Classification scheme. Both schemes are used internationally by the United Nations and the Organisation for Economic Co-operation and Development. For the purposes of this work, the International Standard Industrial Classification scheme has been selected on the basis that it has the most comprehensive category for medical devices: virtually all of them are included in a single 4-digit classification. The Standard International Trade Classification has a substantial proportion of the industry in just two 3-digit categories, which would be very useful, but unfortunately one significant aspect of the industry—appliances that

are worn, carried, or implanted, which covers everything from prosthetics to pacemakers—is covered in a separate 5-digit category. Much of the data is not available at the 5-digit level and the category is too central to leave out, so the International Standard Industrial Classification system is more appropriate for this work.

4.1.2 Medical Device Products

Medical device products can be grouped into several major sectors (Table 5):

Table 5

Major Medical Device Sectors

	% of WW Sales (2000)
Surgical and medical instruments	28%
Orthopaedic devices & surgical supplies	28%
Diagnostic reagents	19%
Electromedical equipment	14%
Imaging equipment	7%
Dental equipment	4%

Gold, R. (2004). *Healthcare: Medical devices*: Standard & Poors

However, these groupings mask significant divisions within the medical-device industry. Several of these categories operate in such distinct market segments that they rarely compete. For example, imaging is a capital-intensive physics-based industry whose products generally represent a significant capital expenditure for the customer. Its competitive parameters differ almost entirely from those of diagnostic reagents, which is a chemical-based industry that sells large numbers of small units to a very heterogenous customer base Similarly, dental equipment is almost entirely separate from electromedical equipment.

Finally, there is the divide between “conventional” devices, and “high-technology” devices, whether in the surgical, orthopaedic, or electromedical arenas. Conventional products are essentially commodities, with products such as intravenous

products and syringes; anaesthesia products; surgical apparel; surgical tools and supplies such as sutures; and standard instruments such as scalpels, blood pressure cuffs, and thermometers. It is a mature industry with high volumes, low margins, and sales through long-term contracts.

High-technology medical devices on the other hand are more invasive (and thus more heavily regulated), are driven by innovation (and thus have higher margins), and typically are more technologically sophisticated. Examples of products in the main device sectors are summarized in Table 6, below.

Table 6

High Technology Device Products

Group	Mature Products	Emerging Products
Cardiology	Pacemakers	Implantable defibrillators
	Defibrillators	Ablation catheters
	Angioplasty catheters	Drug coated cardiac stents
	Coronary stents	Ventricular assist devices
	Heart valves	Robotic microscopic devices for microsurgery
	Heart-Lung support	
Orthopaedics	Joint replacements	Robotically-enhanced prosthetics
	Internal & external fixation	Vertebral-fusion tools
	Spinal hardware	Electrical spinal stimulators
	Arthroscopic instruments	Electrified mesh for bone growth
		Artificial spinal disks
		Balloon-based treatment for compression fractures

Innovation in the medical-device industry is characterized largely by continuous, incremental change. Funding for research and development (R&D) comes from both the public and private sectors, though the private sector leads in actual product development and commercialization. (Littel, 1994). In the United States, federal funding for medical device R&D is approximately one quarter that for pharmaceuticals; the National Institutes of Health, the primary vehicle for federally

funded research, has allocated 5%–7% of its annual budget to medical devices over the last decade (AdvaMed, 2004; Littel, 1994).

4.1.3 Industry Structure

Overall the global market for medical devices was estimated at \$190 billion in 2002 (Gold, 2004), a 10% increase from 2001. The United States is the dominant producer, accounting for almost half of the global market (AdvaMed, 2004; Gold, 2004), and generating approximately 40% of its sales from overseas sales (U.S. International Trade Commission).

The high-technology medical-device industry is split between very small and very large firms. The innovating firms (about 86% of the total number of firms), are typically small, averaging under \$1.3 million in revenue, with fewer than 100 employees in the United States; similar numbers apply in Europe (AdvaMed, 2004; Eucomed, 2003). These small firms are research-intensive, accounting for almost a third of industry R&D spending, but earn just 10% of sales (Gold, 2004). By contrast, the large firms, with typically more than \$200 million in revenue, are much more concentrated—just over 300 firms in the industry have more than 500 employees, while the top 100 firms account for 50% of industry sales (AdvaMed, 2004). Investment in R&D is typically 9%–11% per annum—as opposed to 3%–4% for manufacturing as a whole (Gold, 2004). Unlike pharmaceuticals, where product-group markets can exceed \$1 billion, most medical-device product groups serve markets of less than \$150 million (Wilkerson Group, 1995). The end market users for medical devices are typically hospitals, physicians, and other healthcare providers and are frequently subject to third-party reimbursement.

It is worth noting that the large and small firms are more connected than it might appear at first glance: although most new innovations come from small firms,

most of these firms have benefited (directly or indirectly) from funding by large medical-products manufacturers.

Finally, outsourcing (also known as contract manufacturing) is a substantial presence in the market, accounting for approximately 27% of the annual spend on cost of goods. The four main areas of outsourcing are metal, plastic, electronics, and value-added services. Growth is highest in metal and value-added services, but the margins are low in all sectors except metal. However if a contractor can undertake the engineering work, they frequently contract the (more profitable) manufacturing work as well.

Trends in outsourcing in the device industry include consolidation, an emphasis on cost containment, and the growth of development centres offering engineering services. One-stop shops that position themselves as “strategic partners,” offering metal, plastic, and electronics, as well as engineering, assembly, and vendor-managed inventory, are becoming more popular. Major users of outsourcing include JNJ (metal, plastic, and value-added); Medtronic (metal), Guidant (metal), St. Jude (metal), Smith & Nephew (metal), Tyco (plastic, value-added), Boston Scientific (plastic, value-added), Baxter (plastic, value-added), GE (electronics), Philips (electronics), Siemens (electronics), and Kodak (electronics).

The drive to cost containment is beginning to push contract manufacturers to low-cost locations. Currently, the biggest cluster is in New England in the United States, with 22% of capacity (measured in terms of facility space available); followed by southern California (12%), Minnesota (11%), Pennsylvania (11%) and Mexico (7%). No other location has more than 5%; Texas, North Carolina, Ireland and Singapore have 3%, and there are another 14 sites with measurable cluster size.

4.1.4 Regulatory and Legal Environment

Given the role that medical devices play in human health care, a high degree of regulation is to be expected; globalization has brought initiatives for regulatory harmonization. Some of the more important participants are noted below.

U.S. Food and Drug Administration (FDA)

The FDA has had some regulatory authority over the medical-device industry since the agency's inception in 1938, but full authority, in line with that applied to the pharmaceutical industry, did not come until 1976 when internal devices (such as pacemakers and valves) had become established.

The approval process for established devices that pose a minimal risk to patients (for example, scalpels) is relatively straightforward, but for devices that are more invasive, or entail significant risk to the patient (i.e., pacemakers), the regulatory process is essentially similar to that for the pharmaceutical industry. The regulations were tightened again in 1990, 1997, and 2002. FDA approval is required for all medical devices sold or manufactured in the United States even if they are manufactured for export.

Approval times are long (an average of about 9 months once the application—which is quite involved—is accepted as complete (DeMarco, Hobbs, & Gornick, 2003)). It has been noted that regulatory agencies such as the FDA should be considered customers for the pharmaceutical industry, given the importance of the relationship (McGahan, 2004), and the same holds true for the device industry.

For the time being, the FDA's oversight of the industry is relevant to virtually all players in the device industry, including non-U.S. firms. First, any product that is manufactured or sold in the United States is under FDA authority, and as the United States currently accounts for half the market, any firm interested in that market must

come under the aegis of the FDA. Japan and the European Union have fundamentally similar systems and are working closely with the FDA to harmonize the regulatory systems further. Latin America is now becoming involved in this process and in the longer term a global regulatory environment can be expected.

International Electrotechnical Commission

A global regulatory environment for one end of the medical-devices industry is already evolving. The International Electrotechnical Commission (IEC) prepares and publishes international standards for all electrical, electronic, and related technologies (Commission, 2007). These serve as a basis for national standardization and as references when drafting international tenders and contracts. The IEC regulates all electrotechnologies including electronics, magnetics and electromagnetics, electroacoustics, multimedia, telecommunication, and energy production and distribution, so devices are only a small part of their mission. However, because of the number of electronic components in many devices, this standardization will have a direct bearing on SCM within the industry (see also Supply Chain, below).

Patents

Medical-device manufacturers patent their products extensively, but less precisely than the pharmaceutical industry; as a result there is a lot of patent litigation. In practice, however, medical-device manufacturers are less dependent on patents than the pharmaceutical industry because new devices are usually developed before the original patent expires.

World Trade Organization

The tariff reductions, improved intellectual property rights protection, and lengthened patent protection established by the World Trade Organization in 1995 have acted as a significant spur to international growth in the medical-device industry.

European Medical Device Directives

This directive harmonized all of the regulations relating to devices throughout the EU, and will also apply to the incoming member states on accession. The directive allows for centralized approval of all devices sold within the EU.

4.1.5 Outlook

The existing types of technology are expected to continue evolving and expanding over the next 25 to 50 years, thanks to advances in microelectronics, software algorithms, sensors, and biomaterials (Citron & Nerem, 2004). Combination devices, such as drug-coated stents and spinal-fusion cages with rBMP will become more common. Also, monitoring and diagnostic devices will become implantable, for continuous assessment of patients with chronic diseases (Citron & Nerem, 2004).

Growth and development areas for the industry comes from the continuing fusion of science and engineering as well as advances in biomaterial, tissue engineering, genomics, and computing (Eucomed, 2003). Further integration of bioengineering, biomaterials, genomics, computing and telecommunications will also drive the industry forward.

The long-term growth prospects of the industry are very positive: aging populations, growing global wealth in underserved markets, and modernizing healthcare systems in less developed countries should combine to keep demand strong. The benefits of standardization of specifications, increased intellectual property protection, and even standardization of regulatory environments should outweigh the increased costs of regulatory compliance.

Growth rates remain strong in the United States (7% p.a. in the United States), and even stronger growth in Europe and the rest of the world has led to projections of

global growth rates of 10% per annum over the next several years. Markets in China, Brazil, and Mexico are of particular interest in the near to mid term.

4.1.6 Challenges

Major issues facing the industry include:

Conservative capital funding: small, innovative firms periodically find it difficult to source venture capital for innovative products (Cates, 2002; AdvaMed, 2004). This can be expected to be somewhat cyclical and can be addressed to some extent through joint ventures and industry consolidation.

Uncertain regulatory requirements for some technologies: for example, some of the leading-edge products that do not fall neatly into one set of regulations or another. For example, drug-coated stents are both a drug (and therefore under pharmaceutical regulations) and a delivery device (and therefore under medical devices).

Payment (reimbursement) requirements, and cost-containment efforts. The vast majority of payments are through government agencies or third-party providers, which means a bureaucratic process at best. Approval of payment, especially for more innovative technologies, is particularly problematic. The industry's profit margins are known to be high, making them a relatively easy target for those seeking to control medical spending.

Industry structure: Medical devices is a fragmented industry and the speculation in industry trade journals is that there will be substantial consolidation over the next few years. The challenges of integrating the innovative culture of the smaller firms with the more established larger firms will likely mirror those of the IT industry at a similar stage.

Tissue engineering (growing replacement tissue) may, by the 2020s start to replace medical devices for many functions (Citron & Nerem, 2004). Other forms of

combined treatments will require integration of specialists from different areas. The differences between an engineering perspective (common in the device industry) and a chemical perspective (as in the pharmaceutical industry) have already been noted.

4.1.7 Supply Chain Management

Online Device Exchanges

At the commodity end of the industry, device manufacturers are aggressively using SC techniques to reduce pricing pressures. Internet-based purchasing and auction sites have led to the formation of the Global Healthcare Exchange (GHX), a website that matches buyers and sellers (www.ghx.com). Still heavily dominated by the United States and Europe, there are more than 100 supplier members and 380 hospital members. This trend toward online networks for SCM will clearly affect the existing distribution network, as well as the developing market for SC services. These online trading sites, are well suited to the routinized buying of low-end medical devices. However, even GHX member firms operating in both the commodity device industry and the high-technology device industry do not put their higher end (and higher profit) devices online, as it would tend to speed up the commoditization process.

Moreover, at the high-technology end of the industry there is a complex relationship between the medical personnel who traditionally specify which devices are to be ordered, and the institutional body that places the order. The device industry has long cultivated medical practitioners, whose authority was definitive. However in recent years the growing authority of the paying body has meant that the industry increasingly has to address the needs of both the user and the buyer.

Downstream SC

The downstream, or customer end, of the supply chain is going through a significant change: it is estimated that within 2 years more than 80% of all medical-

device purchases will be made by managed-care buyers, including government agencies (Advanced Medical Technology Association). This consolidation of buyers—though not necessarily outlets—offers both challenges (the buyer has more power in the relationship) and opportunities (product standardization, economies of scale, and the opportunity to develop long-term relationships).

Upstream

The upstream or supplier end of the SC has typically been of less importance, particularly in the high-technology end of the industry. Levels of vertical integration are typically high, and suppliers generally provide materials and parts rather than key components. This is changing however, with the integration of more elements in devices, which in turn is leading to an interesting new aspect of SCM in the industry. For example, an increasing number of devices have an electronic element such as a semiconductor. Semiconductors are increasingly important for microcontrollers, microprocessors, programmable logic, and analog products used in high-end medical devices. Electronic suppliers, especially mid-sized companies at a disadvantage in price-sensitive commodity markets, are finding the medical-devices industry a good outlet for their higher-margin products. This market has grown to the extent that medical devices can account for as much as 25% of sales for some semiconductor manufacturers (L. Sullivan, 2003). Display, data storage-system, and connector manufacturers have similarly found a new customer base in the medical-device industry. This interdependence is seen by the device industry as a worrisome level of dependency on other industries for their underlying technologies, such as microprocessors, sensors, and lasers (Benson, 1994).

Models

In the Literature Review (Chapter 2), a number of supply chain types were discussed. The Fisher (1997) and Lee (2002) models were used as archetypes, and are

applied below to the information gathered for the device industry. First, the demand type was identified. This is based on the type of product: whether the product can be considered a ‘functional’ product or an ‘innovative’ product. The findings for the device industry are summarized in Table 7, below, and point quite clearly to high technology devices being considered ‘innovative’ products.

Table 7

Demand Characteristics: High Technology Device Industry

FISHER / LEE CRITERIA	APPLICATION TO DEVICE INDUSTRY
Demand uncertainty	Short plc w/ high innovation
Demand predictability	Unpredictable demand
PLC	Short
Inventory costs	High
Profit margins	High
Product variety	High
Volumes per SKU	Low
Stockout costs	High
Obsolescence costs	High

Next, the Supply type was identified (Table 8, below, summarizes the findings). Here, the type is more difficult to establish. The mature manufacturing process, established supply base and long term contracts are characteristic of a Stable supply type, whereas the changing technology, high level of manufacturing complexity, low level of automation and high level of fine tuning in manufacturing suggest an evolving supply type. On balance, given the changing nature of the industry, the evolving supply type is a better fit for the high technology medical device industry. In the Fisher model this would suggest a Responsive supply chain, and in the Lee model a Agile supply chain.

A Responsive supply chain is based on a build-to-order and mass customization approach; an Agile supply chain uses similar tactics, but adds pooling

of inventory or other capacity management techniques. In both cases, the emphasis is on being able to minimize the risk of supply disruptions while being flexible enough to meet the demands of unpredictable customers. Internet based communications systems to monitor supply and demand, and tight links with partners to whom work is outsourced (the build to order element) are recommended strategies, and overall, a modified responsive SC is the closest fit.

Table 8

Supply Characteristics: High Technology Device Industry

Mature manufacturing process	Yes
Mature underlying technology	No
Established supply base	Yes
Level of manufacturing complexity	High
Level of automation	Low
Long term contracts	High
Level of fine-tuning in manufacturing	High

4.1.8 Summary Analysis

The Porter (1980) five forces model is a well-established tool for analyzing a firm or an industry. It is used here to both to integrate and augment the information that has been gathered in this industry study.

Barriers to Entry

Most new entrants into the device industry are small, innovator companies, who face relatively few barriers to entry. Once in the industry, however, they are dependent on alliances with larger companies to overcome the challenges of scale, access to distribution, regulatory requirements and the capital requirements for scaling up production.

Entrance on a larger scale is most often through acquisition, because the barriers to entry are so high. Although the scale of production of most devices is

relatively modest in manufacturing terms, there are important economies of scale in terms of access to research. Further, while the scale of production may be limited, the capital requirements can be substantial: the production equipment can be quite specialized, and inventory levels can be high. Product differentiation (through patents and first to market advantages), and government policy (through regulatory requirements) are significant barriers to entry as well. Access to distribution channels has recently become a problem for newer or smaller device firms, due to the advent of buying groups (see Bargaining Power of Buyers, below). And, in some cases, switching costs can be high, particularly in terms of training.

Therefore, the barriers to entry are high enough to keep the larger firms in the device industry relatively safe from new entrants.

Intensity of Rivalry Amongst Competitors

Relative safety from new entrants, however, is off-set by the intensity of intra-industry rivalry. Many of the most common rivalry drivers do not apply to the device industry: the large firms are concentrated, but relatively balanced, the industry is growing quickly, the products are not commodities, and capacity can be added in small increments. However, the strategic stakes are very high: prestige and technological credibility are central. Moreover, while historically firms could be extremely successful operating within one a given product group (such as cardiac or orthopedics), there is increasing pressure to be able to provide a range of devices. As a result, more of the top tier firms are competing with each other in more arenas.

Substitute Products

Because of the high barriers to entry, the primary threat to a device firm has been innovation by a rival. However, many of the emerging treatment methods are coming not from engineering-based devices, but from applications of chemistry, biology and physics. The new treatments serve the same function- speeding the

successful healing of a broken bone, but where the engineering-based device firm uses surgically implanted screws and rods, the biology-based tissue lab uses an electrified mesh coated with recombinant DNA. Many in the device industry see the new approaches as an opportunity, but is also clearly a potential threat.

Buyer Power

Some of the characteristics that are associated with high levels of buyer power are irrelevant to the device industry: there is no credible threat of backward integration, the products are not commodity products and the quality of the devices is obviously important. Other characteristics are more ambiguous. The most important buying criteria has been the quality and functionality of the product; price has historically not been an important variable (though it is becoming one). Because the costs are passed on to the end user (the patient), devices have not been a significant cost centre for the buyer. Moreover, it is still difficult for buyers to get good information on pricing and demand. These factors all tilt the balance of power toward the device industry.

On the other hand, until recently, the trading relationships between buyers (doctors, hospitals, health organizations) were fragmented and individual. Each firm had to have large numbers of salespeople cultivating relationships with medical practitioners, in the hopes of gaining a customer. Also, buyers typically buy large volumes compared to the level of the device firm's sales. These factors tend to tip the balance of power toward the buyer. As the buyers become more concentrated and more professional the balance of power is likely to continue to tip towards the buyer, with the caveat that a genuine innovation may gain the firm a (temporary) trump card.

Supplier power

The ambiguous character of buyer power is echoed in the balance of power with suppliers. Device firms tend to have two levels of suppliers. Because the industry

is vertically integrated, most supplies will be in raw material or early stage form. This means that the threat of forward integration is minimal, and even if the numbers of suppliers is relatively concentrated there are likely to be viable substitutes. On the other hand, because of the relatively small scale of manufacturing, firms in the device industry tend not to be important customers. Thus, for these products, except for very large companies, the supplier is likely to have somewhat higher levels of bargaining power.

Increasingly, however, device firms are buying in (or co-designing) important elements of the product. On the one hand, the supplier has a high level of relative power because of the importance of the component, and the difficulty in switching suppliers (because of regulatory policies). The industry uses alliances and equity relationships to try to keep a favorable power balance.

4.1.9 Conclusions

The high technology medical device industry is somewhat paradoxical: on the one hand, it is in the enviable position of being highly profitable, fast growing, with high barriers to entry. On the other hand, competition is intense, there is a constant (and growing) threat of substitution, and power relative to both customers and suppliers is at best fluid- in some circumstances higher, others lower. Many industry characteristics are double-edged swords: regulation is expensive and demanding to manage, but acts as a barrier to entry; high profits are attractive to shareholders and allow for continuing investment in innovation, but make the firms attractive targets for increasingly budget-conscious buyers. And everything rides on the latest innovation.

It is clear that the nature of the industry plays a significant role in many aspects of SCM in the device industry. Knowledge flows between trading partners are

affected by the need for confidentiality as well as the need for regulatory compliance; the mean that firms need to continuously manage variable power levels between themselves and their trading partners, and a range of governance mechanisms are used in their trading relationships.

4.2 Focus Group

The first phase of the empirical work involved using the IMDA SCMWG as a focus group to identify views on SCM within the industry, to identify the relative importance of different SCM strategies or tools in the device industry, and to identify aspects of SCM that would be useful to explore in more depth in the case studies. The focus group work began with an extensive interview with the IMDA executive who coordinates the SCMWG and was followed by a meeting with the group. The group also participated in the final stage of the research, validation.

The findings from these three phases are outlined below.

4.2.1 Background Meeting

Susan Doyle, 18 September 2004, IMDA offices, Dublin

The background meeting with the IMDA executive liaison, Susan Doyle, was important on both sides. Before the SCMWG would agree to cooperate with the project they wanted assurances on the relevance of the project, the researcher *bona fides* and, crucially, on the confidentiality with which any information gleaned would be treated. Confidentiality turned out to be a *leitmotif* in working with the device industry and has coloured every element of this research. From a research perspective the meeting was important as a means of establishing a working relationship; of gaining an understanding of the structures, priorities and interests of the IMDA and the SCMWG; and for identifying potentially fruitful areas for discussion.

In her role as liaison with the IMDA, Doyle identified three areas as being of particular importance to the SCMWG: the role of SCM, education, and access to information.

Despite being one of the six working groups, there is a sense in the group that SCM is not seen as a top priority, within the industry in general and to some extent even within the IMDA. The group has recently asked for stronger links to the IMDA board, and would like more “legitimization” from the board.

Education is a priority on several levels. Operationally, the group sees a need for more trained/certified workers, and a desire for the existing courses to be better synthesized. Within the group there is a tremendous appetite for more training and workshops. And at a general level, there is frustration that people outside of SCM do not understand it.

This links directly to the third area that Doyle emphasized, which is a strong desire for information on what is happening in the area of SCM both outside of the device industry, and outside of Ireland. Here the emphasis is on trends and strategies, as opposed to the latest tools and techniques. Following this meeting an agenda for the group meeting was drawn up, and circulated to the SCMWG (see Appendix 7).

4.2.2 IMDA SCMWG Meeting

14 October 2004, Bayer Healthcare offices, Dublin

Attendees: IMDA, Executive liaison; DePuy, Global Supply Manager; Olympus Diagnostics, Materials Manager; Boston Scientific, Logistics Director; Bayer Healthcare, European SC Director; Bausch and Lomb, SC Manager; Isotron, Regional Director; Clearstream Technologies, SC Manager; Lake Region Manufacturing, Materials Manager.

The meeting included both directed questioning, working from the agenda, and broad-ranging conversation on supply chain issues. After an introduction to the project, the group was asked how advanced they considered SCM to be within the industry. The group clearly felt that although the industry has a number of firms on the leading edge of SCM, it is significantly behind the electronics, textiles, food, and automotive industries. This was ascribed to the nature of the industry, which was described as very conservative and risk averse.

For many of the companies in the group, the desire to become “best in class” is also hindered by their role within their parent firm. To broaden that role they would like to become linked into new product development, because R&D is a “power centre,” which tends to be collocated with production. The idea is that more R&D sited locally will mean more production and therefore more SCM. Further, strength in a “know-how” area such as product development could in turn offset the increasing costs of being based in Ireland. There is a fear that the device industry has stayed in Ireland because of “inertia” and that as reinvestment decisions are made the operations may be closed down.

Another approach is to try to manage other elements of the SC (one firm is managing the firm’s Asian SC through Ireland), or even the global SC (as one firm is doing). The firms in the group use a variety of SC tactics, including typical SC metrics and SC teams, but the participants said that the industry avoids outsourcing or changing suppliers (except for packaging).

The major focal area at the moment is cost-containment measures, which are “getting more important every day.” Lean techniques, Six-Sigma initiatives, inventory reduction (there was a consensus amongst most of the members of the group that “we own too much inventory”), and waste management were identified as the biggest

priorities for current and planned investment. The drive to contain costs is beginning to overcome the resistance to sending production to China, at least for low-end/older products for which the intellectual property risk is hoped to be less.

Other SC performance-improvement initiatives noted were procurement (including vendor management, cited as an important area for future improvement), which has not historically been as important (because the cost of materials is a relatively small part of the overall cost); customer service; and planning. The emphasis on enterprise resource planning and systems integration is shifting to sales and operations planning. Although none of the members of the group are currently using an advanced planning system, several were planning to implement them in the near future.

Beyond their own operations, regional infrastructure, developing the local supplier base, and connecting SCs were identified as important issues for SCM for the group. However, it was education that was cited as “a real priority.” This need exists at two levels: at an operational level there is a desire to consolidate the various training schemes and (in particular) highlight the career potential in order to get more better-trained people. At a managerial level the group expressed a strong interest in learning more about current SCM trends. It was noted that defining benchmarks in the industry is difficult, because the differences between the subsectors are so big. There was a strong interest in identifying good benchmarks for full SC inventory; the use of (and levels for) key performance indicators in SCM; and time to market. It was noted that these operational benchmarks would need to consider where SCM is going, the business dynamics, product evolution (especially technology), cost, and regulatory environment. Finally, when asked what else they would like to know about SCM,

there was a desire to know more about their parent firms' SCs. And rather plaintively, there was a desire expressed to get an idea of "what good SCM looks like."

4.3 Interviews

4.3.1 DePuy

Donal O'Malley, GSC Director, 1 June 2005, DePuy offices, Cork

JNJ is a healthcare conglomerate whose businesses include high-technology and commodity medical devices (which operate completely separately), consumer products, and diagnostics. The company is structured through more than 200 operating companies and has a reputation for balancing a strong corporate ethos with a high degree of independence for their operating companies. DePuy was a leading orthopaedic-device company before being bought, along with several smaller competitors, and merged with JNJ's existing orthopaedic business. Because of its market value, the name was kept for the new group.

The new DePuy is headquartered in the United States and has manufacturing sites in the United States (California, New Mexico, and Ohio), the UK, Ireland, and China (starting mid 2005). R&D is carried out at the Indiana headquarters and in the UK. There are also divisional offices in Asia, South America, and Africa. All sites are served by global Quality, Commodity, Finance, Legal, and Operations divisions.

The Operations division is led by the Worldwide (WW) Vice President of Operations (a board-level position). The U.S. Vice President reports to the WW VP Operations and in turn has two main reports the Strategy Director and the GSC Director. The Strategy Director is a new position that looks at new product concepts and strategies in a time horizon of 5-years or more. The GSC Director (Donal) has four main reports: Sales and Operations Planning, Global Inventory Management,

Customer Service (International, i.e., all non-U.S.) and International Distribution (i.e.,



all non-U.S.). Figure 3, below shows the relationship between these various elements.

Figure 3. DePuy organizational structure.

Because of legacy sites from the merged companies, the new DePuy group was initially fragmented and there was a lot of duplication. JNJ already had a strong emphasis on SCM, and the GSC group worked with the newly formed DePuy group to rationalize operations and establish a global-supply chain. Initially there were three operations centres (the United States, the UK, and France) until they were combined into the Global SCM in Cork in 2001. The new centre was a joint effort by operations, finance, and legal, who worked together to identify ways to add value to the operation. This led to the GSC group in Cork funding R&D to look for product and/or process improvements. The resulting profits/margins are applied to the GSC (through Ireland) to take advantage of the tax regime.

O'Malley's background is in electronics, and he came to DePuy two years ago from Flextronics. He sees the electronics industry SC as being aggressive, immediate, tactical, and day to day, and thus very different from medical devices. He attributes some of this to the confidence that the device industry has in its market, and notes that the industry is high growth and high margin, which has insulated it from SC pressures. Also, he agrees with his colleague, Ger Cronin at Guidant, that in the

device industry, technology will always be the first priority with senior management and SCM will remain a secondary service.

O'Malley sees DePuy as being "above average" in the device industry in SCM and attributes their success to three factors: corporate support and expertise, strategic integration stretching beyond the operations group, and good implementation.

O'Malley feels that corporate sees the GSC groups work as "good" so far, but that to get to 'great' they will need to demonstrate a significant impact on gross margins.

They are planning to do this by working to reduce inventory by one third and reducing the product portfolio by 25–40% (they have 54,000 SKUs). A reduction in the number of hubs and some outsourcing to China will also help. This mix of strategy with more operational tactics is possible because of the SCM structure, which is well linked into senior management and the board.

There are a number of other SC issues that O'Malley sees as a concern, for DePuy in particular, or for the industry in general. For DePuy, the two areas that he sees as most problematic relate to internal information flows and external customer links. O'Malley has seen substantial improvement in the information flows between sales and marketing and operations: they are now all using the same language as operations, and the operations group supplies one set of numbers to be used across the firm. However, they still need one set of real-time numbers. Currently there are two, one from the international group (on a JD Edwards system) and the other from the United States (a Peoplesoft system). They have to upload both and merge them. The plan had been to roll out the JD Edwards system globally by now, but mergers in the United States (JD Edwards merged with Peoplesoft, which has subsequently been bought by Oracle) have delayed the process. However the JD Edwards advanced planning and scheduling system has been rolled out globally.

The other major issue is customer links, both internal and external. At DePuy, manufacturing operations are considered “subcontractors” to GSC and their “market” is the distribution centre hubs. The hubs then deal directly with the external customers. The GSC would like to get closer to both their internal and external customers by reducing the number of hubs.

A separate issue is their links to their external customers through the distribution hubs. Kits for orthopaedic surgery include all the parts and instruments needed for a procedure. There can be up to 20 different sizes of a given part included in the kit along with any special instruments needed for the procedure. Hospitals order the kits on a consignment basis, paying for the kits only after it has been used. Larger hospitals and clinics keep the instruments and sterilize and reuse them; smaller ones are sent the equipment and return it within 5 days. O’Malley noted that there can be “millions” tied up in consignment goods within a hospital. The issue of consignment sales applies to many segments of the device industry.

Other industry issues that O’Malley notes as being particularly relevant in the near term are the pace of change and branding, and in the longer term, the need for a strategic view and to prepare for “indigenous” production (that is manufacturing by firms indigenous to nontriad countries). The pace of change in the industry is one of the most striking changes that O’Malley has noted. Product life cycles—already short when he came into the industry—have shortened even further, while product rationalization has accelerated. Outsourcing in general and moving production to China in particular are becoming more common. However when it comes to sending the manufacture of older or lower-technology products to China or other low-cost sites, he notes that they used to do that but not any more because “it makes more sense to build factories for the future than the past.”

The other industry change noted was branding, which is relatively new in the device industry. JNJ has just started its first branding initiative, which is very successful (and in turn challenging for manufacturing and SCM, as the volume of orders has risen sharply). The campaign draws on the JNJ brand name (“It helped to know that it was Johnson and Johnson”), a particular asset for DePuy, as the few of their competitors would have the brand recognition and loyalty associated with JNJ.

Finally, for the future O’Malley notes that the industry has good data but feels that it has to be more strategic, and look further ahead. Capacity planning in the longer term will be an issue and the industry has perhaps 10 years until “indigenous” manufacturing is a real threat, yet this is “off the radar” for most firms.

4.3.2 Boston Scientific

Joe Heffernan, Director of Logistics; 2 June 2005; Boston Scientific offices, Cork

Boston Scientific is a relatively young company (25 years) that specializes in less-invasive medical technology. There are four regions (the United States, Europe, Japan, and Intercontinental), but all products are made for the world market and shipped to either Boston or Holland.

Corporate headquarters controls Human Resources, Finance, Distribution and Operations (including Manufacturing); additionally there are five relatively autonomous product groups who follow very different sales and marketing strategies. Each product group is headed by a Divisional President, who in turn has Vice Presidents of R&D, Marketing, Sales, and GSC Management reporting to them. The Vice-Presidents are all part of the GSC Council within the firm as well.

The Operations Vice President reports to the Chief Executive Officer (CEO) and in turn the heads of Manufacturing, Distribution and GSC report to the Vice

President. The SC structure is very segmented with little connection between different segments even internally, and each element has clearly defined roles to play.

Heffernan studied business in college, and has done further studies in marketing and SCM. He has worked in SCM for more than 20 years starting in the freight, metal, and computer industries before coming to the healthcare sector and then into the device industry, where he has been for the last 12 years. He has led the development of the SC operation in the Cork facility from its inception 8 years ago.

Operationally, the focus is on lean manufacturing. There are some difficulties in achieving this because the facility operates in low volumes (“a big product is 150,000 units a year”), and yet has to be very flexible as it serves all of the product groups, manufacturing 30–40 product lines in five engineering disciplines. The small number of units and the variety of products means that they cannot invest in automation or build engineering expertise in any one area. SC initiatives try to balance the focus on lean manufacturing while maintaining flexibility. There is a SAP (a leading brand of enterprise resource planning software) system, now being upgraded to SAP’s Advanced Planner and Optimizer. The move to Advanced Planner and Optimizer is being driven by a need to increase responsiveness of the manufacturing and supply base and thereby increase flexibility. Among other things, the new system will reduce the planning cycle to one month (currently the planning cycle takes three months: in the first month a forecast is generated, in month two a production plan agreement is reached, and in month three the plan starts). Kanban and Supplier-Managed Inventory are also used. The major metrics are available inventory (customer line fill; target: 98%), finished goods turns, forecast accuracy, and market share against plan.

The only outsourcing they do is contracting out for some manufacturing engineering elements (such as repair work on lines; some extrusion, machining; and some consumables or indirect components). All other manufacturing and process or engineering development is kept in-house. On the supplier side there are six or seven U.S.-based suppliers and one Irish-based supplier who are part of the development team; corporate has a Strategic Sourcing Initiative that is aimed at reducing the number of suppliers overall.

Heffernan sees a number of SCM challenges ranging from general issues for the industry to specific issues for the Cork operation. In the industry, managing regulations is getting harder because the standard required of submissions keeps going up: competitors turn in better submissions and then the regulatory authority wants everybody to meet that standard. At the same time, he sees regulation as “a useful way to keep out new competition.”

For both the firm and the industry globalization has brought a number of different challenges. Eastern Europe is probably just a “flash in the pan” in terms of moving manufacturing, because “the demographics are against it”; however “there is good sales potential.” Both manufacturing and sales in China and India are “hot topics” and the company is “tip-toeing” into China, testing sales through a distributor. Theft of intellectual property and grey-market resales are major issues. The question of resales also came up when the company tried to donate product to third-world medical teams but found that the SC is not secure enough and too much donated product was turning up on the black, and even the grey market. Heffernan sees China as currently a bigger threat than India, but sees better long-term prospects for India.

The company is open to opportunistic relocation: they opened a manufacturing operation in Costa Rica simply because they “got an incredible deal.” On the other

hand, the Irish operation is going to have to justify itself before the 2012 tax code changes. Heffernan feels that if they “have succeeded in demonstrating excellence—which will matter more than cost” they will be fine. They need to show “engineering brilliance” and understanding of product/process. Equally, though the operation should “be broadminded about being a profit centre and if a product should move to another location they should take the initiative, instead of waiting to have it moved.” This will “give credibility” when they fight for other things.

Heffernan feels that the biggest obstacle to evolution of the Irish operation is the Department of Health, which could do more to help with “stickiness” of industry in Ireland. Ideally there would be two or three hospitals identified as “Centres of Excellence” for medical devices, to which world-class medical people would come to do trials with Irish-developed products.

Within Boston Scientific, the corporate focus is on “proprietary technology.” High margins allow for innovation and provide money to buy indigenous companies if they come up with something useful; as much as half of the firm’s innovation is bought in this way. The firm has “learned to buy a company and leave it alone” because trying to integrate the new company usually backfires. A particular problem is that the locus of innovation within the new company is often hard to identify, and the key people can end up leaving before anybody realizes that they are the key.

Despite the appearance of high-level involvement in SCM, Heffernan feels that “SCM is a low priority” in the firm. The segmentation within the firm emphasizes this: each group has clearly defined roles and information is “siloe” within each segment. For example in Sales, the role of the sales representatives is to get shelf space and keep it full, and to develop/maintain doctor relationships. These customers drive innovation: R&D creates a plan, which is in turn driven by

marketing. The GSC Council “listens” to Sales and Marketing, works with Distribution, and gives everybody “numbers” (targets). However, this is a “one-way” system, as the SC group has “limited” involvement in product/process development. The SC group is essentially “a buffer between S&M and Sales & Op planning—if the plants could make everything that Sales wants there wouldn’t be a need for GSCM”. Even procurement strategy is driven by corporate. Heffernan would prefer to have direct contact with his “customers” (Sales and Marketing), because “both sides would understand each other better.”

4.4 Case Studies

Having established some parameters, a more detailed look at two device firms was carried out. These case studies examined SCM within the organization through semistructured interviews, seeking to understand the reasons for the firm’s approach to SCM, and included questions specifically addressing the knowledge, power, and governance aspects of SCM.

4.4.1 Case Study: Medtronic

Introduction

Medtronic embodies the classic medical-device company story: founded by an individual who sees a need and uses their mechanical or engineering skills to fill the gap. At Medtronic, founder Earl Bakken started repairing medical equipment for local hospitals, essentially creating the cardiac-pacemaker industry. From the inception of the pacemaker business in the late 1950s until the mid 1980s, Medtronic had more than 70% of the world market share of pacemakers and is still the market leader with 53% of global sales. This business is now the Cardiac Rhythm Management (CRM) business unit and still accounts for almost half of Medtronic’s revenue.

Fortune magazine has dubbed Medtronic the “Microsoft of the medical devices industry” (McLean, 1999). Certainly it is substantially the biggest of the pure play medical-device firms (i.e., those whose primary business is high-technology medical devices): it is more than twice the size of its next competitor. However Medtronic seems to manage its public relations better than Microsoft, and even when it stumbles (in a rare product recall or unsuccessful acquisition, for example), the press coverage is not particularly harsh.

The following narrative and analysis looks at the intersection of strategy and SCM at Medtronic. As such, it is not a linear narrative; rather, it describes and characterizes a range of aspects of Medtronics as part of identifying the variables that shape the strategic use of SCM within the firm. The first section looks at the firm as a whole, particularly its history, the ways that it organizes itself and the challenges it faces. The second section explores the SC elements more directly, including where SCM fits within the organization, the SC practices employed, and the SC issues on which the SC group is focused.

The narrative is derived from interviews with a vice-president of operations and general manager of a product group at the national level, an SC vice-president at the product group level and an SC vice-president at the international level. This information was supported by additional sources gathered both before and after the interview process including private and public publications (newspapers, business and industry journals, and industry studies) as well as discussions with other industry participants. See Appendix 8 for more information about the Medtronic sources.

History and Evolution

Earl Bakken, then an engineering graduate student, started Medtronic in 1949. When waiting to pick up his wife from her job as a medical technologist at a local

hospital, the staff would ask him to help repair electronic laboratory equipment. Recognizing an opportunity, Bakken dropped out of graduate school, recruited a friend and established a shop. The first year was difficult but in the second year they became representatives for medical equipment manufacturers as an additional source of income. Increasingly they modified equipment or built new devices to meet a particular need. Through this work they developed relationships with medical teams throughout the region including the research team at the University of Minnesota where Dr. Lillehei, a pioneer in open-heart surgery, was based. Bakken worked with Lillehei's team and in 1957 invented a battery-powered external pacemaker. Recognizing the potential for growth and needing the cash for expansion, Medtronic was listed on the stock exchange that year. Within three years an implantable version had been invented (by Chardack and Gage), with Medtronic as the exclusive producer and distributor.

Although the term did not exist at the time, Medtronic was a "born global" company with significant global sales (first directly, then through a distribution agreement) by 1960: once the product was invented there was a global market waiting for it. A second wave of internationalization followed in 1967, with the opening of the first international operation, a service centre at Schipol Airport in Amsterdam (necessary for the speed of service required in such a sensitive product) and later manufacturing operation (prompted by local price competition). Subsequent waves of internationalization were in 1972–1974 (when Medtronic bought out international distributors, opened regional headquarters in Brazil, France and Japan, and opened a manufacturing centre in Puerto Rico), the 1980s (through competitor acquisitions), and 1996–1999 (operations opened in Denmark, Switzerland, Ireland and China;

European headquarters moved to Switzerland; See Appendix 9 for a list of current operating locations.

However in the medical-technology industry market leadership is volatile: an innovation can bring market dominance as it did for Medtronic for the first 20 years, but continuing innovation and the inevitable spread of technological expertise means that constant reinvention is necessary. By contemporary standards Medtronic held market dominance for a remarkably long period, but by the mid 1980s a combination of increased competition and quality problems had led to a fall in share of the CRM market from 70+% to 29%.

Medtronic undertook major changes to their management structure, starting with the retirement of founder Bakken and a new CEO and followed by a new president. A layer of project managers was added to coordinate across functional groups. These changes (and the introduction of an unexpected breakthrough product) were credited with the return to market leadership in the mid 1990s.

With the change in management came a policy of continuous reinvention, with planning cycles of 5+ years. In recent years their strategic foci have included:

1989–1994: Evolution from pacemaker producer to cardiovascular specialists.

1995–1999: Evolution from cardiovascular to implantable medical technologies.

1999–2004: Expansion from implantable medical technologies to interventional therapies.

2005–2010: Evolution from technologies and therapies to chronic-disease management.

The focus on chronic-disease management includes internet-based patient-management systems (in particular, remote monitoring), with an increased emphasis on lifelong management of disease (integrating care across traditional medical

divisions) and on solutions rather than products. The company feels that this reflects a change from being a medical-technology company to being an information-technology and information-services company.

In 1996 further organizational changes were made to improve the product development process, which was seen as slow, unfocused, and as having too little integration across platforms. A structured approach to product development was put in place including changes in organizational responsibilities that led to the role of project manager (previously “a relatively toothless job”) becoming a career-advancing position. A specific and mutual link between engineering and marketing was established. Finally, “micro companies,” with internal “customers” and “suppliers” within the organization were implemented.

As part of maintaining the overall growth rate of the firm, during the mid-to-late 1990s the firm underwent one of the most aggressive acquisition sprees in the medical-devices industry, virtually all of which was outside the CRM business.

Strategic Challenges

Apart from the core challenge of maintaining innovation, Medtronic faces strategic challenges in four key areas: coping with growth, changing competitive characteristics associated with product life-cycle evolution, changing customer dynamics associated with structural changes in the marketplace, and changes in the core competencies necessary for innovation.

Coping with rapid growth, both organic and through acquisition, has been one of the biggest challenges for the company. The pressures of coping with a bigger organization and more product groups, as well as the integration of recent acquisitions, has recently led to a new emphasis on improving systems.

In the meantime, the growth rate for some core products has slowed. For example, the “boom days” of pacemakers are past; growth is estimated at just 4% per annum in coming years. At the same time, product life cycles are getting even shorter: 2 years is typical, and can be as short as 6 months. This makes it harder to hold onto market dominance. Medtronic had more than 50–70% of the implantable-pacemaker market for the first 20 years after introduction, whereas the market for pacemakers with remote-monitoring capability, only approved by the FDA in 2002, is already split between more than a dozen competitors in addition to market leaders Medtronic and Guidant. Shorter life cycles also shorten the time between a product being innovative (and thus high margin) and becoming a commodity. Typically device firms have kept innovative and commodity product groups separate (either as separate divisions or separate subsidiaries), because the selling paths, cost structures, and competitive environments are so different.

Changes in selling paths are a particular issue for Medtronic. Historically the key customers have been cardiac surgeons, who have been at the top of the medical hierarchy and until very recently, able to dictate what products they used. The key sales and marketing tools have been education and relationship management, through direct visits as well as through seminars and hands-on training courses. However for a number of reasons even cardiac surgeons hold less sway than they used to, and as Medtronic’s customer groups broaden to include buying groups, hospital buyers, clinics, and service providers, educating them about Medtronic products becomes more challenging. Further, as patients are playing a greater role in their own care (especially with remote monitoring devices), ensuring that they are “using their products optimally” becomes critical.

Not only do individual medical practitioners have less of a say in buying decisions, and buying groups are more becoming common, but the buying groups are also becoming more powerful, leading to pricing pressures. The pressure from buying groups and the increasingly professional approaches to buying throughout the healthcare system not only has put pressure on Medtronic to improve its systems, but to diversify. The diversification strategy that Medtronic pursued at the turn of the millennium reflected both a need to spur growth and a response to the increased pressure to offer a full line of cardiac surgical equipment. In particular, “arch-rival” Guidant offered both stents and pacemakers; in response Medtronic entered the stent market through acquisitions.

Finally, the need to diversify is also being driven by changes in the core competencies needed for innovation. Medtronic believes that the trend toward convergence of surgical, chemical, and biological treatment approaches will accelerate, and has made acquisitions and alliances in anticipation of these trends.

Supply Chain Management

SCM is part of the Operations group, and is loosely linked through the business units via an SC council run by the Chief Information Officer (CIO), with whom there is a “faint dotted line” relationship. The SC council oversees SCM from “suppliers to customer.” The corporate SC team coordinates the business units, but takes a “soft approach”, trying to encourage rather than mandate cooperative efforts.

SC Structure

The SC at Medtronic has three distinct segments. External suppliers are “owned” by the business units, which operate as “micro-companies” with internal “customers” and “suppliers” within the organization. Each business unit is responsible for its own GSC, but is also overseen by the GSC council.

Most products are produced at a single site for the global market. External customers are “owned” by the regions, which manage demand and inventory in conjunction with production.

Figure 4, below, outlines the structure of the SC in Medtronic:

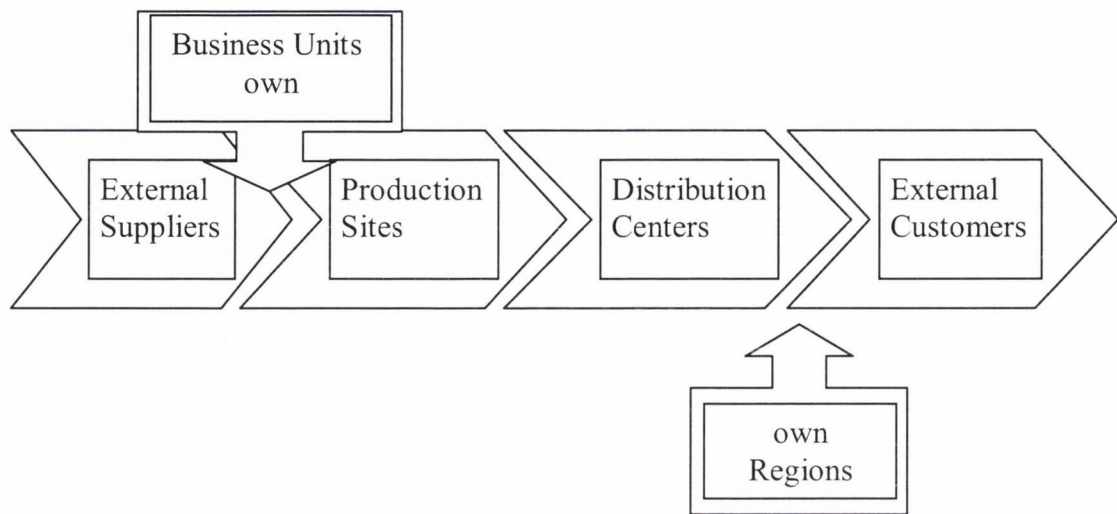


Figure 4. Medtronic supply chain.

Trading Relationships: Suppliers

Medtronic has two types of suppliers: general supplies and components. The bulk of their suppliers are local (60–70%), with the rest split between internal suppliers (i.e., other Medtronic divisions) and international suppliers. The majority of Medtronic’s external suppliers would be considered “market” sourcing, though given the sensitivity of the marketplace contracts are standard. As the relationship with a supplier gets closer, it is increasingly formalized into binding contracts (both to ensure fulfillment and to ensure nondisclosure). As costs have become more of an issue the company is working harder with suppliers in order to drive better deals.

Trading Relationships: Outsourcing

Medtronic is very cautious about outsourcing. However some manufacturing of older technologies has been outsourced, both to the Medtronic operation in Mexico and to outside contractors in Mexico.

There is some disagreement within Medtronic about outsourcing. In particular Medtronic has produced its own microchips (an implantable defibrillator has more than 13 million transistors, as against 7 million in a Pentium II) since 1973. To get into the microchip business Medtronic bought Motorola's semiconductor business and established a wholly owned subsidiary now known as Medtronic Microelectronics. Many of the senior managers in manufacturing came from Motorola and are resistant to outsourcing microchip production. Some of the SC team feel that Medtronic is now behind the leaders in microchip technology and production, while some of the executive team feel that Medtronic is better off using tried and tested technology.

Trading Relationships: Alliances

Medtronic is involved in dozens of strategic alliances (see Appendix 10: Timeline and Genealogy for a listing of known alliances). The most common form of strategic alliance for Medtronic is minority stakeholdings, many of which later turn into acquisitions. This is a familiar pattern in the medical-device industry, where bigger firms support the development of promising product development in small firms and establish a proprietary hold in case the technology becomes marketable.

Distribution and licensing agreements are the next most common forms of alliances. Other types of alliances include joint marketing, joint R&D, and "strategic agreements" (such as the use of a drug from Abbott pharmaceuticals on Medtronic's stent).

SC Practices

Medtronic's SC practices reflect the support function of SCM within the firm. For example, the product-development process was "overhauled" in 1996 and designs for manufacturing processes that affected SCM were put in place. Product "platforms were redesigned for modularity and standardization as well as customization and variations." More recently, lead time, work steps, and turnaround time have been

explicitly considered in product design within the company, though these are seen as “an aspect of the focus on process engineering” rather than as SCM initiatives.

Management techniques have primarily focused on the customer end of the SC. For many products consignment, wherein Medtronic delivers stock to the medical facility but retains ownership until it is actually used, is standard practice. This results in Medtronic carrying very high levels of off-site inventory. At the supplier end Medtronic is currently exploring the possibility of a vendor-managed inventory (VMI) system with daily deliveries, but the level of cautiousness is evident: the vendor in question is already located on the same campus as the Medtronic plant.

Forecasting is a chronic problem (because demand is so variable) so management techniques such as just-in-time manufacturing are not seen as appropriate. Even within the organization, each manufacturing technology and each business division operate separately. At the manufacturing level Medtronic is currently installing a manager to integrate the SCs of each technology group. This exists at the corporate level but at a distance. The requirements planning systems (distribution requirements planning and material requirements planning) are “inadequate.”

Operational tools (such as warehouse design, transport optimization, and automated identification systems), informational tools (such as online connections like EDI and the internet for intercompany transfer of data and business information or integrated databases) and organization tools (such as cross-functional interface managers for SC to facilitate information flows, manage/establish process, and coordinate new projects) are mostly absent. Medtronic is beginning to roll out SAP, but the process is in the very early stages and is expected to take several years.

Medtronics uses a number of SC metrics. At the executive level the key metrics are delivery reliability, product quality, obsolescence, talent management, productivity (lean/Six Sigma, purchasing, and distribution centres), and inventory turns. Performance against these metrics is reviewed every six months by the senior executive team (the CEO, CIO, Chief Operating Officer (COO) and Chief Financial Officer (CFO). At the plant level the key metric is product availability, followed by inventory management, and lead times.

SC Challenges

The SC challenges to some extent mirror the strategic challenges: managing product flows to meet production demands, nurturing customer relationships, and managing the information flows between disparate groups in an increasingly horizontal value chain, all in order to meet the requirements of the competitive environment. SCM within the organization is also a challenge in itself. Areas of specific concern include:

1. Managing Product Flows

The level of manufacturing flexibility is low, not because of manufacturing constraints but because of the corporate culture. In the period of very fast growth, manufacturing was measured solely by a count of output; forecasts were made 3–4 months out and each segment focused on getting their own part done. As price elasticity drops, there is a need to decrease lead times, but culture and turf issues are hampering change.

Lean manufacturing is an SCM technique that is meant to improve product flows and operating efficiency, but there is a striking difference in perspective on the subject of lean manufacturing at Medtronic. At the manufacturing end, there is “a strong culture of lean and sigma” whereas at corporate “the company is only just

accepting that lean manufacturing is the right model for it.” Many of the senior managers in manufacturing came from Motorola and are oriented toward old-style automation (such as the Bosch conveyor system). Managers brought in to improve the SC systems from other industries, who have different perspectives and experience, are frustrated by this internal divide.

On the other hand, both sides agree that there is a need to “streamline the SC,” “correct” quality control (systems) and “decrease the volume” of inventory. Both because of the nature of the product and the high margins, it is critical to have the right product in the right place at the right time. Therefore, Medtronic carries very big inventories. A major objective is to improve asset management/inventory turns, which are poor because of the need to “protect the SC at any cost.” Medtronic is somewhat better than average compared to their major competitors: for example, Boston Scientific and Guidant average 1.6 inventory turns whereas Medtronic averages 2 to 2.2 (United States) or 2–3/3.5 (Europe). However, the target is to get to “5 for the chain as a whole,” and “10 for the internal chain.” Some of the management team feels that Medtronic “needs to learn that there is a point of diminishing returns, when holding more inventory doesn’t help.”

One of the challenges to improving inventory management is poor forecasting: “improving forecasting accuracy is Medtronic’s primary SCM issue.” The business is highly volatile and forecasting inaccuracy puts tremendous pressures on the production process. The company has introduced demand-planning software programs into some regions but the larger problem is the lack of a common information system or SC system across the facilities. At present the facilities do not have access to comparable data, much less timely data. Because information is not available in real time or common formats, each location has different data to work

with and they have built up informal systems for working around that. Clearing up these old, informal, systems is slowing down implementation of the new systems. Medtronic is introducing SAP, but it is expected that it will take 4–5 years to have an operable CRM system in place.

2. Customer Relationships

Customer service “is not what it should be”; in particular delivery reliability is only 90%. This is because the organizational structure creates “split accountability and responsibility.” One effort to address this is bringing the former CIO back into that position from the broader role to which he had been assigned.

For Medtronic, customer integration has traditionally meant intensive, direct, personal selling backed up with training and continuing-education seminars. The most common distribution method is direct product shipment to sales representatives, who then hold the product (“a lot of our inventory rides around in the back of the salespeople’s cars”). Almost half of U.S. sales are still directly from sales representatives to end-users; the proportion is even higher in the Europe.

However as has been noted above, the sales process for medical facilities is changing. The doctor is becoming less powerful: although advocacy by the doctor is still important, now the financial office typically also has to sign off on the purchase or the doctor must choose from a preapproved list of suppliers (at preapproved prices). This change in the balance of power has been accompanied by a sharp drop in price elasticity as buying groups become more powerful. Buying groups provide member hospitals with a list of approved products and the hospitals shop from that list. On the one hand, Medtronic’s strong market position ensures that it is usually on the list for the products it sells, but on the other hand Medtronic’s premium prices are put under heavy pressure in the contracting process.

An interesting aspect of direct sales to hospitals is that they spike at the end of each quarter. The hospitals know that the prices go down toward the end of the quarter because sales representatives need to reach their targets, so they hold off ordering. The result is that product is shipped in high value at the end of the quarter. This is common in the medical-device industry and the customers are “trained to it.” Medtronic has tried to back out but isn’t “powerful enough to buck the system,” so they “level load” production, using forecasts to produce in advance and then hold at distribution centres so as not to disrupt production cycles. However, this “aggravates” the already-high inventory levels.

Medtronic has tried to keep some control through leadership in various alliances. In 1998 Medtronic introduced the Cardiovascular Alliance, which joined Medtronic with hospitals and physicians in long-term contractual agreements that reflected both pricing and product innovation. The following year Medtronic signed agreements with Novation (a healthcare SCM company) to supply spinal and cardiac-care products through national healthcare alliances. Agreements were based on a public competitive bid process. And in 2000 Medtronic became a founder member of GHX.

3. Competitive Environment

The highly vertically integrated model is under threat, particularly from cost pressures and from the broadening of areas in which the company needs expertise. For Medtronic, these converge on the question of outsourcing.

As has been noted, Medtronic outsources very little—mostly some moulding and subassembly. There is an effort to encourage more, especially of plastic injection moulding and circuits, areas in which Medtronic is “no longer at the leading edge” but which are increasingly important elements of their products. It is not a straightforward

decision however, because the fast-cycle times that Medtronic requires and the low level of purchasing leverage (given the small volumes involved) are an obstacle. One possibility is to look for something like EDS¹ : “sell it off to a better EDS and have a tight contracting agreement.”

Cost containment is another aspect of outsourcing. Medtronic has moved some manufacturing of older technologies to lower-cost manufacturing centres while introducing newer technologies in R&D-linked manufacturing sites. So for example Medtronic Ireland has outsourced some production of older technologies to Medtronic Mexico, but there were no job losses: the employees were retrained on newer technologies. This process was not driven by corporate. However quality and intellectual property concerns have kept most “outsourcing” within the Medtronic family.

4. Supply Chain Management

There is a consensus that there has been a “big change” in the attitudes toward SCM within Medtronic but historically SCM has not been a high priority within either the device industry or Medtronic. As a result there is a shortage of experience in the firm, so Medtronic is now actively recruiting people with experience. The new recruits are being drawn from industries in which SCM is seen as being more advanced (in particular automotive and industrial manufacturing).

The SCM group is seen as still being “too weak” to work with a university or other SC development entity, but “the necessary organization building needed is underway.” Medtronic is involved with some industry support groups at four to five targeted universities, and managers are being sent to SC courses. Although some

¹ EDS is an IT company that General Motors bought in 1984, In 1996, EDS was spun-off as an independent entity, but with a long term service agreement with GM. It is seen as a good (though flawed in the execution) example of keeping the skills sharp through exposure to the marketplace, while maintaining a close relationship.

managers have gone to IMD Business School, in general the European operation is less active in developing university links than the U.S. operation.

For Medtronic, high margins and product uniqueness have obscured the need for SCM. Now the competitive environment is changing. Some of their products are moving closer to commodity status and their customer relationships are changing. They are looking to follow the GE/IBM model of “evolving from delivering a product to delivering a service” as “the way forward.”

4.4.2 Case Study: Bard

Introduction

Bard was founded in 1907 when Charles R. Bard began to import Gomenol, an herbal remedy for urinary ailments. In the early 1930s a medical student named Frederick Foley developed an idea for a catheter to drain the bladder. CR Bard developed the prototypes, naming them Foley Catheters in honour of Dr. Foley. First marketed in 1934, sales took off quickly and in just over a decade net sales were over \$1 million. For almost 30 years Bard specialized in catheter development including the first sterile pack Foley catheters, the first Bipolar Temporary Pacing Catheters, and the first latex balloon catheters. Starting in 1961 the firm began diversifying from urology into cardiology, radiology, and anaesthesiology. The firm went public in 1963 and in 1968 was listed on the stock exchange. Once considered a “second-tier” hospital supplier, Bard now specializes in vascular, urology, oncology, and specialty surgical products, and pioneered single-use products for hospitals. It still holds more than 80% of the hospital market for Foley catheters, and is able to get high margins for new models, such as silver-coated catheters. They are either the market leader or second in most of their six business divisions. With turnover of \$1.7 billion, profits of

\$337 million, an R&D budget of \$114 million, and 8,900 employees, Bard is at the lower end of the top-ten medical-device firms.

The following narrative and analysis looks at the intersection of strategy and SCM at Bard. As such, it is not a linear narrative; rather, it describes and characterizes a range of aspects of Bard as part of identifying the variables that shape the strategic use of SCM within the firm. The first section looks at the firm as a whole, particularly its history, the ways that it organizes itself, and the challenges it faces. The second section explores SC elements more directly, including where SCM fits within the organization, the SC practices employed, and the SC issues on which the SC group is focused.

The narrative is derived from interviews with a vice-president of customer operations at the national level and a group vice president at the international level. This information was supported by additional sources gathered both before and after the interview process, including private and public publications (newspapers, business and industry journals, and industry studies) as well as discussions with other industry participants.

History and Evolution

While Bard's first 60 years were relatively stable and profitable, the next 30 were tumultuous. Through the 1960s Bard had a strong market position but the market for catheters was increasingly competitive, and by the mid-1970s Bard was trying to diversify. In 1975 Bard invested heavily and unsuccessfully in developing new kidney-dialysis membranes. In 1978 a serious product recall hurt catheter sales badly. Between 1978 and 1980 Bard divested a number of "underperforming" product groups including kidney-dialysis membranes.

The 1980s were even more challenging for Bard. There were significant changes in the competitive environment, in both products and competitors, and in the financial environment.

Bard's strategic focus was on "making the transition to high technology," and they were (briefly) extremely successful: the company effectively created the angioplasty market. The Bard catheter became the "first choice of two-thirds of heart surgeons," and held more than a 70% market share. However advantage can be difficult to hold in the medical-device industry, and by 1987 that share had fallen to 45% with Eli Lilly (in a division that would be spun off in 1995 as Guidant, which in turn is now being bought by Boston Scientific) also holding 45%. In the meantime, in 1984, American Hospital Supply, one of Bards biggest distributors, began to manufacture competitive products, leading Bard to end their distribution agreement.

In the financial arena, in the 1980s the U.S. government and third-party payers started to put pressure on prices, culminating in reimbursement caps in 1984. These caps immediately hit the profits of all device makers, who tried various strategies to deal with this change including by increasing R&D (e.g., Abbott, a combination pharmaceutical and device firm) and reducing overhead (e.g., Becton-Dickinson, a commodity device manufacturer). Bard's strategy was to focus on their proprietary products, increasing the number of models, and to diversify. Nonetheless, in the U.S. stock market crash of 1987 Bard's stock market price fell by 50%.

By the beginning of the 1990s Bard was already embroiled in a scandal that nearly ruined the company and saw it effectively banished from the angioplasty market that it had created. Beginning in 1989 there were product recalls on a group of Bard's leading-edge angioplasty balloon catheters. Worse, it became clear that the company had wilfully not cooperated with the FDA. Some of the problems included

misuse of the 510(k) provisions that allow for easier approval of “substantially equivalent” products; significant under reporting of post-approval problems; and continuing to manufacture certain products for as much as 2 years after being told to cease by the FDA (Kindel, 1990). By 1993 five senior executives including the CEO had been indicted. By the time it was all over, three of the executives had jail sentences, 700 employees had been dismissed, the company was (temporarily) banned from contracts with the federal government (because the company had pleaded guilty to felony charges), the FDA had (temporarily) put in stringent monitoring of Bard’s operations, Bard had paid the highest criminal penalty fine to date (\$61 million) and the bulk of its cardiovascular (essentially, angioplasty) business had been sold. By 1995, when stents came onto the market and rejuvenated the angioplasty market, Boston Scientific, Guidant, and Cordis had 77% of the market; Bard had 6%.

In the meantime the 1990s saw another round of cost-cutting in anticipation of proposed healthcare reforms. By the late 1990s all of the punitive strictures on Bard had been lifted. Significant management changes first in 1991 and then in 1995 had put in place new managers determined to return the company to strength. Although the product-recall problems had come out of a subsidiary (USCI, a partner since 1941 that Bard finally bought in 1966), Bard reiterated its commitment to a “decentralized business strategy.” Bard came out of this period “refocusing on urological catheters, surgery and oncology devices and peripheral (i.e., not cardiac) vascular devices, and with a new strategic emphasis on disease management’. The business was restructured into three divisions (Vascular, Urology, and Oncology), each with a WW VP of Sales and Marketing. This shift was credited with a 5% increase in sales in the first year. A 1998 restructuring plan of manufacturing operations saw six plants

closed and four downsized, leaving 22 facilities (see Appendix 11 for a lists of current sites).

The new strategy also called for a renewed emphasis on R&D, for which the budget was increased from 7% in 1997 to 9% in 1999 and was projected to grow to 11% in 2002. In the event however, the early 2000s proved to be as tumultuous for Bard as the early 1990s.

The rumours had started by 1998 first mentioning Tyco, then Baxter (for whom Bard was and is an original equipment manufacturer), then Tyco again, as possible suitors for Bard. In 2001 Bard was seen as a mid-sized “mundane” medical-products manufacturer, with a “so-so” track record, and was under pressure to sell. Although rumours were already swirling about Tyco’s accounting practices, the Tyco–Bard match was seen as a good one: the company’s product groups meshed well and Tyco had an international distribution system that could increase Bard’s international presence. However it was also clear that Tyco’s vision for Bard was significantly different from the one that the new management team was building. Where Bard’s management had ambitious plans to rebuild Bard’s R&D capabilities and grow through innovation, Tyco indicated that it planned to “milk” the existing product base and improve profits through cost-cutting and outsourcing. A small delay in the acquisition (instigated by the Federal Trade Commission evaluating the size of the combined Bard–Tyco share of the urology market) delayed the closing by a quarter—and that was the quarter that Tyco imploded.

This near-death experience led to even greater commitment to growth. Unusually for a device firm, the Bard senior management team comes from marketing, human resources, and sales rather than science or engineering. Even the few of the top officers with a science or engineering background have only

undergraduate science degrees. The senior management team is also relatively young, with most being in their late 40s. The senior leadership positions are divided between the Chair/CEO, whose focus is longer-term strategy (more than 10 years out) and the President/COO, whose focus is near-term strategy (5–10 years). A stylised schematic of the organization structure is outlined below.

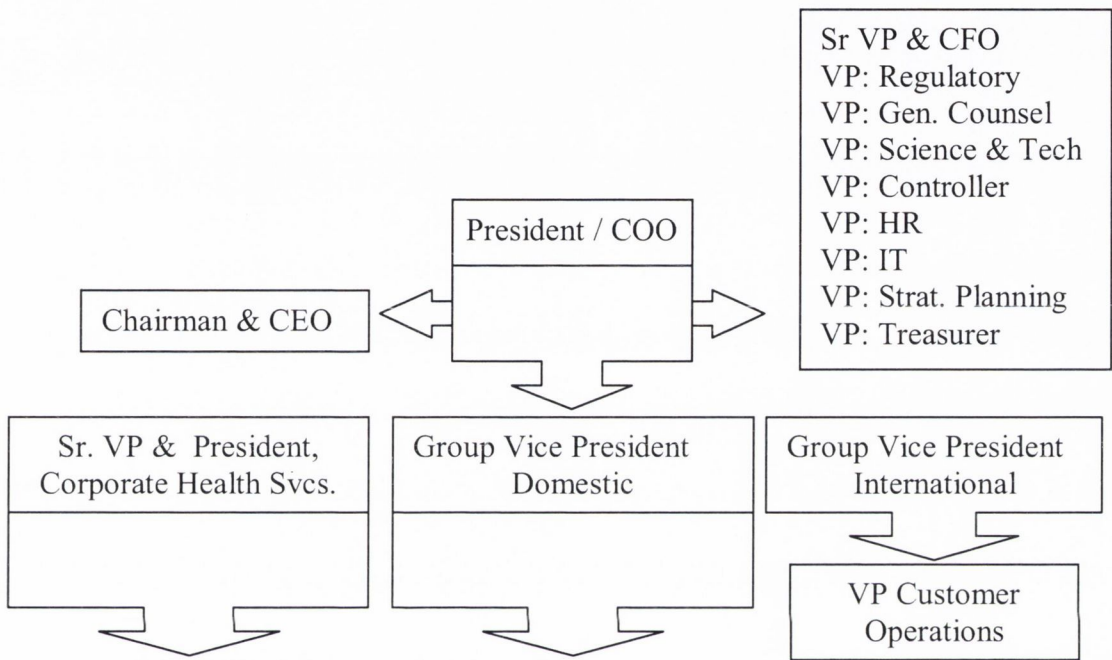


Figure 5. Bard organization structure.

Strategic Challenges

Although the medical-device industry is increasingly divided into “small caps” (i.e., market capitalization under \$500 million) and “large caps” (over \$10 billion), Bard is confident that there is a niche for them in “high value products in selected market segments.” The strategy is to have “numbers of small successes” rather than blockbuster products;; and to treat a broader range of diseases but maintain “market segment leadership.” Bard’s R&D investment went down considerably during the period in which a takeover was anticipated, but it has rebounded and has also been augmented through acquisitions. It is now implementing a growth strategy

by pursuing R&D (both internally and through acquisition), expanding its sales force, and improving operations.

Supply Chain Management

Bard is somewhat unusual as a device firm in that its core product, catheters, has both a commodity element and an innovative element. Basic Foley catheters are such a core commodity that their prices are part of the basket of products used to track changes in medical costs, yet innovations such as silver-coated catheters (which are better at preventing infection and easier to insert) command high margins (US\$17 versus US\$5 for basic catheters). Even the higher priced units however, are (by the standards of the device industry) relatively low cost, and sold in relatively high volumes.

Bard has had an explicit SC function since at least 1992, but the long-standing policy of decentralization led to individual business units developing their SC capabilities independently. Until the late 1990s Bard extended its policy of decentralized management to SCM resulting in an ad-hoc approach to SCM. In 2000 the company moved toward a more centralized approach when it established an integrated e-commerce and consolidated SC system through an outsourced logistics-service subsidiary of Owens & Minor (a major medical supplies distributor). Bard's philosophy of SCM is "a strong focus on forward integration," with direct continuing involvement and partnering with major customers.

SC Structure

Bard is in the process of integrating the SC functions within one group. Most recently, Distribution, Logistics, Accounts Receivable, Contract Administration, Data Management, and Customer Service were integrated with the Sales structure. Procurement is not yet in the group but is expected to come.

Trading Relationships: Suppliers

Bard, like most device firms, is vertically integrated and is more focused on their customer trading relationships than their supplier trading relationships. For their commodity products, contracts lock in prices or strictly limit price increases. In 2001 Bard joined Novation's SC provider Marketplace@Novation, which has approximately 100 participating manufacturers and distributors and is powered by Neoforma, which also powers GHX.

Bard consolidates its global procurement through one office. There is an emphasis on access to real-time online information, but not at the expense of direct communication: it is important for suppliers to remember that "sometimes a phone call is just as easy to make and more beneficial," because "on-line updates give you the project status, not a prognosis, and only tell you what is being done, not what can be done."

Because outsourcing now often includes development, engineering, and design, the "top concern" is the protection of patents and IP [intellectual property]." In particular, it is important that any technology that is developed is kept for Bard, "not shopped around to everyone else." As an original equipment manufacturer, other firms outsource to Bard, and in that role they have noted a trend to more "full service" outsourcing, including dealing with regulatory issues, engineering, and design, as well as packaging, sterilization, and production. See Appendix 12 for the timeline and genealogy.

Trading Relationships: Customers

Bard's primary customers in the United States are hospitals and healthcare institutions. About a third of sales are to hospital-supply distributors; of those, about 70% of sales are to the five largest customers. Outside the United States Bard distributes directly through its own subsidiaries or through distributors.

There are 23 subsidiaries and one joint venture (a 50:50 joint venture with Kobayashi Pharmaceuticals, formed in 1972 to distribute Bard products in Japan). As with most medical-device companies, they are clear that their primary markets are the United States, Europe, and Japan.

Two thirds of products that are sold internationally are manufactured in the United States, Puerto Rico, and Mexico; the other third are manufactured in France, Germany, Japan, and Brazil. Not all products are sold in all markets.

In the mid-1990s, as part of repairing its reputation and in recognition of the changing nature of customer relationships, the new management team created the Corporate Marketing and Services group. This CMS group—composed entirely of vice-presidents—was charged with developing relationships with corporate-level decision makers at healthcare buying groups, distributors, and “kit packers” (firms that collect the range of materials needed for individual procedures and package them into treatment ready “kits”). Bard was one of the first device companies to target kit makers, and did so because they were “looking at the supply chain as a whole.” Although initially the Corporate Marketing and Services group was remunerated in part through commission, the basis for compensation was shifted to market share and customer-satisfaction metrics. A particular feature of the sales approach used is a “total cost” rather than incremental or unit price, and specifically included elements such as EDI, logistics, support, and regulation compliance as part of the value added. They were also “pioneers” in using a single point of contact instead of a different contact for each product group. However a trial with capitated supply contracts² was

² Capitated supply contracts were seen as the answer to spiraling health costs in the mid-1990s. Volume price breaks, use reduction, and value analysis were combined into fixed-price contracts, variously based on a flat fee, a fixed fee with a ceiling, a fixed value per month, etc. These were pushed by hospital and health-management groups but played into the commoditization of products and were thus particularly unattractive to a high-margin, innovation-driven industry. (Kowalski, 1997; Werner, 1995)

unsuccessful because it proved too hard to manage. Instead long-term pricing agreements and shared incentive structures have emerged.

Trading Relationships: Alliances

Bard seeks to acquire expertise through small research or “early stage” companies, and market share through larger companies. In addition to acquisitions, Bard uses licensing agreements, joint ventures, and equity investments.

Bard has made at least 10 “significant” alliances since the mid-1990s. However, recently there have been some complications with these alliances. Post-Enron accounting regulations now require companies to identify firms in which they may have an indirect controlling financial interest. These firms, or variable interest entities, have to be specified in the company’s annual accounts. In some cases this is straightforward. For example, Bard formed an alliance with Genyx (a small technology based urology firm) through investment in their R&D efforts. The agreement, which is fairly typical, gives Bard the right (but not the obligation) to buy specific assets of the company if it gets FDA approval for a product in development (as in fact happened in 2005; Bard immediately exercised their option to buy the firm). In the alliance Bard, although a minority stakeholder, was considered the “primary beneficiary” of Genyx. Genyx was therefore considered to be a variable interest entity for Bard and Bard was obliged to include it in their annual accounts. In turn, this means that the sharing of information between the two companies must be comprehensive—notably from Genyx to Bard—and in the “confidentiality obsessed” device industry that is challenging.

The same confidentiality issues have kept Bard from being able to ascertain whether another supplier is in fact a variable interest entity for accounting purposes. There is a long-standing relationship but there is no exchange of financial or operating

data. Bard buys a considerable quantity of material from this supplier, but it is not clear if the company is in fact dependent on Bard to the extent that it would be considered a variable interest entity. This increasing obligation to account for the level of integration between trading partners is an issue for Bard in determining whether, and how deeply, to integrate information systems, especially when the relationship is speculative.

SC Practices

Bard has a long standing “strategy of improving operating systems”; the big change in recent times is to assert a corporate-led planning approach, a move away from the decentralized, “ad-hoc” approach of letting the facilities work out their own systems. The new strategy applies both within and across functional areas, particularly IT, production, and distribution.

An example of the old approach is a small supplier in San Diego that Bard bought in 1988. The company had 16 employees, eight warehouses, numerous subcontractors and vendors and manufactured half of the product before shipping it on to the customer (Bard) for finishing. The plant manager (who came from the acquired company) sets up a microcomputer based material requirements planning which calculated requirements weekly. Similarly, a subsidiary impatient for better informations built their own local sales-reporting system. The

Bard was an early-adopter of EDI, and was seen as “a leader in the healthcare industry” in EDI by the late 1980s, and the experience with EDI highlighted the need for interoperability. In the 1990s, Bard moved toward a cross-firm systems strategy, and by the late 1990s in anticipation of Y2K compliance problems, they had more than 50 suppliers and approximately 350 customers linked by EDI, all Y2K ready. In the process, an IT infrastructure that enables system interoperability among remote

divisions and across platforms was put in place. Most recently a standardized enterprise-resource-planning platform has been established in three of the six divisions that can handle greater volumes while increasing shipping accuracy and on-time delivery levels. An accompanying “overhaul” of information systems is aimed at streamlining processes and gaining visibility in manufacturing, warehousing, and transportation operations across facilities and divisions. One of its challenges was that some products pass through two or three separate facilities for manufacturing, sterilization, and distribution but no system had a global view of the business: all information was on local databases. It has now instituted a centralized system through three divisions and is proceeding with the remaining three. The new system has already reduced time between shipping and invoicing. Bard already uses an extensive barcode scanning system, and sees radio-frequency identification as “inevitable,” although “it is more of a plan” at this stage.

In production, Bard is rolling out a lean manufacturing system globally and the plants are estimated to be about mid-way through the process. In distribution, Bard has recently concentrated its distribution system into two hubs, one in the United States and one in Europe. In the United States six distribution centres were consolidated into one, which is located within a mile of Bard’s primary sterilization plant. The objectives of the consolidation were to consolidate products from multiple divisions into one shipment from Bard to the customer; to improve distribution efficiency; to improve service quality; and to allow room for growth (the facility was built to allow for nearly 50% expansion).

Although the new centre has to accommodate the different shipping strategies of each division (from single-item same-day delivery to traditional full-case pallets); consolidation of orders and generation of a single manifest; and customer control over

both pick-up and delivery schedules, the new strategy has already yielded quantifiable benefits. Order accuracy has improved, the new system is more flexible, timeliness has “improved dramatically,” and inventory has been reduced from \$3 million to \$500,000. Turnaround time is now down to as little as three hours from receiving the order to being ready to ship. The warehouse handles 90% of global distribution and has moved Bard from “being behind to being cutting edge.”

The key metrics for Bard emphasize “a customer focus”: on-time shipment; shipment accuracy by line item (%); orders received complete and intact; customer-service response time; inventory variance; and ready-to-ship inventory. Best in class is estimated at “near” 100% serviceability level of product, and 100% on-time delivery of 100% of product.

SC Challenges

Bard benchmarks itself against industry leaders such as JNJ. They are generally happy with their manufacturing strategy distribution system (especially the new warehouse) and with the direction of their internal restructuring. The major issue appears to be customer power: the balance of power has always been with the customer but the power is increasingly concentrated in the hands of the major distributors. Overall, they feel that they are “in the middle of the SC curve,” as measured against their benchmark company, JNJ.

CHAPTER 5:

DISCUSSION

5.1 Introduction

The previous chapter began with an introduction to the device industry as a whole, then proceeded to gather data from various elements of the industry: a representative SC body, a large device firm based within a conglomerate, and a small, medium, and large sized 'pure-play' device firm. The information was gathered through interviews. This is a straightforward approach to data collection and the first step in the data analysis is similarly straightforward. Informed by the data gathered at the industry level, the data from the focus group, interviews, and cases was coded along several parameters, and the cross-source findings considered. In coding the data, a number of SC themes were identified. Industry factors in shaping the participants SC views and practices was emerged as a clear theme, and elements with knowledge, power, and governance implications were also identified, so further exploration was made between these themes and theories. A renewed and focused literature search identified useful models characterizing each theory group, as well as the role of industry, which were then linked to the present work. This integrative approach is characteristic of and appropriate for theory building work (Charmaz, 2005; Edmondson & McManus, 2005).

5.2 Cross-Source Review

Consistent with grounded-theory methodology, the data from the focus group, interviews, and case firms was coded. This coding process facilitated the identification of factors that applied across the data sources. Thirty coding groups were consolidated into nine categories, from which four themes emerged: SC

practices, SC issues, General Strategy, and Industry (see Table 9, below, for a Data Tree).

5.2.1 Cross-Source Key Findings

In reviewing the findings across the data sources, a number of key findings emerged. These findings fell naturally into nine categories: metrics, production, inventory, structure, systems, trading relationships, outsourcing, SCM, and industry. Table 10, below summarizes these findings from across the data sources, which are discussed individually in the following sections.

5.2.2 Metrics

Conventional metrics (such as unit cost, plant utilization, and labour-cost metrics in manufacturing; sales growth and market share in sales and marketing; or functions in engineering) do not fit well in the cross-functional and cross-boundary world of SCM. Of the four major metric focal areas (service, inventory, time/flexibility, and finances), the majority found in this work were inventory (nearly a third) and service (nearly half). Time was cited by only one source, though “costs” were cited by all of the sources.

Service Metrics

Service metrics generally differentiate between a BTS model and a BTO model. BTS models are associated with lean supply chains; the usual service metric is the fill rate (the percentage of the order that can be filled without delay). BTO models are associated with responsive SC; the usual service metric is lead time (the percentage of goods completed on time; see speed & flexibility metrics below). All of the sources cited fill rates as an important metric, but Medtronic also cited lead times. There is a deep division within Medtronic on the relative merits of a lean approach.

Table 9
Coding tree for Data Analysis

Theme	Tier 1	Tier 2
SC Practices	SC Structure	Organization
		Suppliers
		Internal
	Outsourcing	Customers
		Use
		Issues
	SC Tactics	Systems
		Production
		Inventory
		Metrics
SC Issues	SC Tactics Issues	Other
		Costs
		Inventory
		Systems
		Training
		Production
		Suppliers
	General Strategic SC Issues	Customers
		Importance of SCM
		Understanding of SCM
		External issues
		Customers
	Operations SC Strategic Issues	Production
		Organization
		Systems
Strategic Issues	Internal	Organization
		Current issues
	External	External
Industry	Device Industry Characteristics	Nature
	Other Industries	Issues

Table 10
Data Source Findings

	Current Practice	Issues
Operations		
Metrics	Approximately 1/3 (6/17) of the metrics cited relate to inventory management. Approximately 1/2 (8/17) of the metrics cited are customer-centric. Only three of the metrics cited have broader strategic implications: market share versus plan, obsolescence, and talent management; two of them were in Bard. Not counting inventory-focused metrics, half of the remaining metrics are operations focused. In all but Bard, production-oriented metrics were clearly dominant. In Bard outbound customer-centric metrics dominated. Costs are a crucial metric, and becoming more and more important. Small run sizes and variable demand limit the SC techniques that can be used. Alignment of internal systems improves SCM Inventory reduction is a priority, <i>but</i> consignment practices keep off-site inventory levels high.	
Production		A lot of talk about lean, but mixed views on whether, when, or to what extent. Contradictory practices and foci: simultaneously pursuing more lean, more flexible, and more responsive

Table 8 Data Source Findings (Continued)

	Current Practice	Issues
Inventory		Own too much inventory Inventory turns too low responsive.
SC Structure	There is a very high level of internal segmentation: each “segment” of the SC hands off to the next, with minimal interaction or integration. The language is of “ownership” of segments. SCM is clearly located in Operations. The internal segmentation and product-based structure of the device firms is reflected in the “coordinating” of SC initiatives. Historically corporate has coordinated SC activities rather than directed them. However, this is changing and in some cases SCM is not a core corporate function, along with Finance, HR, etc.	
Systems	SAP is the dominant brand of management software: they are rolling it out, converting to it, upgrading it.	Lack of integrated IS and IT systems is a dominant complaint: lack of access to a single set of real-time, or at least current, numbers across the organization is seen as a significant obstacle. Forecasting accuracy is a problem Capacity planning will become an issue
Trading Relationships	Very limited integration with suppliers. More and deeper initiatives with customers than with supplier, with a strong focus on developing and maintaining relationships. The focus is on customers, whether internal (i.e., Distribution), or external.	Underdeveloped relationships with suppliers Lack of power with customers; need ways to maintain, improve Want more contact with customers (segmentation blocks access) Changing customer characteristics mean that they need to work harder to reach customers, and to change the ways that they handle customer relationships. Relative power is decreasing
Outsourcing	Mostly low-tech or noncritical elements. Broadening to include “full-service,” including development and engineering	Divide between outsourcing older products and newer products. Protection of intellectual property is a major issue Divide between the benefits of in-house control and out-of-house expertise.
SCM	Feeling of low status Top-level support for SCM big factor in driving forward	Sense of being “behind” in SCM practices Sense that others are better at SCM and need to access that expertise
Industry	Device industry is conservative, risk averse and protected by high margins	Convergence is a coming challenge Branding is a new element

Table 8 Data Source Findings (Continued)

Current Practice	Issues
Primary emphasis is technology/innovation; all other areas are support	Price elasticity is dropping
Customer expectations and power are high	PLC's getting even shorter; time to commoditization is shortening
Industry is "confident of market"	Regulations tightening
High margins allow for R&D and innovation acquisition	Hard to define good benchmarks
High growth "insulates" industry	Buying groups are professionalizing buyer relationships; consolidating power
	Industry is "behind" other industries in SCM

Inventory Metrics

Inventory levels are sometimes used as a surrogate metric for SCM, so it is not surprising that nearly one third of the metrics cited relate to inventory. However, inventory metrics sometimes conflict with service metrics (one aiming to minimize inventory and the other to maximize customer service). Most commonly cited inventory metrics focused on inventory turns; the other two most common SCM inventory metrics (inventory value and days of inventory) were not mentioned.

Speed & Flexibility Metrics

Speed and flexibility metrics generally focus on lead times (either customer lead times or flow times between the nodes in the SC). As noted above, only Medtronic cited lead times as a metric. Another metric, the cash conversion cycle, overlaps speed metrics and financial metrics because it measures the time between when the company first pays for the materials and labour until it gets paid for the final product. This would be a problematic metric for the device industry, given the consignment issue.

Financial Metrics

The most common financial metrics used by management for evaluating SCM initiatives are return on investment and market capitalization, both of which are seen

as having limitations as evaluators of SCM practice (Camerinelli, 2007), and neither of which were cited by any of the sources. “Costs,” however, were cited by all the sources as an important and growing area of assessment. What costs are measured and against what benchmarks was not specified.

Utilization and other single-factor productivity metrics, which are problematic metrics for SCM, were not cited by any of the sources. Instead nearly half of the metrics cited related to end-customer service, which is considered to be “best practice” in SCM.

5.2.3 Production

The pull between the efficient and responsive SC approaches is evident in the production findings. On one hand, it was noted that small run sizes and variable demand limit the SC techniques that can be used; on the other the low level of manufacturing flexibility is an issue. There was a lot of talk about lean (i.e., efficient) practices being implemented, but disagreement as to whether, when, where, and to what extent it should be done. At the same time, there was a desire to have more responsive systems. These contradictions are reflected in the production practices identified.

The usual ways to improve a responsive SC include improving information flows (particularly demand forecasting), shortening lead times, and risk-based production planning (starting production with the most certain products and using later production time for the less certain products). The usual ways to improve an efficient SC are postponement of product differentiation (in production, packaging, software, etc.), using commonality, modularity, and universality, and the firms in the data set were using most of these approaches.

The push-pull point is the trigger that moves production from BTS to BTO. Where upstream pushes the inventory based on forecasts, downstream pulls demand based on orders. One of the elements at play for the device industry may be that the push-pull point is in flux: the growing influence of buying groups and other large customers may be moving the balance point. The downside of this change—more pressure on prices—is noted (see 5.2.5, Trading Relationships below), but a potential upside is more predictable demand. In the meantime the industry would appear to be caught in the middle.

5.2.4 Inventory

Inventory was one of the most frequently mentioned topics in the operations group. Inventory reduction is clearly a priority—there is a clear feeling of owning too much inventory, but consignment practices keep off-site inventory levels high. In the meantime, inventory turns are seen as being too low. Despite a constant emphasis on confidentiality in every aspect of their operations, all of the participants were able to cite the level of inventory turns for several of their competitors and had specific targets or goals that they wanted to achieve. Again, there is a tension between efficiency and responsiveness.

5.2.5 Structure

The most striking aspect of the structure of the SCs was the level of segmentation. Given the paradigm of integrated SCM in which all of the participants in an SC are linked by information flows; in which they all work together to take costs out of the SC; and in which they understand each others needs and work together to achieve “win-win” trading relationships, it is striking how segmented the *internal* SCs are in the participating device firms: each “segment” of the SC is self contained with minimal interaction or integration with other segments. The language

is of “ownership” of segments. Moreover for those in the central segment (internal operations), the in-house segments on either side who deal with the external suppliers or customers function as an absolute block between the two parties; despite a desire to get closer to customers in order to better understand their needs there is no mechanism for doing so.

Traditionally the device industry, like the pharmaceutical industry, has used a product-based organizational structure. This has meant that each product group operated as nearly a stand-alone operation with corporate providing a limited range of firm services (most often finance, sometimes human resources, some press relations and/or corporate marketing, and noncore supplies), and perhaps coordinating cross-firm services (most often IT; sometimes SCM). However, the coordination of SC activities is increasingly directive, and in some cases SCM is now a core corporate function along with finance and human resources.

These product-based organizational structures may be overlaid with a regional structure creating a matrix organizational structure. This is the case with Medtronic, who have found that such a structure is complex and hampers operations. As a result they are working to change their structures to facilitate the flow of information across the organization.

The rule of metrics is that you get what you measure; to some extent you also get what you organize. The organizational structure in Bard is at first glance a fairly straightforward hierarchy: a CEO charged with long-term strategy, a COO looking after near-term strategy and worldwide operations, followed by two group vice presidents (one responsible for domestic business units, one for international) and the CFO. However, a closer look at the third level, which contains an array of vice presidents, gives some indicators as to where the firms strategic priorities are: Science

and Technology, Strategic Planning and Business Development, IT, International Business, and Regulatory and Clinical Affairs complement the traditional Operations, Human Resources, General Counsel, and Treasurer. Interestingly, there is no vice president of Sales or Marketing.

This organization structure is consistent with the firm's strategic focus on operating efficiencies; the structure is an explicit element in operationalizing the strategy. It is also the *de facto* SCM strategy: the SCM structure is not separate from the organizational structure. In the integrated SC paradigm (section 2.4.3) such enterprise-wide information flows are extended to external trading partners.

5.2.6 Systems

The lack of integrated information systems and IT systems is a dominant complaint amongst the participants: lack of access to a single set of real-time, or at least current, numbers across the organization is seen as a significant obstacle to SCM for all of the participants except Bard (and even that system is not as good as they would like it to be). Forecasting accuracy is a problem, which is interesting in light of the ambivalence between an efficient and a responsive approach to SCM. The focus on SAP can be seen as a way to get some control over the situation. SAP is clearly the dominant brand of management software—most of the participants are evaluating it, using it, converting to it, or upgrading to it—despite the long (3–6 years) transitions cited. It is clear that changing their knowledge-management practices to accommodate the demands of SCM is a priority, even if the process of change acts as a constraint in the short term

5.2.7 Trading Relationships

The segmentation of the SC is evident in the difference between approaches to upstream (supplier) and downstream (customer) trading relationships. Supplier

relationships are more limited and less developed than customer relationships. In part this reflects the strong history of vertical integration in which suppliers were relatively unimportant. However with the convergence of chemical, biological, electronics, and engineering skills that are increasingly required, access to outside expertise is increasingly important; further, the capabilities of outsourcing contractors (see 5.2.8, Outsourcing below) combined with cost pressures is making outsourcing and/or deeper relationships with suppliers both a more viable and a more valuable option. In turn this is leading to more supplier integration. Most of the major forms of supplier integration were mentioned by one or more of the participants. In particular Bard is a long-standing leader in EDI, and Medtronic is considering entering into a VMI relationship with a supplier (though the fact that they are only considering it with a supplier whose operations are already on-site indicates the level of cautiousness). However, just-in-time manufacturing has been ruled out as being incompatible with the variable nature of demand (which again brings up the tensions between an efficient and a responsive approach).

There is already a strong focus on developing and maintaining relationships with customers, whether internal (i.e., distribution) or external. These relationships are ways of improving or at least maintaining the power balance with the customer. Changing customer characteristics means that the firms need to work harder to reach their customers, and to change the ways that they handle customer relationships. These relationships are developed on an individual level through the sales-representative system but also through firm initiatives (such as the Corporate Accounts Group in Bard) or industry alliances (such as the Cardiovascular Alliance in Medtronic).

Another element of trading relationships is the level of trust: confidentiality, product quality, and delivery reliability are critical in the device industry and are the underpinning for both the level of vertical integration and the caution with suppliers.

5.2.8 Outsourcing

A number of the participants in this research argued that outsourcing in the device industry is limited to nonessential elements and that the outsourcing that is happening is mostly cost driven, sending production to low-cost production locations. However, it is clear that outsourcing (or contract manufacturing as it is still often called in the device industry) is growing rapidly, particularly amongst the larger firms in the areas of metal, plastics, electronics, and “value-added services.” Interestingly, DePuy, Boston Scientific and Medtronic are among some of the larger users of outsourcing (particularly in the areas of metals and plastics), while Bard, which is significantly smaller than the other firms, is actively growing its original -equipment manufacturing business: that is, other device firms outsource to them).

Deciding what, when, where, and how to outsource is challenging in the device industry. Using typical transaction cost analysis such as the relative frequency of the transaction, the level of specific investments required, and the level of uncertainty, would militate against outsourcing in the device industry. However, the same analysis would weigh against outsourcing IT as well, yet it is the single most outsourced activity because the complexity and specialized expertise required outweigh the other considerations. The core-competence approach is equally problematic because for most firms their core competence is innovation and outsourcing that may compromise either the maintenance of in-house expertise or product confidentiality—a major concern for most of the participants. On the other hand, the convergence of different kinds of expertise (e.g., electronics, chemistry,

biology, and engineering) will require access to new areas of competence. This has been achieved in the past by acquisition of, or alliances with, firms with the necessary expertise, but the pace of change and the scope of change is increasing such that outsourcing may be an increasingly attractive option. As the contracting industry broadens to include “value added” services including development and engineering, the balance between the benefits of in-house control and out-of-house expertise outsourcing is changing.

5.2.9 SCM

There is a strong sense amongst the participants that the industry is “behind” in SCM practices: that other industries are better at SCM. Bard, where SCM is unusually integrated into the firm’s infrastructure, sees itself as only being about mid-point on the bell curve, and not particularly adept at SCM. There is a feeling that medical devices in general are at the level of SC evolution that the food industry was in the 1980s and there is a strong desire to move that forward.

In order to do so there are conscious efforts to access expertise from other industries that are perceived to be more advanced in SCM. New hires trying to apply their experience from other industries to the device industry are a factor in the internal debates between approaches to SCM—notably the tension between efficient and responsive SCs—within several of the participating firms.

Internally there is a feeling that SCM has a low status within the firm, some of which is accepted as inevitable in a business in which innovation is the driver of success. Nonetheless it is clear that top-level support for SCM is a big factor in driving the development of SCM practices. In particular firms in which some element of the company has experience with a commodity and/or fast moving consumer-goods

industry (such as Bard's commodity segment, or DePuy's corporate parent, JNJ) were more likely to have a systems focus, and thus more developed SCM practices.

5.2.10 Industry

The device industry is, by its own description, conservative, risk averse, and protected by high margins. The primary emphasis is technology and innovation; traditionally, all other areas within the firm support those. Customer expectations are high.

It is clear that industry characteristics affect the SC. A current challenge for the industry is the changing nature of customer relationships (see also 5.2.5, Trading Relationships above).

Unlike the pharmaceutical industry, the device industry has relatively low power. They have neither the financial nor the political clout that the pharmaceutical industry has and in most cases they have very limited repeat business relative to a regularly prescribed medication. Patents, though important, offer less protection in the device industry than the pharmaceutical industry.

The device industry invests heavily in customer relationships, which helps offset their relatively low power. That was an effective mechanism when the physician could simply order what they wanted and it made sense to make sure that their representatives always had sample devices with them in their car. Increasingly however, their customers are bigger than they are. Major distributors are becoming more important, which has led to a divergence in the requirements of the sales focus from the technological focus that is appropriate for practitioners or hospitals in which practitioners play a strong role in selecting medical devices, to the much more cost-driven focus of distributors. Hospitals, buying groups, and major distributors are increasingly professional in their supplier relations.

Apart from the changing nature of their trading relationships, there is also the issue of knowledge flows. The larger trading partners have higher expectations of professional sales and service, order in larger quantities, and are able to enforce consignment agreements. At a minimum this increases the level of information necessary to manage the transactions; in order to manage these transactions cost effectively (in procedural, inventory management, and logistics terms), information systems become important. When the complexity of most device firms' organizational structures is factored in (each product group operating as effectively a separate unit), the importance of the organization of information flows becomes apparent.

The device industry has other issues in controlling knowledge flows, as it is both a knowledge-intensive field and extremely confidential. The need for knowledge is balanced by the need to control access to that knowledge. The highly vertically integrated and geographically concentrated nature of the device industry is consistent with these twin objectives.

Finally, branding is a new phenomenon in the device industry. GE and Tyco have done some corporate advertising in the past, largely emphasizing the range of business units within the company. Recently, JNJ—which has a strong name with consumers—has started direct advertising of devices to consumers (with the tag line, "it helped to know that it was Johnson & Johnson"). This strategy effectively makes an end run around the buying groups and distributors and could, if successful, contribute to a shift in relative power.

5.2.11 Integration

As has been noted, the emphasis in SCM is often on operational issues; it is an objective of this work to consider SCM from a strategic level as well as a theoretical level. The operational level can be visualized as nesting within the strategic level,

which can in turn be seen as being embedded in the competitive environment (see Figure 6A below).

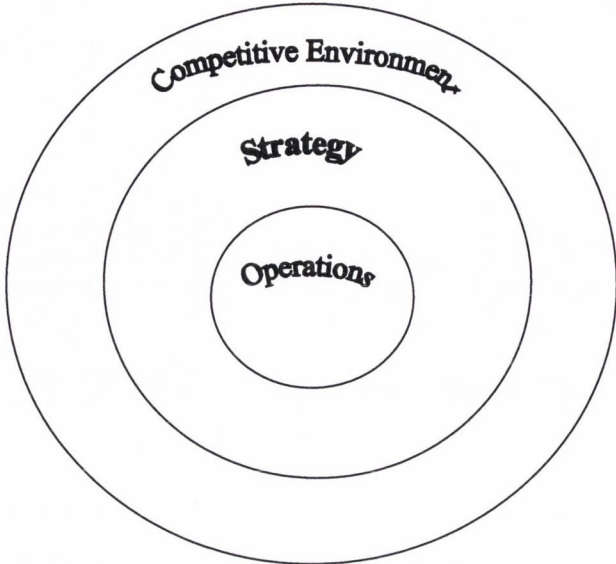


Figure 6A. Nesting of operations, strategy, and competitive environment.

An examination of the nine categories reviewed above (metrics, inventory, production, outsourcing, structure, systems, trading relationships, outsourcing, SCM, and industry) suggests that they can all be considered in the context of operations, knowledge, power, governance and industry. Some of the categories largely fit within one area: industry effects are an element of the competitive environment; metrics, and inventory can be consolidated into Operations; and structures and outsourcing fit within the governance element of strategy. Others span boundaries: systems are a critical element of Operations, yet are also strongly linked to the knowledge element of strategy. The SCM issues identified touched on elements of operations, as well as power and knowledge elements of the strategy level, and the competitive environment. Similarly, trading relationships touch on knowledge, power and governance theory. Figure 6B, below, applies the nine categories to Figure 6A with the theory groups of knowledge, power, and governance noted in the strategy level.

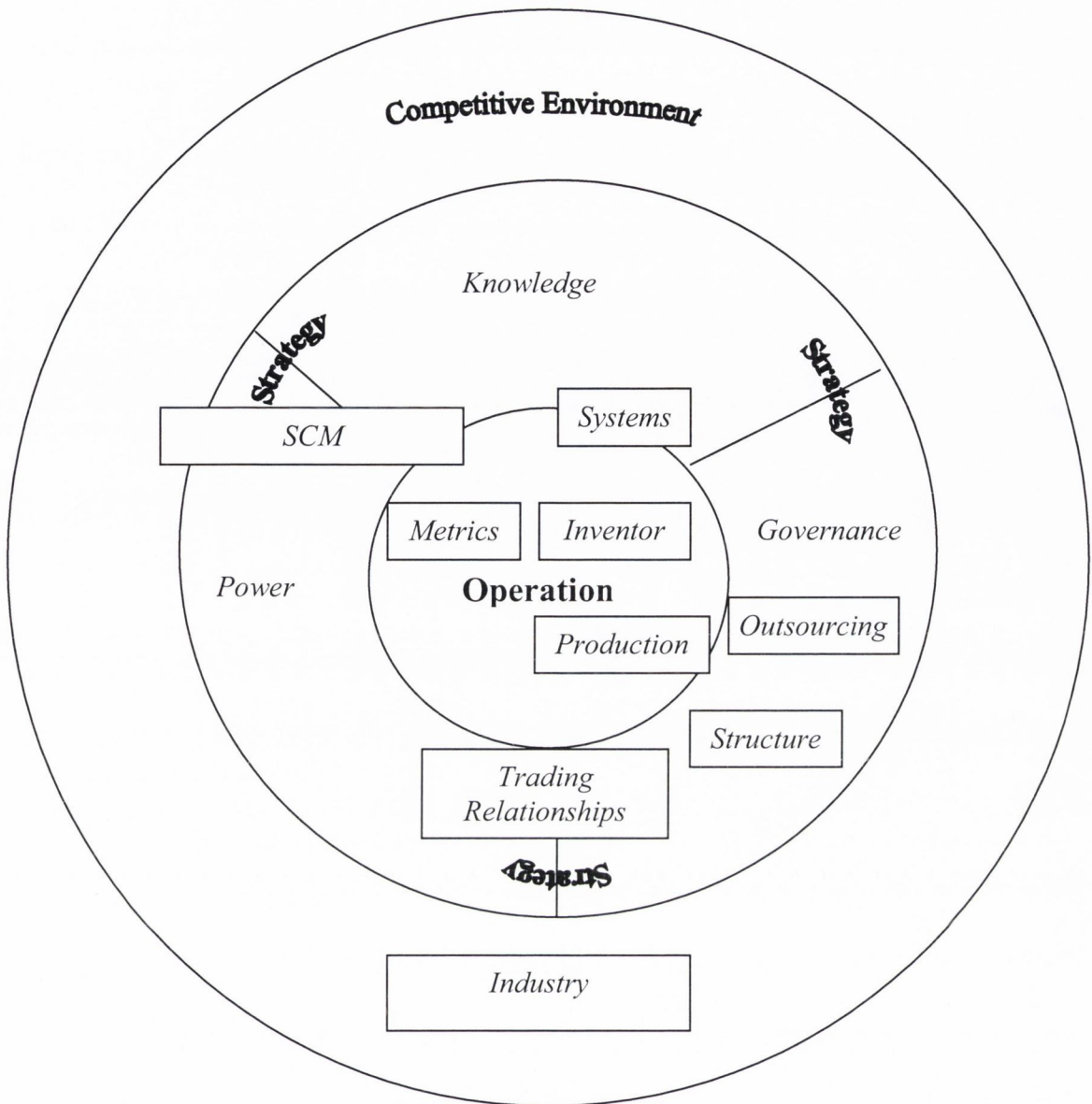


Figure 6B. Application of categories to theory groups.

In the following sections, models for applying knowledge, power, and governance to SCM, and a further model reflecting the role of industry are discussed in the context of their contribution to a theoretical understanding of SCM. The basic operations model (including the integration paradigm) has been discussed (see Section 2.3), but further elaboration and links are made with each of the models.

5.3. Knowledge

Knowledge is accepted as a core competence in the device industry, where innovation and new product development are critical success factors cited by all the participants. However, knowledge—particularly in the context of information flows—is also a key element in SCM. Externally, firms must move information rapidly across the boundaries; internally, firms must exchange information effectively across regions and departments. Conveying knowledge within and outside firm boundaries requires connectivity and communication, yet one of the major complaints from the participants in this research (with the exception of Bard) was the poor visibility of information flows across the SC. A high degree of visibility would allow all users in the chain to make business decisions that maximize customer value while reducing costs and cycle times. Operationally, this can be facilitated by real-time collaboration in the form of information systems, which provide for the multidirectional flow of knowledge across the SC, and all of the participants are engaged to some degree in improving their systems. On the other hand, control over who has access to what information can be important in the highly confidential device industry; control of intellectual property was cited as a concern by all of the participants. Thus, identifying the best way to manage information flows is not a straightforward undertaking.

This is reflected in the model of knowledge coordination in SCs developed by Simatupang, Wright and Sridharan (Simatupang, Wright, & Sridharan, 2002, hereafter Simatupang). They note that the coordination of information is “the act of managing interdependencies between activities” and that different types of coordination are appropriate in different operating circumstances.

Simatupang identifies two dimensions of coordination: mutuality and focus.

Mutuality of coordination refers to the extent to which the partners want to build a sustaining relationship for attaining a goal—that is, the depth and direction of information sharing required. Within the mutuality segment, complementarity refers to information that is shared at an operational level to handle the requisite interdependencies of supply interfaces, whereas coherency refers to diffusion and sharing of information and knowledge across firm borders to understand and manage the supply chain. Although Simatupang does not position their taxonomy on axes, it would be consistent to add a directional X axis going from relatively objective information to more integrated knowledge.

The other dimension, focus of coordination, characterizes the linkages or interfaces for coordinating joint decisions. Operational linkages are those between trading partners for decision making, whereas organizational linkages deal with understanding partnership activities and bargaining realities on the part of independent actors. Again, a directional Y axis going from the operational to the strategic would be appropriate. Table 11 below outlines the Simatupang model.

The two coordination dimensions yield four coordination modes:

- Logistics synchronization—delivering products and services to fill customer needs/wants;
- Incentive alignment—distribution of benefits and risks to motivate independent actors;
- Collective learning—initiation and knowledge across borders; and
- Information sharing—cooperation between actors for diffusing information across company borders.

Table 11
Simatupang et al Model of Knowledge Coordination Mechanisms in Supply Chains

		Mutuality of coordination	
		Complementarity	Coherency
↑ Operational to Strategic FOCUS OF COORDINATION	Organizational linkages	Incentive alignment	Collective learning
	Operational linkages	Logistics synchronization	Information sharing
Adapted from Simatupang, T. M., Wright, A. C., & Sridharan, R. (2002). The knowledge of coordination for supply chain integration. <i>Business Process Management Journal</i> , 8(3), 289–309.		→ Increasing integration	

5.3.1 Logistics Synchronization

Logistics synchronization refers to the coordination of the information necessary to manage the practicalities of supply chain interfaces. Information is gathered to facilitate market mediation (e.g., customer demand patterns and inventory management) and other SC activities [rapid response, lower inventory costs, improved product availability, minimum obsolescence, and minimum variance (forecasting errors/delays)]. Tactics include collaborative logistics, operational flexibility, postponement, collaborative transportation; joint forecasting, joint inventory management, and replenishment.

At the industry level, logistics synchronization is suggested for industries in which there is high demand uncertainty, a short selling period, long procurement lead time, a high variety of customer preferences, or when product obsolescence requires collaborative forecasting, inventory management, and rapid response.

Logistics synchronization is important on an operational level for all SCs. However the relative strategic importance of different elements of logistics

synchronization will vary in different circumstances. In the device industry, some of the industry drivers are present (especially demand uncertainty and obsolescence), while others are less important (notably short selling period and long procurement lead time). Some logistics synchronization tools are in evidence (such as postponement), and others are the subject of much discussion (forecasting accuracy, operational flexibility, and inventory costs) but the focus is not strong.

5.3.2 Information Sharing

Information sharing operates at a more integrated level than logistics synchronization but is still operationally oriented: the objective is to ensure that relevant, accurate, and timely information is available to decision makers. However, the emphasis is on making information availability more symmetrical with a high level of information sharing. For customers this involves information-based services such as online information and transactions. With trading partners the emphasis is on visibility of customer demand, resource planning, and contract terms. This high level of information sharing acts as a “glue” to integrate the supply chain.

Bilateral sharing of information is very limited in the device industry and generally only happens at the most operational level. Device firms are still working to make this level of information available internally, and have not yet adequately addressed the relative merits of letting this information go out of house.

5.3.3 Incentive Alignment

Incentive alignment operates at a less-integrated but more strategic level than information sharing. It coordinates the information used to encourage trading partners to work to their mutual self-interest. The objective is to encourage firms to align their businesses processes. Information is shared through relational contracts (specifying price, quality, and deadlines, as well as performance metrics) and forms the basis for

relationship pricing, consignment, capacity reservation, and performance-tied bonuses. The information is also used to establish how decision makers are rewarded and/or punished for decisions.

Incentive alignment practices are seen throughout the downstream (customer) segment of the device industry SC. In particular, relational contacts, consignment, and bonus/discount schemes are widely used.

5.3.4 Collective Learning

Collective learning is the most integrated and most strategic information coordination mechanism, and encapsulates the type of information flow typified in the integrated SC paradigm. At its core are intensive dialogue, experimentation, and discussion of data, information, and knowledge between trading partners. There is an emphasis on practical learning between trading partners for understanding and tacit capability. The objective of the diffusion of knowledge across organizational borders is to extend each partner's capability for "accomplishing ongoing improvement." In turn, this facilitates the 'buy-in' of key collaborators.

Collective learning in the device industry has been largely internal (because of vertical integration) but the industry's predilection for alliances reflects another form of collective learning. And with the increasing convergence in the underlying skills required for success, it is likely that collective learning will become even more important as a knowledge-sharing mechanism.

5.3.5 Summary

The Simatupang taxonomy of knowledge-coordination modes looks at the levels and types of information and information mechanisms found in a supply chain, broadening the focus of knowledge coordination from an operational to a more strategic perspective. As such it refines the application of knowledge theory, which

has been characterized as being too linear and limited, and needing to be more “directly about the state of knowing ... [and having] less to do with control, systems, production, processes, mechanics or methodologies” (Maloney, 2000). This parallels evolving thinking about SCs, which have traditionally been seen in terms of operationally focused SCs, their controls and processes but which is becoming more conceptual and strategic.

5.4 Power

Power in the device industry can be considered in terms of the locus of power within the organization and relative to buyers and suppliers. Relative power can be considered in terms of the balance and directionality of power: whether the power balance is generally unidirectional (one side holds the preponderance of power) or bidirectional (in which both sides have some power over each other).

In the device industry even large firms tend to have relatively limited power with their suppliers. In part this is a limitation of vertical integration and the relatively small production volumes: even large device firms are relatively small customers to most of their suppliers. In the case of high-level components the device firm has more weight, but the collaborative nature of the undertaking acts as a counterbalance to relative power.

R& D is also a power base. As the focus group noted, not only is the R&D group seen as having a high status within the firm, but production is often co-located with R&D, raising the status of that site even further. Small, innovating firms use the power of their potential innovation to try and secure the best possible terms of alliance with the larger- and more powerful- firms.

At the other end of the SC, as noted particularly by the focus group and DePuy, the device industry has markedly low power relative to their customers.

However, the power imbalance is not fixed: a quirk of the industry is that the introduction of a genuinely innovative product gives a firm a high level of power—at least until the rest of the industry catches up.

Harland *et al* developed a taxonomy of supply networks from a power/network perspective (Harland, Lamming, Zheng, & Johnsen, 2001) (hereafter, Harland). Two dimensions are identified: the relative dynamism of the industry and the relative power of the trading partners.

The dynamic aspect of the supply network incorporates the internal operations process characteristics with the external competitive environment. High process variety and/or low volumes contribute to an internally dynamic environment; uncertain demand and demand management challenges are external characteristics. In a dynamic network competition is driven by innovation more than cost and there may be a lot of technological change. The key strategies for dealing with a dynamic network are resource integration (especially human resource) and knowledge capture.

When a supply network is not dynamic it is considered to be routinized and operating under relatively stable competitive conditions. Internally this comes from low variety or high volumes, so production processes are stable; externally, demand is also relatively stable due to either limited competition or limited new product launches. Routinized networks compete more on cost and quality than innovation and tend to have established SCM practices. The focus is on information processing rather than knowledge capture.

The power aspect characterizes the relative power of the “focal firm” within its supply network. High power is derived either from the actual value added by the firm, the perceived indirect value, or its control of access to the network (e.g., as a

bottleneck or conduit). Low power comes from being a relatively small or unimportant participant in the network or from a low profile or poor image.

Table 12
Taxonomy of Supply Networks

	Dynamic Supply Network	Routinized Supply Network
Relative Power Low	Low Power/Dynamic	Low Power/Routinized
Relative Power High	High Power/Dynamic	High Power/Routinized

Adapted from Harland, C. M., Lamming, R. C., Zheng, J., & Johnsen, T. E. (2001). A taxonomy of supply networks. *Journal of Supply Chain Management*, 37(4), 21–28.

Four types of power balances in supply networks are identified, with implications for both operations and strategy.

5.4.1 High power/Routinized

Operating in a comparatively stable environment with high relative power makes this the most manageable supply-network type. The firm can choose its trading partners, take a leadership role in the supply network. Operationally the emphasis is on stock minimization and operational improvements. This is clearly not applicable to the device industry, which has neither a stable competitive environment nor high power.

5.4.2 High power/Dynamic

Although a dynamic environment is challenging, and requires continuing innovation, relatively high power in the supply network enables the firm to take a role in managing the supply network. Strategies for dealing with trading partners focus more on the choice of partner (something they are in position to do). Operationally, the emphasis is on demand management. Although the power dimension is not

applicable to the device industry, the dynamic element is, and the emphasis on demand management touches on one of the recurrent issues cited by the research participants.

5.4.3 Low Power/Routinized

Key strategies in a routinized/low power network will focus on trading-partner relationships: motivating trading partners to participate with them, using risk-and-benefit sharing as a tool. Operationally, stock minimization, equipment integration, and information processing are critical. The routinized aspect does not pertain to the device industry but the low power element does, and the research participants cited a number of practices that are used as motivators (such as consignment).

5.4.4 Dynamic/Low Power

This is the most challenging of the four types, because there is little scope for management control. Competition tends to be on innovation more than cost and it is often found in industries in which there is rapid technological change. Key strategies are human resource integration, knowledge capture, and innovation. Strategies for dealing with supply-network partners centre around motivating them to participate and using risk-and-benefit sharing to offset relatively low power. Operationally the emphasis is on demand management and coping with the requirements of the network. The device industry fits within this group.

5.4.5. Summary

The Harland taxonomy is unique in linking two competitive characteristics—the nature of the environment and the relative circumstances of a firm operating in that environment—and applying them to SCM practice. It affirms the importance of power within SCM. It also tends to confirm the two major strands of SC practice: the

characteristics and approaches to a dynamic environment align neatly with the responsive SC model as do the routinized environment and the efficient SC model.

5.5 Governance

The range of governance mechanisms has expanded from “make or buy” to “make, buy, or ally” (Landry, 1998), and this nomenclature is appropriate for the device industry. Historically strongly vertically integrated, the range of trading relationships has broadened substantially. Some of this reflects consolidation- (as with DePuy, created by Johnson & Johnson from a number of acquisitions), which leads to governance challenges of rationalization and integration. Some of the change reflects the adoption of SC practices such as vendor/supplier managed inventory, noted by the focus group as an important trend, which changes the nature of trading relationships (in turn, these changes are shaped by relative power, and require changes in knowledge flows). The interview firms and the case firms felt that the governance structures in place- even with internal trading partners- hindered their ability to work effectively.

Externally, device firms form multiple alliances. Frequently there is a significant size disparity between the two parties with both sides getting something important from the alliance: the (smaller) innovating firm gets needed investment capital (and/or marketing and distribution support), while the larger firm gets access to potentially important innovations. In other instances two firms with complementary areas of expertise work together (as in drug-coated stents). Outsourcing is a particularly challenging arena for device firms: in structuring the relationship both knowledge issues (including intellectual property, as well as coordination and depth of knowledge flows) and power issues (including security of supply, interdependence with the trading partner, and control of intellectual property). The participants vary in

their receptiveness to the concept of outsourcing, but all of them approach it with considerable caution.

A typology of control and coordination mechanisms through which the organization can manage the range of trading relationships was described by Lejeune and Yakova (2005, hereafter Lejeune), through four configurations, based on the depth and breadth of dependence. Although Lejeune did not put these elements into figure form, they can be arranged as such (see Table 13, below).

The first dimension is depth, as characterized by the extent of information sharing and the level of goal congruence. The second dimension is interdependence, which encompasses the extent to which decision-making is uni- or bilateral, and the level or type of trust. Four types of supply network configurations are described: communicative, coordinated, collaborative, and coopetitive.

Table 13
The Four C's of Supply Chain Management

	Complementarity	Coherency
Organizational Linkages	Collaborative	Coopetitive
	Equality Matching	Communal Sharing
Operational Linkages	Communicative	Coordinated
	Market Pricing	Authority Ranking

Derived from Lejeune, M. A., & Yakova, N. (2005b). On characterizing the 4 C's in supply chain management. *Journal of Operations Management*, 23, 81–100, based on the framework adapted from Simatupang, T. M., Wright, A. C., & Sridharan, R. (2002). The knowledge of coordination for supply chain integration. *Business Process Management Journal*, 8(3), 289–309.

5.5.1 Communicative

The communicative supply network is characterized by shallow dependence and is based on market pricing: it is essentially the “buy” of the make versus buy decision. The network is not “managed”—it exists and is used as needed.

Relationships are short-term, trust is based on reliability, and information exchange is limited to what is necessary for the transaction. There is frequent partner switching,

competitive bidding among suppliers, and no set of common goals or objectives. This would be typical of noncore purchases in the device industry.

5.5.2 Coordinated

The coordinated supply network is familiar as an integrated, dominated supply chain (e.g., Wal-Mart and the discount-store industry): there is a hierarchy of trading partners and the dominant member manages the supply network. It is characterized by a deep dependence and is authority based. Trust is based on deterrence and reliability and the goal congruence reflects the willingness (or need) of the trading partners to ensure that their goals are aligned with those of the dominant member. Information flows are as broad as the dominant member determines but they tend to be asymmetrical. There is some anxiety in the device industry that the buying groups may achieve this sort of dominance but the variability of power levels suggest that it is unlikely to become established as a major governance mechanism in the device industry.

5.5.3 Collaborative

Goal congruence in the collaborative supply networks reflects the (reasonably) symmetric power balance among the trading partners. There is some interdependence, but it is shallow and broadly equitable. There are commonly agreed objectives and the participants try to use their complementary assets to gain competitive advantage. Operationally there is often a “focal function” (such as inventory) that is the focus of process improvements (e.g., vendor managed inventory or capacity requirements planning). Trust is based on competence and reliability. Information sharing is high in the focal areas but may be limited in others. Although the model positions this in terms of downstream trading relationships, in the device industry it is also common upstream in the form of alliances.

5.5.4 Coopetitive

The most integrated of the configurations, communal sharing can include both competition and cooperation through lateral collaboration between competitors. In this configuration there are commonly agreed goals, extensive information flows, and cooperation on strategic efforts such as R&D. There may be a focal function, but it will be broader in scope than in the collaborative configuration (generally, it will encompass more than one functional area). Again, in the device industries these relationships may form as purpose-driven alliances.

5.5.5. Summary

At the outset of this research several characteristics of the device industry (fast moving, knowledge based, innovation driven, and fragmented) had led to an expectation that network forms of governance would be found. In fact, the industry is strongly vertically integrated for the same reasons as the pharmaceutical industry: the need for absolute quality control, stringent regulatory requirements, and (perhaps most importantly) the need to control access to proprietary information. However there are a range of governance mechanisms in play, and they reflect the sometimes conflicting needs of confidentiality, knowledge flow, and relationships with trading partners.

5.6 Industry

The role and influence of industry was a recurrent theme with all of the participants (see Table 10, Data Source Findings, and section 5.2.10, for a listing and discussion of the participant views). In Section 4.1.7, drawing on the industry study, the Fisher and Lee archetypes were applied to the device industry. These findings suggested that, in demand terms products in the device industry are in the “innovative” category. The supply type was more ambiguous, but given the choices,

the “evolving” supply type seemed the better fit. Based on these models, then, the device industry would seem to be suited for a responsive (Fisher) or agile (Lee) type of SC.

In practice then, the device industry should be trying to create SCs based on a build-to-order and mass customization approach (Responsive), with pooling of inventory or other capacity management techniques when dealing with suppliers (Agile). Outsourcing should be used to transfer risk of uneven supply and demand to the trading partner.

The experience of the participants in this research suggests that not only are they not following this model- or even trying to- but some of it is simply not possible (volumes are too low for mass customization; build-to-order not only goes against the inventory practices in the industry, but are counter to the central tenet of the device industry: the device must already be there when it is needed. The industry does not have the power to use outsourcing in this way, even if such flexibility was possible given the regulatory restrictions. However, the close ties with outsourcing partners are appropriate, especially given the confidentiality issues. And flexibility of production was specifically cited by an interviewee- though in the context of trying to balance lean production with flexibility. The conflict between efficient and responsive type SCs was evident, and exacerbated by the presence of people from other industries.

Supply networks link across industries, yet most research is done *within* specific industries; there is little work that looks at industry effects. In part this lack of industry-level attention reflects the shift in research away from the industry level to the firm level during the 1980s, which was in part a natural correction but also a reflection of the emergent work in resource-based theory.

Early efforts to characterize the comparative importance of firm versus industry effects have evolved into more nuanced work, examining the relative importance of firm, corporate, strategic group, and industry effects in different aspects of the competitive and operating environments. For example, one cross-industry study found that firm effects are more important in overall firm performance, but that industry effects are more important for core strategies such as technology and marketing (Mauri & Michaels, 1998). Mauri and Michaels use Chandler's characterization of core strategies as those that involve the allocation of existing resources and the development of new ones, a clear fit with supply networks (Chandler, 1962, 383, as cited in Mauri & Michaels, 1998).

Another study emphasized that industry influence is particularly important with regard to strategic factors (Misangyi, Elms, Greckhamer, & Lepine, 2006). This work and others (such as Chang & Rosenzweig, 1998; Chang & Singh, 2000; Short, Ketchen, Palmer, & Hult, 2007) found that the relative level of industry, strategic group, corporate, and firm effects varied depending on a variety of factors, but all concluded that it is important to include industry effects in strategy planning and development. Hawawini found that firm-specific assets matter most at the extremes, for the "dominant value creators/destroyers" (i.e., leaders and losers), but for most firms in an industry, industry effects are more important—and the more homogenous the industry the more important industry factors are—(Hawawini, Subramanian, & Verdin, 2003).

McGahan (2004) developed a typology of change trajectories that define the key strategic issues for companies within an industry. Drawing on a base of ten detailed statistical studies (examining more than 700 industries), and more than twenty-five case studies completed over a period of ten years at the Harvard Business

School, Stanford University and Boston College four types of industry trajectories. Depending on the combination of threats to the core assets (property of durable value) and/or core activities (i.e., activities necessary to generate profits), an industry can be characterized as being on the “Progressive” trajectory (discount retailing); an “Intermediating” trajectory (car dealerships); a “Radical” trajectory (typewriter manufacturers); or the “Creative” trajectory (medical devices). Industries can and do change trajectories but “all” industries are “always” operating within one of the four trajectories. Further, firms in an industry that align their strategies with the trajectory of the industry will be more successful. Each of these trajectories are reviewed briefly in the following sections, with an emphasis on those elements that are most germane for SCM.

5.6.1. Progressive Trajectory

The Progressive trajectory is the most prevalent trajectory, encompassing just under half (43%) of all industries. Industries on the trajectory are characterized by long life cycles (lasting many decades), relatively stable buyer–seller relationships, high standards of operational effectiveness, and a clear dominant model of competition. Another characteristic is distributed benefits: all participants in the industry tend to benefit to some degree from innovations. For example, Wal-Mart divides supply network-derived savings equally between the supplier, Wal-Mart, and the customer (Ketchen & Hult, 2006).

Importantly, change on the Progressive trajectory is incremental: major changes to the dominant model send the industry onto the Intermediating or Radical trajectories. The relative stability of the competitive environment allows for intense competition, though volatility in the marketplace is sometimes mistaken for volatility in the industry.

The early stages of the Progressive trajectory are in essence the beginnings of a new industry in which there is considerable experimentation; as the industry begins to take form a dominant model emerges, and the importance of efficiency and effectiveness grows as the market grows. By the time the industry has reached maturity there is a clear industry structure and the familiar treadmill of innovative improvements that become industry standards begins. As the industry moves along the trajectory, competition intensifies and improvements in efficiency are necessary to maintain profitability. Industries on the Progressive trajectory benefit from a strategy of having a highly efficient set of interlocking activities supported by an ability to respond quickly to buyer/seller feedback. Further along the trajectory relative power tends to tip to the buyer, but this can be offset by dependence on the specialist suppliers that tend to evolve with the industry. Organic growth tends to be more successful than growth by acquisition or alliance on the Progressive trajectory. Alliances are primarily with suppliers.

The Progressive trajectory unfolds slowly, and industries stay on it until something moves them onto the Radical or Intermediating trajectory. This move can be driven by changes in buyer preferences; by changes in the supply of raw materials; by a decrease in competition that leads to increasing prices and decreasing quality and innovation; by saturated demand/supply; or by substitution.

5.6.2. Intermediating Trajectory

On the Intermediating trajectory shifting market boundaries threaten the core activities of the industry, particularly the structure of information flows. This in turn changes the core relationships between buyers, suppliers, and competitors. It is the hardest trajectory to manage: the scale of change and the net impact on the industry, is almost as extreme as on the Radical trajectory, but the pace of change is faster by an

order of magnitude: where the Radical trajectory unfolds over a period of decades, the Intermediating trajectory generally unfolds in the course of a decade. It is also the second most common trajectory encompassing nearly a third of all industries (32%).

The first challenge is recognizing that the industry has indeed moved to the Intermediating trajectory: the new structure of the core activities may initially appear to be simply a new segment or niche. For example, online music distribution was initially seen by the music-publishing industry as a way to sell more music, not as a threat. Even when the threat became apparent, the nature of the threat was seen in terms of the old paradigm: as a copyright theft issue. The deeper threat—the potential impact of independent uploading of music, circumventing the industry’s control of access, was overlooked, as was the return of music by the song (last seen in the 45rpm records of the 1950s) rather than the concept album. In turn, in conjunction with ever shorter artist product life cycles, the economics of developing and marketing new “talent” changed.

The music publishing industry is now in the convergence stage of the Intermediating trajectory, trying to protect its assets (back catalogues and established performers) while trying to reorganize itself to compete in the new environment. This introduces the second challenge of the Intermediating trajectory—the need to quickly and repeatedly reinvent the business model as the trajectory unfolds. Both the speed of change and the distinctiveness of the stages mean that any given manager is likely to have to manage two or even three significant strategy shifts within their tenure in a position, and senior management will have to manage the internal repercussions of the requisite strategic changes. This is extremely challenging for any organization and it is not surprising that there is high attrition rate on this trajectory.

On the Intermediating trajectory the industry's assets retain their value: the challenge is to find ways to package or leverage that value so that customers will pay for it. The changing nature of core activities, particularly information flows and relationships, means that understanding the value nodes in both the existing and emerging supply networks is critical.

5.6.3. Radical Trajectory

The Radical trajectory is perhaps the most authentic parallel in business of the biological concept of the life cycle, though the trajectory generally starts when the industry is a healthy adult, and deteriorates from there. As in biology, some individuals in the industry will fail quickly and others will still be spry (all things considered) until very near the end, but the trend is clear and irreversible. Although McGahan argues that some remnants of the industry can survive, albeit in a much-reduced form and with different competitive characteristics, in fact the "survivors" in the examples that she gives (such as horse-drawn carriages in big cities), usually have been reintroduced into the industry as a subset of another industry (e.g., tourism). None of the original players are still in the game.

These profound changes require industries on the Radical trajectory to reconfigure their activities in order to create value in new ways from changing assets, which in turn generally requires the unbundling of old assets and unwinding of old relationships. Unfortunately, as with the Intermediating trajectory, often the relationships that are currently the most profitable may become those that are the biggest liabilities in the emerging paradigm. As relationships become increasingly unstable, with both buyers and sellers looking to change their nature of the relationship, relative power ends up being low. Successfully managing the trajectory requires divesting assets, resources, and even relationships that may have been very

profitable but are liabilities in the new order; both the timing and management of this process tend to be difficult. Last ditch improvements in operations may keep the old industry apparently competitive, which can extend profit extraction—but can also mislead participants into thinking that the threat has been deflected, not just postponed.

As with the Intermediating trajectory, one of the most difficult aspects of the Radical trajectory is recognizing when the threat of obsolescence has become real—that is, when a novel approach moves past being a concept or niche and into the mainstream. As with the Intermediating trajectory, this requires information gathering on the new approach, benchmarking the relative benefits, and particularly the potential benefits (as the limitations of early iterations may mask the potential impact). Once a threat becomes clear and serious, the emphasis shifts to the activity system and in particular in keeping the standard high for the new approach while systematically rationalizing capacity.

The one advantage that the Radical trajectory has over the Intermediating trajectory is timing: the Radical trajectory typically takes decades to unfold. This allows the old industry time to extract profits from its assets and activities while adapting to the new order (to postpone the inevitable end for as long as possible). As the old industry contracts through firms leaving the industry, mergers, and acquisitions, there can be a prolonged period of relative profitability for the survivors. It is exceptionally rare for a leader from the old paradigm to succeed as a leader in the new industry, but a judicious approach to supply-network management can contribute to a maximization of returns during the long transition.

5.6.4. Creative Trajectory

The Creative trajectory is characterized by stable relationships between the industry and its customers but with a high rate of obsolescence of assets. The short life cycle and constant threat to core assets are at the core of the differences between the Progressive and the Creative trajectories: where the Progressive trajectory unfolds in a series of long stages, stages on the Creative trajectory are more variable. When a new industry is formed on the Creative trajectory there is a period of years when it is fragmented and entrepreneurial, with a diversity of firms and products and low industry volumes. However once a dominant model emerges there is a short, sharp shakeout, in which volumes jump and a new emphasis on efficiency emerges. By contrast, the shakeout phase on the Progressive trajectory can last for decades. Maturity, when the industry structure is stable and continuous improvement becomes important, can be long for both trajectories but the last stage, decline, which can also be measured in decades on the Progressive trajectory, is again relatively short on the Creative trajectory. One of the biggest challenges of the Creative trajectory is not mistaking the “usual” changes for changes signifying a shift of trajectory. Change of trajectory is sometimes self-inflicted on the Creative trajectory: It is often precipitated by a decline in innovation and/or quality due to industry dominance by a small number of competitors. The stability of the group of leading firms within the industry is notable: their market share relative to each other tends to be volatile, but the top tier of firms is generally stable. On the other hand, the growth rate of an industry on the Creative trajectory is comparatively volatile because of the unpredictable nature of buyer preferences (and buyer feedback is notably unreliable), supplier capabilities, competitor innovation, and internal project-management abilities.

Success on the Creative trajectory is a combination of successfully managing a new project portfolio on the one hand, and managing relationships with buyers and suppliers on the other. Although the Creative trajectory can be seen as one of “constant crisis” because of the constant threat of obsolescence to the core assets, it also tends to be very profitable for successful firms.

5.6.5 Classification of Industries

McGahan outlines a four step process for identifying the trajectory of any given industry. The first step is to identify the industry, through commonality of buyers and / or suppliers; shared competitive intent, and shared technical platform. Next, the nature of change in the industry is considered: is it architectural? And, is it foundational? From these three steps, the trajectory can be identified, and then the stage of evolution within the trajectory can be determined. These steps are elaborated below, through application to the device industry.

The McGahan sequence of industry definition is increasingly nuanced. The first element is commonality of trading partners: firms that share common buyers and common suppliers are considered to be the same industry. All firms in the device industry share common buyers and (potentially some) common suppliers, but the firms in the high technology end share only some suppliers with the commodity end. The second element is shared competitive intent. Although in the device industry, some firms sell devices that lie at, or across, the high-technology border, this element indicates a distinction within the industry, as most commodity end firms (or divisions) do not compete directly with high-technology firms (or divisions). The third and narrowest of McGahan’s element confirms high technology medical devices as an industry in it’s own right: shared technical platforms. This refers to the interchangeability of employees, and the acceptance by buyers of the product of a

competitor. Thus, the high technology industry includes “close competitors with the capability to attract each other’s buyers and suppliers” (p.104), and as such is clearly distinct from the commodity end. It is worth noting that within the medical device industry different product groups have been treated as separate businesses (eg, cardiology, orthopedics). Although these separate groups are being increasingly integrated, and previously sole-segment firms are branching into other segments, these groups could perhaps be considered to be considered as separate industries, and could thus be on different trajectories. However, for this work, the industry is high-technology medical devices.

The second step in identifying the trajectory of an industry is to determine whether the nature of change within the industry is architectural: are there threats to the core activities of the industry? Core activities are those that are essential to the industry’s ability to create value, that affect both current revenue and current costs and affect both buyers and sellers simultaneously. The “acid test” (p.109) is whether buyer willingness to pay or supplier willingness to sell are dropping. While buyers are complaining about how much they have to pay (and are looking for ways to control their costs), there is no question that what the industry is selling is still considered to be worth paying for. Upstream, as the industry becomes less vertically integrated and simultaneously expands the range of inputs required, there is a proliferation of suppliers. Thus, the device industry would not be considered to be under threat of architectural change.

The third step is to determine whether there is foundational change, resulting from a threat to core assets, in the industry. Core assets are those that are essential to the industry’s ability to create value, but unlike core activities they are durable. The acid test is whether the value created by the industry is declining because of the threat

to the core assets. In the device industry, the core assets are the portfolio of products available to meet patient needs. As patents expire, and new products emerge, the value of the portfolio is under constant threat. Thus, the device industry would be considered to be facing foundational change.

McGahons framework characterizes industries in which there is foundational but not architectural change as being on the Creative trajectory. The Creative trajectory is characterized by a series of stages beginning with a prolonged period of fragmentation, followed by a short sharp shakeout, then a long maturity, and finally a short, sharp decline. Industries whose rate of growth in aggregate volume increases quarter over quarter are defined as being in the fragmentation stage of the Creative trajectory; when the rate of growth stops increasing the industry has moved from the fragmentation stage to the shakeout stage (McGahan, 2004). The device industry, which is growing quarter over quarter, is well advanced into the fragmentation stage. It has passed through the beginning phase when project development systems (e.g., R&D) are separated from the systems of commercializing them (sales and marketing), and the middle phase in which project management skills emerge, expertise begins to accumulate, and benchmarking parameters evolve. The device industry is now in the third and final phase of the fragmentation stage, in which support systems of core activities are developed.

5.6.6 Summary

The four change trajectories described by McGahan were developed as a tool for practitioners to use in aligning their strategies with their competitive environment; though not specified by McGahan this can reasonably include SCM strategy. It is clear that SCM strategies for an industry on one trajectory (e.g., Progressive) would necessarily be different from those for industries on another (for example, Creative).

5.7 Conclusions

This chapter began with a discussion of the data gathered from the research participants, then drew out the findings by linking them to models based on knowledge, power, governance, and industry. Connections were made between each model, SCM in general, and the findings from the device data in particular. Together, these models form the basis of a strong framework for the shaping of a novel approach to SCM practice.

CHAPTER 6:

SUPPLY NETWORK TYPES

6.1 Introduction

The findings from the data-gathering process (chapter 4), and the theoretical and strategic elements of SCs (identified in chapter 5), were linked together to build new theory, a task of theory evolution in the nascent stage.

Although it is not possible to fully disentangle the threads that come together to create a new construct, there are several elements that stand out. First, various readings suggested, and the industry information gathered affirmed, a need for a more strategic approach to SCM. However there seemed to be a conceptual barrier to moving away from the operational level: even the best efforts to take a strategic perspective seemed to stall at the design level. Some development was needed to make the leap to a genuinely strategic level.

Second, while SCM within an industry is often studied (particularly in certain industries), and SC approaches for different product types were considered, the effects of the nature of the industry—the competitive environment—itsself were not being addressed. Moreover, very little of what was done in one industry could be applied to another industry, yet the findings of the present work demonstrated how important those effects were.

Third, reading Cox's challenge of the integration paradigm at an early stage of this research led to continued questioning and observation of the merits and applicability of the paradigm throughout the research process. Evidence began to accumulate that not only was integration not always possible, it was not always desirable; this was particularly clear in the device-industry findings.

Reading McGahan's work served as the catalyst that brought these strands together. It was immediately clear that industries on different trajectories would have different strategic and operational SC concerns. Thus, the work turned to theory building: to develop a structure that would integrate SCM, at an operational and theoretic level, to accommodate the strategic concerns of industries on each of the trajectories. The emerging theory would reflect the role of Knowledge, Power and Governance, as well as the importance of industry. And, in doing so, would perhaps even reconcile the difference between theory and practice that led to this research.

The integration of these elements led to a novel construct: four different types of supply networks that are appropriate for different competitive circumstances, reflecting both operational and strategic considerations. This is a material progression from the dominant paradigm of a continuum from market buying through to highly integrated trading relationships and a presumption that the more integrated a supply network is, the better. To reflect the broader approach of the proposed typology there is a change in nomenclature from SC to supply network: SCs, and SCM have acquired an operational reputation that is both more linear and less strategic than is the present case (Harland et al., 2001).

The four types of supply networks—Integrated Supply Network, Reactive Segmentation, Efficient Segmentation, and Mediated Supply Network—are outlined below. For each network type there is a general description of the network followed by its alignment with an industry trajectory. This is followed by characterizations of the operational elements that are appropriate for each trajectory, which were derived by applying SC techniques to the tactics recommended for that trajectory. This makes the SC types immediately accessible for use in practice. Strategic elements, drawing on the SC models for Knowledge, Power and Governance are also offered. Finally,

there is a summary of the major features of the network. The Knowledge, Power and Governance model introduced in 2.5.6 is used to illustrate the key theory elements. Two modifications are made to the model. First, industry characteristics have been added to the center of the model, reflecting the central role of the trajectory. Second, the orientation of the model varies between the models. In the original conception of the model, the three theory groups were seen as being equally important. However, while they all have an important role to play in each SC type, it became clear that in each case there was one that was *primus inter pares*; for each SC type this is indicated by presence in the top circle.

6.2 Integrated Supply Network

6.2.1 Description

The Integrated supply network is an extension of the already established “ideal type” of SC extended from the operational level to the strategic level. In an Integrated supply network all elements of the network are consciously considered, selected, and shaped to maximize the benefit to the firm and its closest trading partners (Cox, 1999; Cox, Sanderson, & Watson, 2001; Frohlich & Westbrook, 2001). Typically, there are highly integrated links with at least some trading partners, but “integrated” also refers to the strategic approach to supply-network management within the firm. It is this model of supply network practice that researchers complain is lacking in practice.

6.2.2 Supply Networks and the Progressive Trajectory

The key to success on the Progressive trajectory is incremental innovations to improve operational effectiveness through tightly linked activities: a nearly textbook definition of the integrated model of supply-network management.

Of particular relevance is the importance of the firm’s activities, nearly all of which are seen as core. The links between these activities are important and

extensive: maps of the links are generally complex. In turn, the systems that interlock these activities become important, and tight coordination within the organization as well as with trading partners is essential. Thus on the Progressive trajectory an integrated approach to supplier selection is important, as supplier collaboration, including IT integration with suppliers (e.g., just-in-time manufacturing and vendor managed inventory systems), is likely to follow.

Although the emphasis shifts through the trajectory, the overriding characteristic of the Progressive trajectory is that once a dominant system develops, it is in the best interests of the participants to adhere to that system: even near the end, it is more advisable to pursue the same strategies of operational effectiveness more aggressively, not to change the system. It is worth noting that McGahan sees Wal-Mart as having set the dominant system for a new industry—discount retailing—not as an evolution of general merchandising. Thus the SC strategy for discount retailing has been set by the dominant player, and the best approach for other players in the field is to try for second-mover advantages: to try different tactics, but not different strategies.

6.2.3 Operational

At an Operational level the Integrated supply network uses an efficient-type SC. The routinized element of the Harland taxonomy epitomizes the Integrated type SC: the industry operates in stable conditions, production processes are relatively stable, and the primary competitive issues are price and quality (as opposed to innovation). Process or operational efficiencies are more important than product innovation. Cost minimization is important, as is the integration of resources and information. This is a well-known and well-understood construct.

6.2.4 Strategic

As with the Operational level, the strategic aspect of the Integrated supply network can be seen as the “classic” model: increasing levels of integration, depending on the nature of the transaction and the relative power balance between trading partners. There is a broader range of strategic approaches that align well with the Progressive industry trajectory than there are for the other trajectories.

Knowledge

The Integrated type supply network aligns well with Simatupang model of knowledge coordination, which clearly fits within the classic supply network paradigm. The core of the Simatupang model is the coordination of information that is “the act of managing interdependencies between activities,” and the operational effectiveness focus of the efficient supply-network model. As Simatupang envisioned, Logistics Synchronization, Information Sharing, Incentive Alignment and Collective Learning are all useful and appropriate knowledge-coordination mechanisms on the Progressive trajectory.

However, relative power between the trading partners will significantly affect which, when, and to what extent each of these modes are strategically sound choices. Access to and control of operationally derived information can lead to the strategic development and management of knowledge flows, which in turn can alter the balance of power between trading partners.

Power

The balance of power is a central element in the Integrated type supply network. The relative power of the “focal firm” is assessed in characterizing the appropriate SC (Harland et al., 2001). Generally there is a dominant player in any given Integrated supply network, but dominance is determined by a number of factors including relative size and access to alternatives (Phillips Connolly et al., 2005b).

Relative power between trading partners is particularly important in an Integrated type supply network because firms with a high degree of influence have more control over the choice of trading partner and the nature of the relationship. They may also be able to exert control over the nature of the network, requiring their suppliers to conform to their trading demands. On the other hand, a firm with a low level of influence may be able to use incentives to get trading partner cooperation.

Governance

The major forms of governance for an Integrated-type supply network will depend on the relative power of the trading partners. Where there is a dominant member of the network, authority-based coordinated mechanisms will be used. The dominant member sets the terms of the supply network. Information flows are wide but are led by the dominant party. Although there will be some goal congruence, the weaker parties may have to (re)align their goals with those of the dominant trading partner. This is the model familiar from such supply icons as Dell and Wal-Mart.

On the other hand, when the relative power of the trading partners is more equal, there is room for collaborative governance mechanisms. Generally there will be a “focal function”— frequently inventory—in which they work together (through EDI, VMI, etc.). Information sharing will be high in the focal area, but limited elsewhere.

However, the nature of the competitive environment is such that the cooperative type is not applicable.

6.2.5 Summary

The strong alignment between the efficient model of SC and the Progressive trajectory cuts two ways. On the one hand there is validation on both sides that the most common trajectory (Progressive) aligns so neatly with the dominant SC model

(efficient). On the other hand, although the efficient SC is clearly appropriate, the limitations of a solely operational perspective are clear when a strategic perspective is added. In particular it is clear that power has a pervasive impact on supply-network management on the Progressive trajectory. Relative power affects the nature of knowledge coordination. If relative power is high a firm in an industry on the Progressive trajectory will be able to direct knowledge-coordination mechanisms; if relative power is low the firm should look for ways to use knowledge coordination to redress the imbalance. Similarly if there is a power imbalance, the power holder is likely to choose governance mechanisms that will generally reinforce that imbalance (for example Wal-Mart controls information flows, limiting what it shares with suppliers). Understanding power balances with trading partners and looking for ways to improve the balance should be an important element of supply-network management in industries on the Progressive trajectory.

Therefore, in SC terms, these can be operationalized in an Integrated supply network should be on:

- improving operational effectiveness through elimination of waste and manufacturing steps, high utilization rates, high inventory turns, minimization of inventory, and shorter lead times;
- efficiency in facility and transport management and inventory management; and
- operations management to reduce forecasting errors and variance and to decrease obsolescence.

These efficient SC practices are all focused on aggressively improving operational effectiveness, as is knowledge coordination through logistics

synchronization and the use of relative power in the management of a routinized supply network.

On a more strategic level, both the type of knowledge coordination and the appropriate governance mechanisms depend on relative power. If the focal firm has relatively low power, then risk-and-benefit sharing and partner-motivation approaches are appropriate, and governance will be through coordinated mechanisms. If the focal firm has relatively high power it will be able to choose its trading partners and be the dominant partner in coordinated-governance mechanisms that are based on information sharing. If the power is relatively evenly balanced (for the trading dynamic in question), collaborative governance mechanisms and collective learning approaches apply.

Table 14 below summarizes the characteristics of the Integrated Supply Network while Figure 7 illustrates the relationship between the strategic elements.

Table 14
Integrated Supply Network

Supply Chain Operations Type	Efficient
Knowledge: Coordination Type	Logistics Synchronization at operations level; Information Sharing; Incentive Alignment and Collective Learning at strategic level (depending on level of power)
Power: Supply-Network Type	Routinized/High influence or Routinized/Low influence
Governance: 4C Type	Coordinated (power asymmetry) Collaborative (power symmetry)

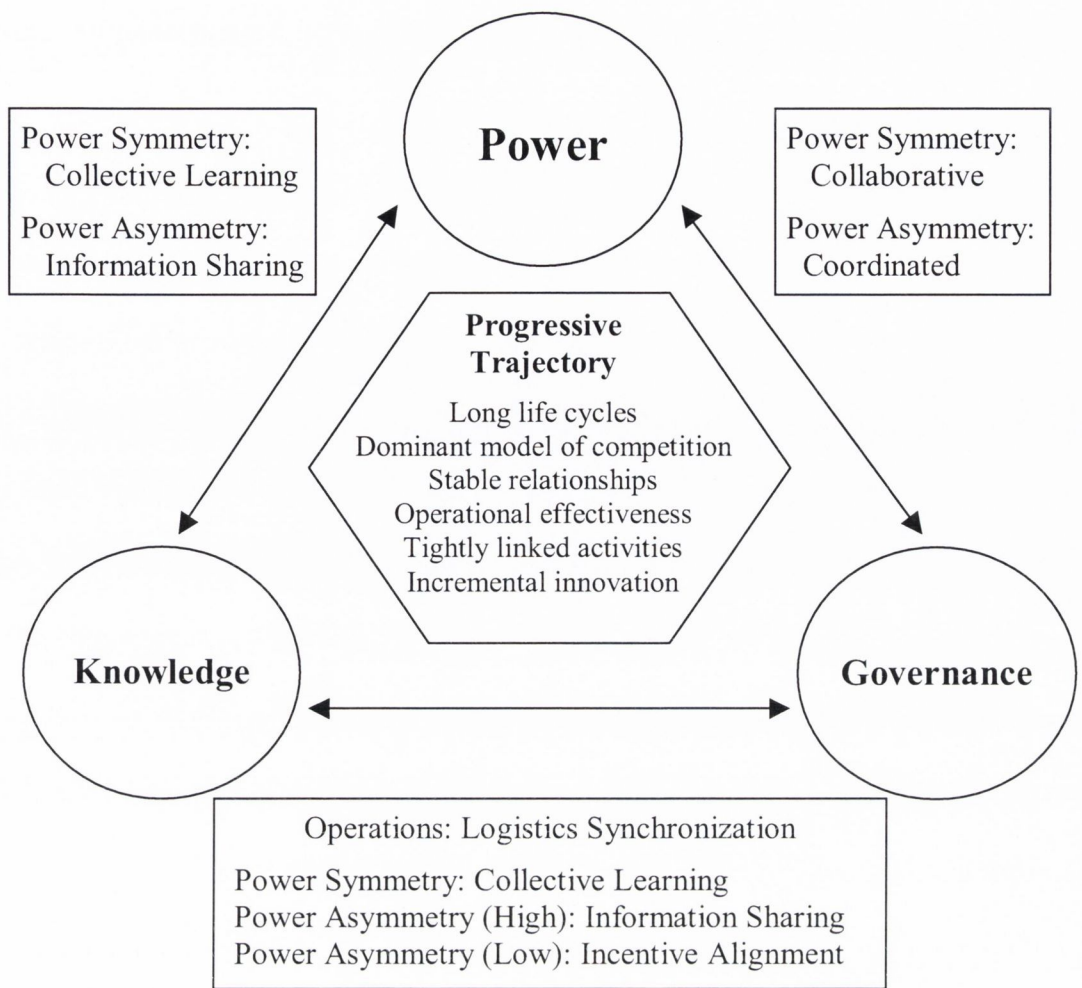


Figure 7. Knowledge, power and governance in the integrated supply network.

6.3 Reactive Segmentation

6.3.1 Description

The Reactive Segmentation supply network takes a modular approach to trading relationships, continuously reevaluating the most appropriate SC approach as the competitive environment changes. Describing something as “reactive” in a business context is generally seen as pejorative and certainly as the antithesis of strategic. Yet a strategically reactive approach to supply networks is necessary on the Intermediating trajectory to accommodate the level of change. The nature of the supply network changes substantially with each phase of the Intermediating

trajectory, and an ability to reassess and reconfigure strategy in response is critical for survival.

6.3.2 Supply Networks and the Intermediating Trajectory

The major characteristic of the Intermediating trajectory is a fundamental change in information flows, which in turn changes the nature of the trading relationship. There is a clear correlation with the phenomenon known as disintermediation in SCM: when a supplier finds a way to bypass their usual customer and sell directly to their customer's customer. On the Intermediating trajectory the major challenge is to manage these changing relationships with a realignment of assets in order to minimize loss while repositioning for success in the new competitive environment. This is done through a changing array of partnerships and alliances with core customers, suppliers, and even rivals.

Because of the changes in the structure of information flows and the nature of the relationship between trading partners, participants have to find new ways of getting value from their existing assets by reconfiguring their activities. The make-buy decision is fundamentally altered as changes in information flows mean that companies do not have to coordinate information internally, while at the same time, the loss of the information bottleneck means that their assets must be repackaged.

Alliances are an important part of managing the Intermediating trajectory, and are made up, down, and across the network; but they are fragile and tend to disintegrate as the industry proceeds along the trajectory. Similarly relative buyer power is variable, increasing and decreasing depending on the threat to the buyer and the way the trajectory unfolds. The degree to which buyers are locked into the existing relationship will also affect the relative power.

6.3.3 Operational

Reactive segmentation depends on information gathering, particularly on the changing nature of the competition (including the emergent industry and its key figures), as well as monitoring industry capacity. The value chain has to be reassessed: core activities have to be decoupled so that they can be outsourced when it is no longer profitable to do them internally. In SCM the 'decoupling' point is typically characterized as the point at which real demand becomes visible in the supply chain (Christopher, 2000). Here the concept is extended beyond Christopher's original application to ordinary demand volatility, to encompass any core activities that are under threat.

Because the core activities are under threat and flexibility is critical, it may appear that the Reactive Segmentation supply type should align with a responsive SC. However although there are clearly several variables that are consistent, it is not the right model: the flexibility of the responsive SC is appropriate in industries in which the value of the assets is short-lived but the industry is otherwise stable and therefore investment in a responsive SC is likely to repay itself. In Reactive Segmentation the firm is preparing to deconstruct the chain; investment in responsiveness may not be appropriate. Similarly investment in an integrated SC-type is also inappropriate: the changes in the industry mean that many existing relationships have to be changed or unwound as the value chain segments and reconfigures. There is a parallel conflict between the dynamic and routinized elements of the power typology: many of the operational requirements are more consistent with a routinized approach such as monitoring industry capacity, cost minimization, incremental process improvements, and stock minimization. However, the environment is dynamic, so significant investment in any of these areas is inappropriate: these operational elements are being

used not as the basis of competition as they would be in a routinized environment, but rather as a part of a strategy for extending survival.

As industries typically move to the Intermediating trajectory from the Progressive or Creative trajectories, they may begin with any of the above types of SCs, but once the industry is on the Intermediating trajectory it is important to be prepared to see the supply network modularly and prepare to modify or remove any element. Equally however, because of the rapidity of the change it is also necessary to be particularly responsive to the interests of core customers. Because of the relative speed of change on the Intermediating trajectory, a Reactive Segmentation approach is needed to meet the competitive challenges.

6.3.4 Strategic

Knowledge

At the beginning of the Intermediating trajectory, market mediation—logistics synchronization—in the existing paradigm is central: postponement and BTO order strategies are appropriate; trying to reduce variance, obsolescence, and forecasting errors are particularly important, and gathering information on industry capacity is crucial. At the same time, information gathering about the new paradigm is necessary and collective learning in the form of alliances may be used to try to gain knowledge about the new industry. This can be difficult as the shape of the new paradigm is still forming, but it is an essential part of understanding the implications of the new approach for trading partners. Being able to segment buyers by profitability and longer-term prospects is also important. Note that the goal congruence that Simatupang identifies may be parallel rather than mutual: the old paradigm is looking for information to help itself survive, and the new paradigm may be using the

resources and/or credibility of the old as a springboard to help itself grow—hence the volatility of these relationships, which rarely last.

As the industry moves along the trajectory the emphasis shifts from logistics synchronization to information sharing, especially for understanding demand information. As the shape of the new industry becomes clear, it is important to be able to identify and protect segments that may be safe from the new paradigm, because they may become a viable subindustry. In particular, relational contracts can be used judiciously to try to shape the nature of new or revised relationships, and the alignment of evolving business practices with trading partners can help to shape the nature of the new relationship.

The strategies recommended for dealing with disintermediation confirm the strategic issues discussed here: rationalization, emergence of new standards, the ability to retain control over customer transactions, and the importance of retaining brand asset value (Chircu & Kauffman, 1999). Some similar solutions are also identified, in particular trying to resecure bottleneck potential (through exclusivity) and access to needed assets through partnering.

Power

Before moving on to the Intermediating trajectory industries may have been routinized or dynamic and may have had relatively high or low levels of power. However once they move on to the Intermediating trajectory they will become more dynamic and have less relative power. Just as McGahan describes the Intermediating trajectory as the most challenging, so Harland describes the dynamic/low-power type as being the most difficult position, and for the same reason: it is the one in which management has least control. Two of the three key elements that McGahan cites for managing the Intermediating trajectory—information gathering, and managing

trading partner relationships—correlate exactly with Harland's strategies for this type of supply network: knowledge capture and networking activity, and motivating trading-partner relationships (the third, modularizing the value chain so that unprofitable elements can be dropped, is outside of Harland's scope, but is reflected in the Governance section below).

Relative power in a supply network comes from high added value, high status (usually from a reputation for innovation or high standards), or control of access to the rest of the network (i.e., the ability to act as a bottleneck or conduit). This is particularly relevant on the Intermediating trajectory where the core issue is that the attractive "added value" increasingly comes from the new industry while simultaneously the old industry's ability to control the bottleneck is eroded.

Governance

Industries on the Intermediating trajectory typically begin with supply networks that are either primarily Collaborative or Coordinated. However when the industry moves onto the Intermediating trajectory, the supply networks go through substantial changes reflecting the profound and continuing level of change inherent in the trajectory. Although elements of both (or either) of the Collaborative/Coordinated supply networks may persist, the relationships will be increasingly volatile and it will be important to segment the trading relationships to be ready to drop, change, or add trading partners as the environment changes. This aligns with the third of McGahan's keys to managing the Intermediating trajectory: modularizing the value chain so that unprofitable elements can be dropped.

The trend will be first toward Communicative networks, with simplified arms-length transactions as existing relationships are unwound. The Communicative model as described in Lejeune does not fit perfectly (in particular the competitive bidding

element is not applicable) but the unilateral aspect and the frequent changes in trading partners apply. At this stage there is no goal congruence, but later as the industry consolidates and the scale of the threat intensifies, Coopetitive supply networks come into play, driven by the shared need for survival. This collaboration may take the form of trading relationships, alliances, joint ventures, or mergers and acquisitions. Lateral collaboration with competitors and even a flow of goods between competitors can be found (particularly in capacity sharing).

It should be noted that Lejeune characterizes the trust between Coopetitive supply-network partners as having a “goodwill” element in which it is presumed that there is a “belief that the other party will always act in the former’s best interests, even where there are opportunities for fraud or defect.” (p. 88). Lejeune is writing from the supposition that the trading partners enter into a coopetitive supply network from a proactive position, whereas firms whose industry is on the Intermediating trajectory would be entering from a defensive position. Thus there is the goal congruence that Lejeune describes but driven by motives of survival rather than general goodwill.

6.3.5 Summary

The Reactive Segmentation supply network draws on elements of several different theoretical tools. While not a perfect fit, in Operational terms the Responsive SC has some appropriate elements for the Intermediating trajectory. For Power the dynamic/low-power supply network model is most relevant. Governance is challenging because firms must have an ability to form a range of changing alliances with trading partners as well as old and emerging competitors. The most demanding area, however, is Knowledge, which requires significant shifts between types as the industry moves along the trajectory.

The crux of the Reactive Segmentation approach to supply networks on the Intermediating trajectory is continuous monitoring and modularization: analyzing each element of the value chain for its relative value to each trading partner and then making each segment of one's own SC as discrete as possible, always with a view to identifying where value can be retained.

Therefore, a Reactive Segmentation Supply Network at an operational level will emphasize:

- Flexibility in the SC, to facilitate the decoupling and modularization of core activities;
- A focus on improving efficiency and effectiveness through incremental process improvements (but not through major investment) as long as business is profitable;
- Reduction of lead times (though again, not through major investment);
- Monitoring of industry capacity; Cost minimization (though not through major investment);
- Postponement and BTO strategies, as part of the modularization of core activities;
- Outsourcing of support activities (for example, using third-party logistics providers) both to reduce costs and to decouple core activities; and
- Minimization of stock levels, both to reduce costs and to reduce the risks of obsolescence.

At a strategic level the firm is increasingly in a dynamic, low-power situation, so the ability to motivate trading partners through risk-and-benefit sharing with an awareness of their partners' long-term interests is important. Although there may be a variety of alliances used, they will typically be limited in both scope and duration.

Trading relationships will be largely communicative, with coopetitive relationships used to manage capacity (through joint ventures, mergers, and acquisitions), and with new entrants, to access knowledge about the new paradigm.

The relatively low level of power and the changing industry environment make knowledge capture important, particularly the development of incentives that will align the interests of both parties, which are in turn central to motivating trading partners with relatively high levels of power. Strong internal-communication systems are crucial for managing information flows and for managing the decoupling of activities successfully.

Table 15 below summarizes the characteristics of the Reactive Segmentation Supply Network, while Figure 8 demonstrates the relationship between the strategic elements.

Table 15
Reactive Segmentation Supply Network

Operational Supply chain Type	Derived from Responsive
Knowledge: Coordination type	Old paradigm: moves from Logistics Synchronization to Information Sharing New paradigm: moves from Collective Learning to Incentive Alignment.
Power: Supply-Network type	Dynamic/Low power
Governance: 4C Type	Balanced between Communicative and Coopetitive

6.4 Efficient Segmentation

6.4.1 Description

The Efficient Segmentation supply network also takes a modular approach but with an emphasis on efficiency rather than reacting to a volatile and uncertain marketplace. It aligns with the Radical trajectory, characterized by long phases often lasting decades. As a result there are long periods in which an efficient operation can

remain profitable, and the supply network can be segmented so that activities can be removed as they become unprofitable or unproductive.

Managing the supply network on the Radical trajectory requires simultaneously following the old path—but doing it better—while dismantling it and moving assets and activities out of the business before they lose their value. Long-term alliances with suppliers may have to be broken in favour of alliances with competitors. Managers must look ahead decades, while minimizing new investment in systems that they know that they (or their successors) will have to break down.

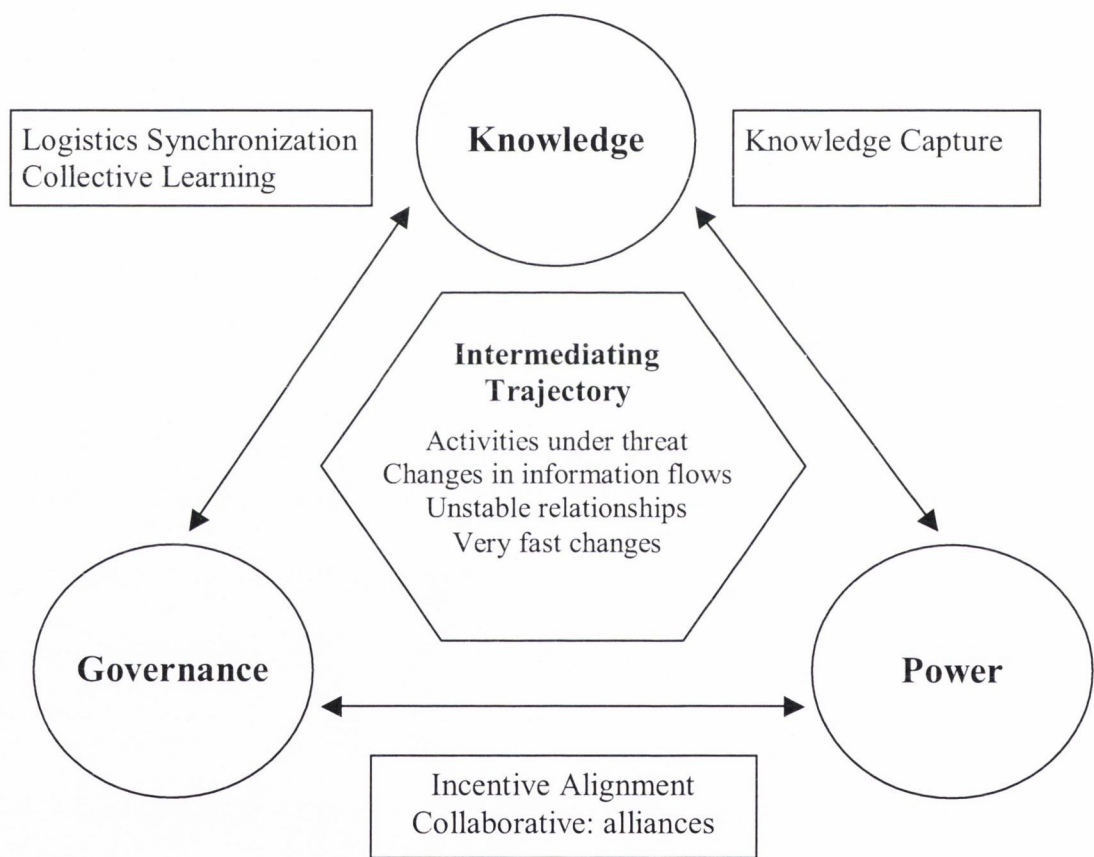


Figure 8. Knowledge, power and governance in the reactive segmentation supply network.

The Radical trajectory requires revisiting the value chain and aggressively reevaluating the relative value—current and future—of each node that the industry touches. Through experimentation and imaginative cost management (in the early

stages), to carefully constructed, modular, activity systems as the trajectory progresses, to greater operational effectiveness and removing of assets and outsourcing of activities (in the late stages), and the management of changing alliances (in all stages), the process calls for Efficient Segmentation of the supply network.

6.4.2 Supply Networks and the Radical Trajectory

The first challenge of the Radical trajectory is recognizing the scale of the risk; the continuing challenge is to determine which activities and relationships to jettison and when. A thoughtful strategic supply-network review should include modularization of the supply network (both operationally and conceptually) so that it is easier to decouple core activities as they become less profitable.

The supply-network implications change significantly as the industry progresses along the trajectory, but there are three main elements to consider: the ability to maximize profits during the long but inevitable descent; the timing and means of shedding activities and capabilities; and managing changing relationships.

These changing relationships become increasingly challenging to manage. One of the reasons that change is slow on the Radical trajectory is that businesses generally start the trajectory locked into existing systems and infrastructures. Initially, trading partners are likely to resist change but later they may come to resent being tied into the old industry. Although buyer power may initially fluctuate, over time it will inevitably strengthen. Relative supplier power will depend on the implications of the new industry for the supplier: if the supplier can reasonably adapt to the new industry, their power will grow; on the other hand if their industry is also threatened by the new industry they will face similar issues of industry contraction. Overall, the key is to balance efficient supply-network systems with flexibility; to manage changing

relationships with both trading partners and competitors while being cautious about integrating with them. Segmentation through replacing fixed assets with variable activities (such as alliances, partnerships, and outsourcing), is a major component of strategy on the Radical trajectory.

6.4.3 Operational

The operational elements of the SC are critical to successful management of the Radical trajectory. Whether the industry started as a Progressive or Creative industry, once on the Radical trajectory the SC emphasis is on ever-increasing efficiency—making the most of what profits remain in the business while paring back investments, assets, and activities through segmentation and devolution. These efforts will have to become increasingly aggressive as the industry contracts.

Greater effectiveness will improve competitiveness within the old industry and prolong overall profitability. The process of improving operational effectiveness will also help to identify supply-network activities that can be isolated later. There is a time factor: the earlier efforts to improve supply-network efficiency start, the more likely that there will be time for the required investments to repay themselves. Benchmarking with competitors SCs is also important.

As the industry moves along the trajectory an efficient-type SC will help the firm to influence the pace and nature of the changing industry. Particular emphasis should be placed on communications to ensure that market information is current and accurate. Outsourcing allows for investment to be focused on areas in which the firm can differentiate itself.

6.4.4 Strategic

The importance of looking at supply networks strategically is manifest on the Radical trajectory: it is a long path of trying to maximize returns in a declining

market. Efficient segmentation can contribute toward keeping the firm relatively fit competitively and maximizing the return on existing investments. Governance is the key: knowledge provides the information for making governance decisions; relative power defines the parameters of the Governance options; but the make–buy–ally governance decision process is pervasive throughout the trajectory.

Knowledge

The Radical trajectory can spend decades in any given phase of the trajectory, but with an inevitable element of decline for most of that time. The more intense integration and strategic linkages found in collective learning are less valuable on the Radical trajectory than on other trajectories. Similarly information sharing, with its emphasis on increasingly symmetrical information flows, features less on the Radical trajectory, in which the relative power balance is generally not favourable to the industry (though information sharing may be relevant with certain suppliers with whom the industry still has a relatively high level of power).

Instead, in keeping with the importance of the operational elements of supply networks on the Radical trajectory, the dominant mode of knowledge management is logistics synchronization: coordination of the information needed to manage the practicalities of the supply-network interfaces (this is consistent with the transaction, production, and process data sharing of the coordinated mode of governance, described below). Market mediation, to minimize obsolescence, avoid forecasting errors, and especially to understand customer demand patterns (in a strategic sense as well as an operational sense) is critical. Recognizing the inflection points at which the nature of the demand changes—for example, when core customers have begun to accept the new industry—is key.

Incentive alignment, based on understanding of the interests of trading partners, plays an important role in managing shifting relationships. Firms can use a combination of motivation and selection to encourage mutuality in trading relationships as relative power changes.

Power

The Radical trajectory aligns with routinized networks, where the primary competitive issues are price and quality, and process or operational efficiencies are more important than product innovation. Cost minimization is important as is capacity reduction and the integration of resources and information.

However although the operational manifestations of an efficient supply network and routinized network are appropriate on the Radical trajectory, there are broader strategic differences. The industry does not operate under the stable conditions associated with both the efficient SC and the routinized supply network—demonstrating again the limitations of using any one approach. The difference relates to relative power, a problematic area for industries on the Radical trajectory: buyer power first fluctuates, then grows; supplier power is variable depending on their own competitive circumstances. However although it may take decades to play out, the trend is inevitably toward lower relative power. Some of the reasons cited for low power are particularly relevant to the Radical trajectory, notably the perception of the firm's relative value or importance. Strategic initiatives based on “motivating” and “risk-benefit” sharing correlate neatly with McGahan's strategic injunctions for the Radical trajectory.

The changing power dynamics affect both old and new alliances. In the early stages of the Radical trajectory the old industry often makes alliances with the new industry, but these alliances tend to fall apart as the industry moves along the

trajectory and the power balance shifts in favour of the new industry. Similarly although alliances with trading partners are important throughout the trajectory, they are vulnerable to changing power relationships as buyers and sellers recognize the limited expectations for the old industry. All of this is characteristic of the Harland routinized/low-power supply network, in which the key strategies focus on trading-partner relationships: motivating trading partners to participate in trading relationships and using risk-and-benefit sharing mechanisms.

Governance

As has been seen, both the Knowledge and Power elements of supply-network strategy for the Radical trajectory focus significantly around Governance mechanisms: the segmentation of the supply network into an evolving array of alliances that seek to lock in existing relationships or align with the new industry (early in the trajectory), position the firm for competitive survival, deal with changing capacity requirements (later in the trajectory), and facilitate the segmentation of activities and the withdrawal of assets.

Industries enter the Radical trajectory with supply networks that are either primarily collaborative or coordinated. Over time however, the balance will shift toward a coordinated supply network with simplified, arms-length transactions as existing relationships are unwound, along with an array of alliances and outsourcing relationships. Although the firm may not dominate the relationship to the extent suggested by Lejeune, it will still be in the lead role because alliances will be undertaken to suit the firms needs even if the firm needs to use incentives to achieve the desired relationship.

Later as the industry consolidates and the scale of the threat intensifies, coopetitive supply networks come into play, particularly when rationalizing capacity

becomes important for preserving profitability. Lateral collaboration with competitors and even a flow of goods between competitors are found. This collaboration may take the form of trading relationships, alliances, joint ventures, or mergers and acquisitions. As with the Intermediating trajectory, the connection in the cooperative supply network is more likely to be based on a shared need for survival rather than a general “goodwill,” but fear of failure can be a potent motivator.

As the industry moves along the trajectory, outsourcing and alliances become increasingly attractive. Outsourcing can both ensure supply and reduce the need to (re)invest in assets. Alliances can be an important tool for keeping suppliers and customers for as long as possible. They can also be part of capacity rationalization and reduce the scale of investment needed in the old industry. Vertical integration of some elements of the SC may also become attractive as a way of ensuring supply or of managing shifting power between trading partners.

6.4.5 Summary

The longer time frames of the Radical trajectory allow time for firms in the industry to harvest profits for extended periods. Putting in systems to maximize efficiency while analyzing each segment of the supply network in terms of its contribution and costs allows more effective management of the invested assets and remaining profits.

Therefore at an operational level an Efficient Segmentation Supply Network should emphasize:

- Elimination of waste and manufacturing steps, high utilization rates, decreasing variance and forecasting errors, minimizing obsolescence and minimization of inventory to manage costs;

- Efficiency, to maximize operating profits and as part of keeping smooth information flows;
- Systems integration of information on customer demand, inventory, and facility and transport management; and
- Subcontracting or outsourcing, as part of the decoupling of core activities, in order to reduce costs and ensure supplier commitment.

These operational considerations follow through to the strategic level where logistics synchronization is the primary mode of knowledge coordination. The market mediation functions outlined above are all part of aggressive cost management and segmentation of the value chain and are consistent with communicative governance mechanisms.

As the trajectory progresses, incentive alignment is the other major mode of knowledge coordination used, reflecting the decline in relative power. Risk and benefit, from the power perspective, are part of the alliance types found in collaborative governance mechanisms. In addition, coopetitive mechanisms such as shared R&D projects with old rivals are found.

Table 16 below summarizes the characteristics of the Efficient Segmentation Supply Network, while Figure 9 demonstrates the relationship between the strategic elements.

Table 16
Efficient Segmentation Supply Network

Operational Supply chain Type	Efficient
Knowledge Coordination Type	Logistics Synchronization, supported by Incentive Alignment
Power: Supply-Network Type	Routinized/Low Influence
Governance: 4C Type	Coordinated; with elements of Coopetitive as the trajectory progresses

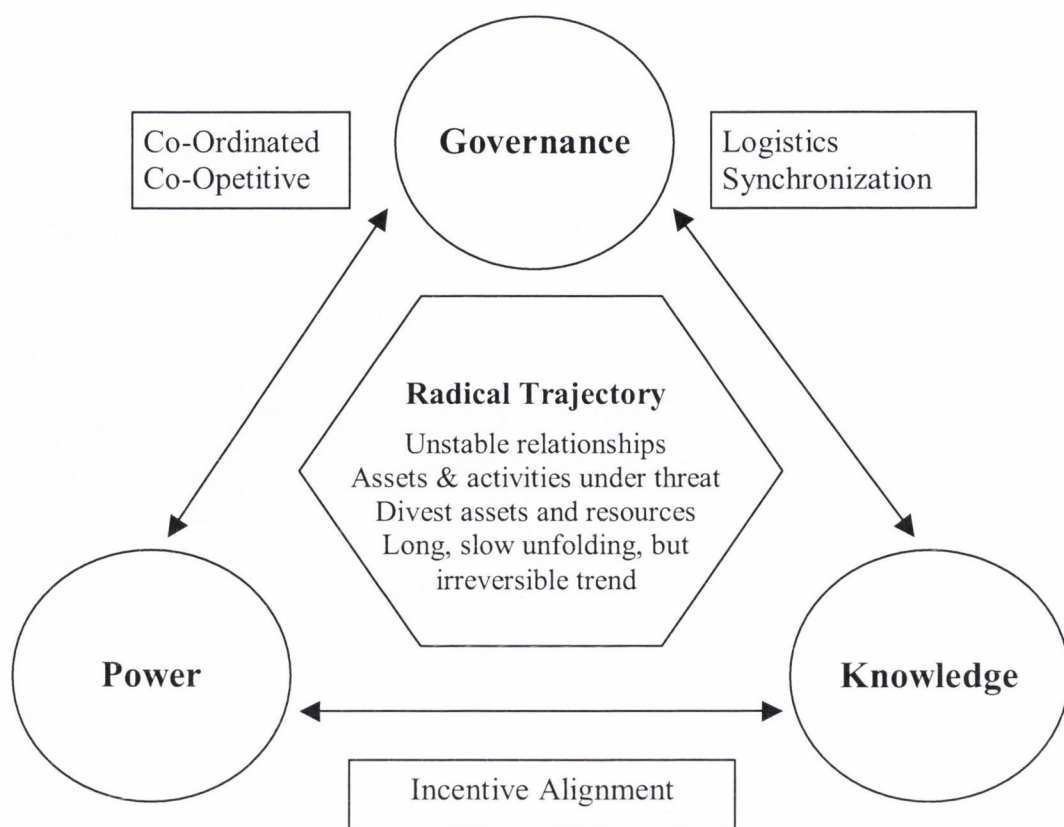


Figure 9. Knowledge, power, and governance in the efficient segmentation supply network.

6.5 Mediated Supply Network

6.5.1 Description

The Mediated supply network segments the upstream and downstream supply network, reflecting both the importance and the nature of the trading relationships on the Creative trajectory. Industries typically begin on either the Progressive or the Creative trajectory, but the difference between the two is stark: where the overriding characteristic of the Progressive trajectory is (relative) stability within the industry, the mark of the Creative trajectory is constant change. Most SCM work addresses the needs of industries on the Progressive trajectory (or from the perspective of an Integrated SC), but the requirements and pressures of the Creative are so different as to require a materially different approach. Where integrating the supply network is key to competing on the Progressive trajectory, supply networks on the Creative

trajectory need to serve as a link between disparate entities: to mediate the relationships between the organization and its trading partners in an active and continuing alignment of the supply network with the competitive environment.

All supply networks require mediation in an operational sense, but on the Creative trajectory the core activity is the management of the very disparate relationships—in very different power circumstances—that are necessary for the commercialization of the core assets. The need for responsiveness to changing circumstances mirrors the reactive element of the Reactive Segmentation supply network on the Intermediating trajectory, but differs substantially in degree: because the activities themselves are not under threat, responses to changes in the environment can be made in a more measured way. It also reflects the modular aspects of the Segmentation supply networks in that different strategic approaches are applied in different segments of the supply network, but the focus is on using the different approaches to preserve the integrity of the chain, not to ultimately break it apart.

6.5.2 Supply Networks and the Creative Trajectory

On the Creative trajectory assets are volatile and activities are stable, but the assets are where both fame and fortune lie and thus where the industry focus is typically found. The emphasis in industries on the Creative trajectory is on the development of assets: activities such as supply networks are often viewed as being important only to the extent that they support the requirements of developing and delivering the assets. However although the activities attract less attention, they are essential for the successful commercialization of the assets. Moreover, given that on the Creative trajectory the core assets are by definition under threat, a development of a threat to the core activities would herald a shift onto the Radical trajectory. Active

monitoring of the core activities may also act as an early warning system of such a change.

A notable feature of supply networks on the Creative trajectory is that the focus tends to be downstream: although there may be partnerships with key suppliers, leadership in these industries depends on downstream partnerships. These downstream relationships are essential: because of the long lead time between initial investment and return on investment, the emphasis on the latest innovation (whether boom or bust) and the variable power balances, long-term relationships are the glue that holds everything together.

6.5.3 Operational

The closest fit with standard supply network types on the Creative trajectory is an Innovative SC (encompassing Responsive, Quick, and Agile type SCs). Industries on the Creative trajectory must innovate in modules to ensure a succession of viable projects and then develop efficient and effective systems for commercialization and delivery to the market. Operational effectiveness is important for managing the project portfolio; as the industry matures, operating efficiency becomes increasingly important. Firms on both the Creative trajectory and innovative-type SCs have been found to take a relatively limited approach to SCM (Fisher, 1997; McGahan, 2004): supply initiatives tend to be operationally focused and limited in scope.

6.5.4 Strategic

Knowledge

Knowledge flows on the Creative trajectory are particularly important, and not just for asset creation. On the Creative trajectory buyers are particularly unpredictable and their feedback is unreliable. Thus having good information flows from buyers is not helpful in the way that it is on the Progressive trajectory. On the other hand,

managing information downstream, that is *to* the buyers/decision makers is absolutely critical, and mediating these flows is central to network management. Knowledge flows upstream to key suppliers are also crucial—hence the frequency of either vertical integration or deep alliances (see Governance, below). Thus the key elements of strategic knowledge coordination are balanced between incentive alignment (downstream), and collective learning (upstream). There may also be joint learning initiatives with customers and incentives used in supplier relationships but they will not be the dominant mode of knowledge coordination in these areas.

Downstream, incentive alignment uses risk-and-benefit sharing to encourage trading partners to work cooperatively. This is particularly important on the Creative trajectory where it is difficult to maintain a high level of relative power with decision makers (see Power below) yet relationships with consumers, merchandisers, distributors, and vendors are essential to success. Using relational contracts can help to redress power imbalances. Incentive alignment on the Creative trajectory is focused less on quantity discount arrangements (as suggested in Simatupang) and more on relational incentives. These incentives include training, junkets, giveaways, and privileged access, as well as preferential terms of business (e.g., credit terms).

Upstream, a collective learning approach to knowledge coordination with particular emphasis on the relationship with key suppliers (whether external or internal) is appropriate. Again, the Simatupang explication is more applicable to industries on the Progressive trajectory, but the construct itself is appropriate for the Creative trajectory: managing the creation, adoption, and diffusion of useful knowledge (Simatupang, p. 299), and in particular allowing breakthrough solutions to flow through is a central component of the process of asset replenishment. Although

the emphasis in the Simatupang model is downstream, it is equally applicable upstream.

Power

Industries on the Creative trajectory are dynamic in the Harland taxonomy, with resource integration, information processing, and knowledge capture central to success on the operational end. On the strategic end, asset replenishment, asset management, and relationships with consumers, merchandisers, distributors, and vendors are essential to success. Important management skills include project management (to develop new assets); risk assessment (to manage the portfolio of current and evolving assets), and most importantly relationship management skills to manage the network of relationships.

Relative power in a supply network comes from high added value, high status (usually from a reputation for innovation or high standards), or control of access to the rest of the network—i.e., bottleneck or conduit—(Harland et al., 2001). On the Creative trajectory, relative buyer power depends to a great extent on product preference: buyers value new and innovative products but their preferences may evolve unpredictably and it is very hard for firms in an industry on the Creative trajectory to maintain a power position relative to their buyers. Asset volatility can lead to a degree of volatility in buyer relationships: having a “hot property” can lead to a more favourable power balance, but short product life cycles and long product-development cycles mean a constant focus on what’s next; a “dud” property can lead to reduced perceived value and loss of status and a harder sell for the next property from the portfolio.

Relative supplier power depends in large part on the nature of what is supplied: core asset creators have the highest power and status whereas core activity

suppliers have less power and status. Suppliers who succeed in having sufficient specialized abilities can have buyers competing for their services.

However, on the Creative trajectory relative power is less likely to stay significantly asymmetrical: because the asset base is so continuously renewed and yet so dependent on the underlying support activities for successful commercialization, it is harder for any one segment of the network to dominate for long. Using motivation and risk/benefit sharing as part of managing the trading relationship (see also Knowledge, above) helps to keep the power balance in line.

Although power is variable between trading partners in an industry on the Creative trajectory, within the trajectory the industry leaders are a small and relatively stable group. Power levels *within* the industry are also relevant. For firms with relatively high power *within* the industry—that is, in the leader group—the dynamic/high-power type applies; for firms with relatively low power within the industry the dynamic/low-power type applies.

Governance

Communicative supply networks have limited value on the Creative trajectory because they are based on short-term relationships with frequent partner switching. Their transitional, transactional nature is appropriate for noncore purchases but is not compatible with a longer-term, relationship-based approach; the sporadic and limited information exchange does not contribute to building a strong activity support base for the effective management of volatile assets where competition is more on innovation than price. Similarly coordinated supply networks in which there is a deep, authority-based dependence with a hierarchy of trading partners are also limited on the Creative trajectory.

Alliances with competitor firms to develop new projects/products are found in some areas of industries on the Creative trajectory in which competencies are highly specialized. As such, coopetitive supply networks may arise on the Creative trajectory as a way of managing innovation and short-lived assets. Capacity sharing—managing assets—with competitors reflects the short time in which value can be leveraged from the asset. Note, however, that capacity sharing in the Creative context is more akin to resource sharing (for example, the old practice of “lending” actors between movie studios) than the sharing of inventory or production capability, which are the more familiar forms of capacity sharing. And when an industry is in the decline phase of the Creative trajectory, alliances, subcontracting, and spinning off supporting activities with and to competitors may be part of a coopetitive supply-network strategy. However, it should be noted although the relationship may be dyadic and in a given focal area even interdependent, it is always in a very circumscribed way. Industries on the Creative trajectory tend to be very secretive, and any collaboration with competitors is be very contained.

Thus, the dominant governance mechanism for interindustry trading relationships on the Creative trajectory is the collaborative type, based around reasonably symmetrical trading relationships. Notably trust here is based on competency and reliability, and the level of information sharing is high in the focal areas in which the trading partners operate and low outside of it. This works particularly well with both the portfolio nature of the Creative trajectory and the level of secrecy typical in these industries. Goal congruence is an important element of relationship management, which is so important on the Creative trajectory and can be reinforced by incentive alignment (see Knowledge above).

6.5.5 Summary

The Mediated supply network reflects elements of the other supply-network types but the focus and priorities are fundamentally different. The Mediated Supply Network constantly looks for changes in the market and tries to respond to them, as the Reactive Segmentation supply network does, but in a more measured way. Unlike the Integrated supply network it views the supply network as a collection of modular activities rather than a tightly integrated whole, yet the objective is to keep the supply network functioning as a whole (unlike with the Segmentation supply networks).

At an Operational level the Mediated Supply Network will broadly follow an innovative approach, with a particular emphasis on:

- Mechanisms for information flows to and from the market, to mitigate unreliable buyer feedback and to maximize buyer interaction and buy-in;
- Investment in SC responsiveness in order to strengthen the depth of relationships and network breadth;
- Use of buffer stock to ensure product availability and maintain relationships;
- Selection of suppliers for timeliness, flexibility, and quality, to maintain product quality and service to the buyer; and
- Maintenance of flexibility in the SC, as part of managing trading relationships.

At a strategic level, if the firm has a high level of power relative to its trading partners it should select trading partners carefully and then actively manage the relationships. Although the firm has a relatively high level of power, it is in its best long-term interests to pursue collaborative relationships as this will build a foundation that will support the relationship through the cycles of portfolio development. With

upstream trading partners these collaborative relationships should take a collective-learning approach to knowledge management. Because of the continuing need for innovation, the benefit of practical learning and building tacit capability is particularly high. The continuing communication required for a collective-learning approach in turn feeds the development of the collaborative relationship. An incentive-alignment approach to downstream trading relationships will work to offset unreliable buyer feedback as well as to develop relationships that will sustain the firm through periods of relatively low power.

To access specialist skills or resources, a carefully structured coopetitive approach may be appropriate. For example two firms may form an alliance for research or product development. However, the parameters of this relationship must be carefully delineated as the firms are likely to compete in other arenas.

If the firm has a low level of power relative to its trading partners it will be important to focus on motivating its trading partners, such as through risk-and-benefit sharing activities which can be a form of incentive alignment that is particularly appropriate with downstream trading partners. Collaborative governance mechanisms encourage and facilitate partner buy in, which is particularly important in low-power situations.

Table 17 below summarizes the characteristics of the Mediated Supply Network, while Figure 10 demonstrates the relationship between the strategic elements.

Table 17
Mediated Supply Network

Operational Supply Chain Type	Innovative
Knowledge	Downstream: Incentive Alignment Upstream: Collective Learning
Power	Industry leaders: Dynamic/High influence Rest of industry: Dynamic/Low influence
Governance	Collaborative Specialists: Coopetitive

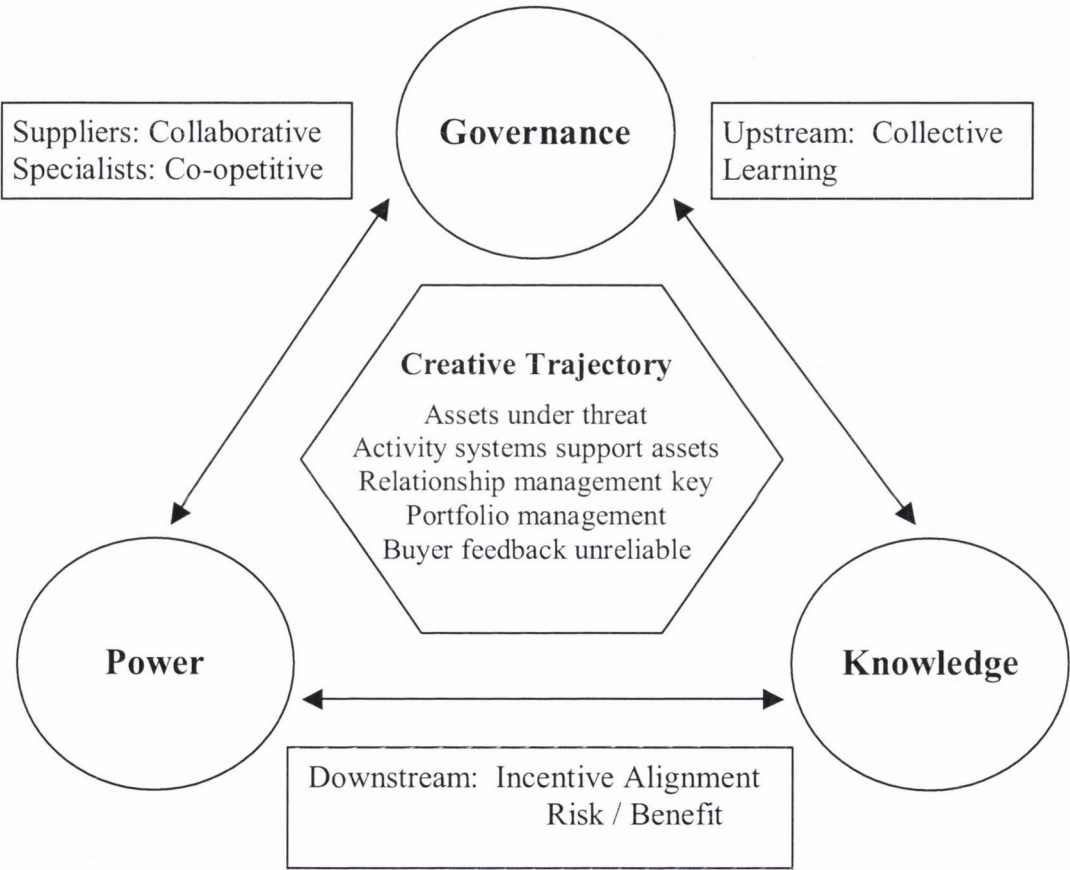


Figure 10. Knowledge, power and governance in the mediated supply network.

6.6 Summary

Drawing on models from supply-network work based in the key theory groups of knowledge, power, and governance, and working from an industry-trajectory perspective, a strategic supply-network approach has been developed. All three of the

theory groups are essential for shaping the supply-network approach, but their relative importance varies between the types.

For the Integrated supply network, power is the dominant element, as relative power determines the extent to which a given firm can shape their supply network. Governance is important in identifying what activities to keep internal and the nature and type of alliances with trading partners; and knowledge coordination mechanisms are essential for understanding the nature of the competition and drivers of success (and operationally derived information can be used as strategic knowledge, and so alter the balance of power). But the relative balance of power between trading partners sets the parameters for supply networks.

On the other hand, on a Reactive Segmentation supply network, while understanding how relative power is changing (including the rate at which is shifting, and the drivers of the change) and managing the changing power relationships is crucial; and decisions about governance (what activities to keep internal; how to segment business; kinds of alliances; timing of alliances, when to start/stop; with whom) are particularly important, knowledge is the dominant element. Coordinating knowledge flows so that there is a sound understanding of the relative value of each segment of the supply network and an understanding of the changing marketplace is essential in order to be able to use cope with the Intermediating trajectory.

In an Efficient Segmentation supply network the dominant element is governance: what activities to keep internal, how to segment the business, what kinds of alliances to form and with whom, and how to time the alliances (when to start/stop). To do this, knowledge coordination is important to understand the changing marketplace and changing consumer parameters, as is an understanding of the shifting power balances in order to manage changes in relative power.

Finally, in a Mediated Supply Network, the dominant element is trading relationships: the variety of types that must be managed and the relationships that need to be mediated in order to optimize the support that the core activities give to the continuously-threatened core assets.

It is worth noting the importance of characterizing the nature of the industry. If product categories within an industry are different enough, they may be on different trajectories, which in turn will affect the SC type. As an example, in the device industry, products that become commoditized are likely to move from the Creative trajectory to the Progressive trajectory, and thus the appropriate type of SC would move from Mediated to Integrated. This is a transition that Bard is managing, as some of their catheters are commodities, and sold through integrated avenues such as GHX, while others are still on the Creative trajectory and are sold through an elite sales force.

These approaches differ substantially from existing models in that they are strategically oriented rather than operational, yet are applicable on a practical level. They are also descriptive rather than prescriptive. Each approach identifies a number of operational considerations and identifies the most appropriate approaches to knowledge coordination and governance mechanisms, as well as power considerations. Yet how each is applied will depend both on the objectives and capabilities of individual firms within the industry as well as the competitive circumstances on the trajectory. As proposed types, they need to be tested. In the next chapter a preliminary validation exercise of one of the types is presented.

CHAPTER 7:

VALIDATION

7.1 Introduction

Immersion in the high-technology medical-device industry, through an industry study, focus group, expert interviews and case studies, led to the development of the role of knowledge, power and governance theory in SCM, as well as the identification of industry as a significant aspect of SCM theory. This theory development process culminated in the development of a SC typology that identified four types of SC, based on the nature of the industry. The typology integrated multiple theoretical, strategic and operational strands, and offers specific strategic and operational guidelines for developing a SC strategy.

The focus of this research was theory development, and it is not within the scope of the project to take the next, crucial, step of theory testing. However, a preliminary testing of the validity of the work can serve both to increase the confidence in the typology, and as preparation for more substantive testing. Therefore, it was decided to test the typology against the device industry.

Applying the trajectory to the device industry takes advantage of the fund of knowledge that has been gathered on the industry, and also broadens the contribution of the project. The trajectory that includes the device industry—the Creative trajectory—is one of the two “normal” trajectories for industries. The other, the Progressive trajectory, is well studied and the corresponding supply network, the Integrated type, is well developed. The Creative trajectory, on the other hand, is the least studied (McGahan, 2004), and the existing supply-network paradigms do not address the strategic and competitive requirements for these industries. Thus, using the device industry may add to the overall contribution of the work.

In the following sections the Mediated supply-network type is tested against the device industry. First, the alignment of the device industry with the Creative trajectory is reviewed (drawing on the discussion in section 5.6.5). Next the Mediated supply network is applied to the device industry, generally, and in terms of strategy and operations (drawing on chapter 5). Finally, the Mediated supply network type is tested against practice, through a survey of, and presentation for, the original focus group.

7.2 Application

7.2.1 Creative Trajectory

As described in 5.6.5, the high-technology medical-device industry is on the Creative trajectory. The key assets (the devices) are under constant threat of obsolescence: the product life cycle averages less than 2 years, and success in the industry depends on managing and constantly renewing a portfolio of products in which the investment (particularly in R&D) is made years before returns can be achieved. Conversely, the core activities are not under threat: relationships with suppliers and customers tend to be long and relatively stable (including those with the emergent buying groups). Power is variable: high when the firm has a popular product, but low when a new product doesn't deliver or an older product is superseded by a competitor's innovation. A small number of firms dominate the industry and relationships are very long term, though buyers are unreliable and demand is typically hard to predict.. The device industry is in what McGahan characterizes as the third and final phase of the fragmentation stage, in which support systems of core activities are developed, and different governance mechanisms are explored both up- and downstream. Thus, we would expect to see evidence of more

attention being paid to support systems and governance mechanisms than would have been previously the case.

The major customers for the device industry are healthcare providers and regulators, and relationships between them and the industry are long and relatively stable. Supplier capabilities are of critical importance, given the duty of care inherent in the provision of medical devices.

Within the industry the leading group of firms is fairly stable. The industry is growing rapidly due in part to a fast pace of innovation but largely to growth in the size of the market. The populations in most of the dominant markets are both aging and becoming wealthier so the potential customer base is growing. All of the characteristics that make industries on the Creative trajectory volatile are present. Buyer preferences can be unpredictable, especially when there are competing new approaches. Similarly buyer feedback about the perceived value of new treatments or approaches is unreliable: a buyer may reject a novel approach until opinion leaders endorse it; similarly they may insist that there is a strong need for a given device but turn out to be entirely wrong. The intense secrecy of the industry is testament to the constant threat of competitor innovation. Internal project-management skills are critical for managing the portfolio of products in various stages of development (this extends to the management of the regulatory agencies who approve the devices).

7.2.2 Supply Networks

Typically device manufacturers have tended to be vertically integrated. Many of the early industry leaders came from an engineering background and many of the early breakthroughs were the work of an individual inventor. Confidentiality, the importance of quality controls, and the inventor-based nature of the innovative process combined to making control over production central to the industry. This

tendency was exacerbated by increasingly tight production regulations. However as the devices become more complex they are beginning to incorporate elements from other industries, particularly electronics and other branches of the sciences. Examples of these hybrid products include drug-coated stents (chemistry/pharmaceuticals and devices) and pacemakers with remote monitoring capability (electronics and devices). These new inputs require new expertise so governance decisions are actively being revisited.

The device industry has historically had low power relative to their customer base but consolidation of customers is aggravating that. It is estimated that within 2 years more than 80% of all medical-device purchases will be made by managed-care buyers (AdvaMed, 2004). This consolidation of buyers—though not necessarily outlets—offers both challenges (the buyer has more power in the relationship) and opportunities (product standardization, economies of scale, and opportunity to develop long-term relationships). The focus of supply networks on the Creative trajectory tends to be on the customer end: leadership depends on downstream partnerships. This is certainly the case in the device industry where the sales and marketing focus is heavily on relationship development and management.

7.2.3 Mediated Supply Network

As is characteristic of the Creative trajectory, the device industry has historically viewed activities such as supply network development and management as being important only to the extent that they support the requirements of developing and delivering the core assets. However, in alignment with the trajectory model, there is evidence of a growing focus in the industry on developing core supply-network activities. For example, all of the top tier firms now have an executive-level position whose role explicitly includes a strategic supply-network function, and one or more

directors whose expertise is in this area. Further, many have hired senior managers from industries that are associated with highly developed supply networks. Though this may create problems (the supply-network strategies that are appropriate in those industries are not, as this paper argues, necessarily appropriate for a different industry), it still reflects a growing awareness and commitment to supply networks at a deeper operational level. This is just as well, as success in the next stage of the Creative trajectory (shake-out) can be dependent on developing these core activities (McGahan, 2004).

A Mediated supply network calls for balancing a modular approach to individual trading relationships, while keeping a holistic view of the overall SC: it reflects the importance of the development and maintenance of a myriad of often-conflicting relationships. On the Creative trajectory in general and in the device industry in particular, two firms can be simultaneously customers, suppliers, and competitors of each other. With the added concern about confidentiality that is endemic in the industry, the importance of mediating relationships is evident.

7.2.4 Operations

The operations area is where industries on the Creative trajectory are most likely to have developed supply networks. The root operational approach is that of a responsive-type SC oriented toward the innovative iteration.

Responsiveness is clearly a greater priority in the device industry than pure efficiency: demand can (obviously) be unpredictable, and the availability of a given device when needed is particularly important. If a salesperson calling on a surgeon about to do an implant has a device to hand, the surgeon may well use it: a short-term sales but also an important step in developing the relationship. In this context, the apparently inefficient system of having up to 40% of inventory of some kinds of

devices in the boot of sales team cars is not as illogical as it first appears (though it may become so over time as the buying mechanisms change). Thus investment in responsiveness systems will yield better returns for the device industry than investment in efficiency, in line with the innovative approach to SCs. Similarly, maintaining buffers, reducing lead times (to avoid both lost sales and obsolescence), and building in flexibility are all appropriate. Supplier selection must emphasize quality, but should also reflect flexibility. Speed is less of an issue than timeliness in this industry (in a responsive supply chain, which is typically a build to order approach), the emphasis is usually on how quickly the customers order can be met; the device industry is generally build to stock as the customer typically maintains relatively high inventories to ensure supply).

The research participants internal struggle (noted in chapter 5) between lean / efficient and responsive SC systems reflects these conflicting elements. First, there is the prevailing SCM paradigm, which emphasizes lean. The hiring of expertise from industries (such as the automotive industry) in which the lean model is dominant has further contributed to the sense that “lean is best.” The growing cost consciousness of the industry makes it seem even more attractive. Further, some device firms either have some commodity-type product lines (for which lean is appropriate) or have a parent firm that has established lean operations in other subsidiaries. It is certainly true (as noted above) that the consolidation of customers means that economies of scale may (for some products) become viable, and that the speed with which innovative products become commodities is increasing. However the fundamental nature of the device industry, its volatile, innovative products, relatively small production scales, and need for absolute quality and traceability require a responsive approach.

Reconciling the need for responsiveness with operating realities that require more cost effectiveness means moving beyond the false paradigm that cost effectiveness is synonymous with lean. Addressing the issue head-on will require going beyond the lean-responsive dichotomy, and even beyond the existing hybrid models. Cost of production is probably the wrong metric; other industry appropriate metrics would allow for more meaningful measurement—and valuation—of different supply-management issues. The focus group firms noted the challenge of finding good benchmarks, and the firm interviewees were also looking for ways to quantify the value of their contribution to the firm. The challenge is to identify or (more likely) develop metrics that meaningfully measure the relative effectiveness of more responsive supply techniques.

7.2.5 Strategy

Knowledge

The Mediated type supply network emphasizes two major forms of knowledge coordination: incentive alignment with downstream trading partners, and collective learning with upstream trading partners. With upstream trading partners, both the Creative trajectory and the Responsive/Innovative approach call for collaborative product design, which correlates with the knowledge coordination mode of collective learning. This is clearly relevant in the device industry particularly as it broadens into other specialist areas (e.g., electronics and biochemical). Collective learning emphasizes “practical learning from one another for understanding and creating tacit capability”. This requires “intensive dialogue, experimentation, and discussion of data information and knowledge to attain collective sense making” (Simatupang, p. 299). We see evidence of this in the device industry, albeit to a limited extent. In the top tier of firms that are involved in collaborative arrangements with suppliers, cross-

functional product-development teams work closely with particular suppliers. Note that consistent with both the Creative trajectory and the Responsive/Innovative SC, these alliances tend to be specific to a particular project.

The upstream approach is different from the approach to downstream trading partners. In the device industry competition is based on product innovation and the key is to get the product into the hands of users. On the Creative trajectory, buyer feedback is unreliable and buyer preferences are volatile, while incentives are an important mechanism for knowledge coordination (they are also important in power mediation, as discussed in the next section). In the device industry relational contracts are the core of the sales and marketing process, and they use a variety of incentives that are meaningful to their target market. Familiar examples include seminars in interesting places, opinion-leader round tables, provision of product samples, and training in new techniques, but some of the credit terms (such as consignment practices) are also a form of incentive. One common sales incentive used in the industry is in fact misaligned: discounts on sales at the end of the month are so standard that there is a huge sales peak in the last days of each month. This has become so institutionalized that firms have begun to amortize the expected sales in the production planning for each month. The device firms do not necessarily have the power to change this practice directly but they can try to address the issue through relational contracts that would remove the incentive to batch order.

Power

Power on the Creative trajectory tends to be variable because of the importance of innovation. In general the device industry has relatively low power compared to its downstream trading partners, but when a “hot” product comes out, the firm who holds the patent will—for a limited time—be in a position of relatively high

power. As the device market is still going through fast-paced growth and change there have been a series of such desirable products. However it is difficult for firms in the industry to retain power: the relative power that derives from having a valued product is limited to that product and is only retained until alternatives are available.

The balance is somewhat more favourable with upstream trading partners whose relative power depends in large part on what is supplied: collaborative partners are in a better position than providers of commodity materials. A supplier with power from a bottleneck position can wield power but in general, because of continuous innovation, which means that any time a newer, better option may appear, relative power is unlikely to stay significantly asymmetrical. This variability means that a long-term perspective is necessary, and that motivation and risk/benefit sharing approaches are important even when relative power is high.

It has already been noted that industries on the Creative trajectory typically have a small group of industry leaders and a much larger group of small firms, and that the device industry fits this profile. The top tier of firms clearly holds a relatively high level of power within the device industry and the dynamic/high-power type applies; for the smaller firms with relatively low power within the industry, the dynamic/low-power type applies. Partner selection and decision making *within* the industry are important in the device industry: as noted above, much of the innovation in the industry comes from the small firms. The large firms select promising small firms and support this research through a myriad of governance mechanisms: investments, development deals, alliances, and joint ventures.

Governance

The importance of mediation is particularly clear when looking at the range and importance of governance mechanisms within the device industry: a pair of firms

can simultaneously be suppliers, customers, and competitors with each other. Coopetitive intra-industry strategic alliances can reflect goal congruence—or competitive preemption. The power balance in such an alliance can be reasonably equitable or can be dominated by one firm. Although Lejeune argues that “goodwill trust” between the parties is essential to the success of coopetitive projects (Lejeune), in the device industry pragmatism is a stronger force: the level of secrecy and competitiveness (as well as hard experience) is such that trust is always tempered by caution.

Interindustry governance is just as complex. As has been noted, the major form of knowledge coordination on the upstream end of the supply network in the device industry is collective learning, which is consistent with the collaborative type of supply-network governance. Collaborative trading relationships are based around reasonably symmetrical trading relationships, but while power imbalances are characteristic of the device industry the asymmetry is not fixed. More importantly, the key on the Creative trajectory—and for the device industry—is relationships. It is that relational aspect that makes the collaborative-governance mechanisms appropriate.

7.3 Industry Fit

In order to test fit between the Mediated SC type and the device industry, follow up work with the original focus group was done. This work had two elements. First, the members of the focus group completed a simple questionnaire designed to identify characteristics of a Mediated SC. Then when the results were analyzed, the overall construct of a Mediated SC along with the findings was presented to the focus group and feedback was solicited. This is consistent with an iterative, grounded methodology.

7.3.1 Focus Group

The focus group was only willing to give direct information about their trading relationships in the form of a completely anonymous questionnaire. A questionnaire was drawn up using the on-line survey site Survey Monkey. A sample questionnaire was provided to the IMDA and evaluated internally by them. Constructive feedback including several suggestions for clarification was provided. This feedback was incorporated into the questionnaire, and the questionnaire returned. A member of the SCMWG then completed the questionnaire as a test. Both the tester's experience and the SurveyMonkey process were satisfactory, so the site link and password were then sent by email to the IMDA contact who then forwarded them to the members of the group. The SCMWG group completed the questionnaire online, with the IMDA taking responsibility for prompting the group to respond until full participation was achieved. The results were then downloaded and analyzed. Because of the very small sample size (there are only eight people in the SCMWG, not counting the liaison, who facilitated the process but did not participate in the survey) the analysis focused on the strongest findings and the response patterns: a more elaborate statistical analysis would not have an acceptable level of significance.

7.3.2 Questionnaire

The questionnaire itself was very short: 12 questions, with an average completion time of less than 10 minutes. This was an important element in gaining cooperation from the group, which was anxious about the time commitment. The questions linked directly to various elements of the SC typology theory (see Appendix 13 for a copy of the full questionnaire). There were several open-ended questions to allow for clarification but most of the questions provided a range of answers via drop-

down menus. The questions either asked for factual information or for ranges based on a 5-point Likert-type scale.

7.3.3 Findings

Although there is some overlap, questions 5 and 6 largely address knowledge; questions 4, 6, and 7 address power; and questions 1, 2, and 3 address governance. Questions 8 and 9 address the strategic role of SCM, and questions 10 and 11 the role of industry. The findings are considered under the headings of Knowledge, Power, Governance, and Industry. Question 12, an open-ended question, asked for any additional thoughts or comments; these responses are included in the relevant sections.

Knowledge

In the Mediated supply network, it was theorized that the emphasis of knowledge flows differs between the upstream and downstream ends of the Mediated SC: upstream, collective learning would be important for product development while downstream incentive alignment should dominate.

The questionnaire asked the respondents to characterize how much information they share with their trading partners. The categories aligned with the four modes of knowledge coordination from the Simatupang model, and the respondents were asked to apply them to “Core” suppliers, “Typical” suppliers, “Core” customers, “Typical” customers, and Intraindustry trading partners. Table 18 below summarizes these findings.

Table 18
Information Shared With Trading Partners

	Logistics Synchronization	Information Sharing	Incentive Alignment	Collaborative Information
Core Suppliers	—	—	33%	67%
Typical Suppliers	17%	17%	33%	33%
Core Customers	—	—	17%	83%
Typical Customers	17%	17%	17%	50%
Intraindustry	50%	33%	—	17%

As expected, the first category (“share as much information as is needed to complete the transaction,” or Logistics Synchronization) does not feature for either core suppliers or core customers but is used to a limited extent with typical suppliers and customers. On the other hand, half of the respondents use Logistics Synchronization with their intraindustry trading partners. This is consistent with the Mediated SC model, the Creative trajectory, and the nature of the device industry: the competitive environment calls for working with firms who are also competitors, but competitive circumstances mean that the trading relationship is usually carefully defined and limited to sharing only information that is directly related to the “focal function.”

Similarly there is no presence of the second category (“share enough information to facilitate the process of the trading relationship,” or Information Sharing) with the core suppliers or core customers, but it is used to a similar extent with typical suppliers and customers. There is still a presence with intraindustry trading partners but it is less common.

The third category (“information to encourage the other party to cooperate,” or Incentive Alignment) is present to some degree with both types of customers, and to a greater degree with suppliers. It was predicted that incentive alignment would be a stronger feature in downstream knowledge management, whereas for these

respondents the reverse was true. Instead the dominant mode for both suppliers and customers was the final category ('as much information as is needed for us to create better systems or products together,' or Collective Learning).

There are several possible explanations for this unexpectedly strong response. First, the respondents, who are in the middle of what may be very segmented SCs, may not be well versed in the nature and extent of different types of incentives or the nature of information sharing with end customers. Second, the theory-development process could have overestimated the importance of incentive alignment and either underestimated the importance of collaboration with customers or the value of collaboration as an incentive. Finally, the respondents may have interpreted the choices offered differently than was intended. In particular the wording of the fourth choice may not have made the level of information sharing intended by the question clear.

In the follow-up discussion with the SCMWG it became clear that the answer was somewhere in the middle of the various reasons identified above. The group did not have the level of intense, bilateral sharing of information, data, and knowledge that Lejeune had in mind for collaborative learning. However, they did mean an emphasis on extending partner capability (although in a more one-sided way—that is, the customer wanting the device firms to extend their capabilities). The reason that this is important however was clear: it is a way of developing and maintaining a strong customer relationship, as well as making sure that any good customer-generated ideas are captured. This is consistent with the emphasis on practical learning in collective-learning knowledge sharing.

This more nuanced understanding of the knowledge flow is validated by the incentives used. The respondents were asked to identify which incentives they use,

how often they use them and how important they are. An advantage of the computer-based survey was that it made this relatively complex question quite simple to answer by providing drop-down menus.

The two most common types of incentives were product samples (83%), and meetings and seminars (67% for on-site and 83% for “destination locations”). Both of these fall under the heading of incentive alignment but the seminars bring in a learning element. This was reinforced by a write-in contribution to the questionnaire, which noted that “international product conferences with product information and clinical trial results are very important to our customers.” Table 19 below indicates the incentives that were identified as being the most frequently used and the most important.

Table 19
Incentives Identified as Most Frequently Used

Incentive	Frequency				Importance			
	Always	Often	Occ.	Rarely	Essent	High	Med.	Low
Printed materials	33%	17%	17%	—	—	50%	17%	—
Product Samples	—	17%	83%	—	—	33%	33%	17%
Giveaways (not product samples)	—	—	17%	50%	—	—	—	67%
Product discounts	—	50%	33%	17%	33%	17%	33%	17%
Product training	17%	33%	50%	—	17%	50%	33%	—
Seminars on—site/locally	—	33%	67%	—	—	17%	67%	—
Seminars in “destination” locations	—	17%	83%	—	—	33%	67%	—
Product development workshops	—	17%	50%	—	—	17%	33%	17%

The underlying reason for the use of incentive alignment in the Mediated supply-network type is to redress power imbalances and relationship management. The device industry (as expected) focuses on the customer relationship as part of that effort. Further, to perhaps a greater extent than in many industries, solving problems with and for customers has always been a driver of innovation in the device industry.

The inward flow of customer information may not be accurate, but both relationship maintenance and the possibility of missing an idea mean that it is important to have access to that information.

Thus while the alignment of these findings with the proposed typology is not perfect, it appears to be simply a difference of degree, not kind. The focus of the Mediated type is relationship management, and in the device industry mediation of information flows is key. The level of information sharing appears to be more intense than was expected, but—allowing for the comments above—it is clear that the general emphasis is somewhere between Lejeune's incentive alignment and collective learning.

Finally, although most information sharing with intraindustry trading partners, is very circumscribed, there is a small but significant presence of deep information sharing. This coopetitive element will be considered again in the context of governance.

Power

In the Mediated supply network, leader firms may sometimes be in a position of relatively high power, but the industry generally is in a position of relatively low power: nobody has a secure grip on power. When relative power is high, firms are in a position to choose their trading partners; when power is relatively low, the emphasis will be on trying to motivate trading partners to deal favourably; at all times managing the trading relationship is important.

The respondents were asked to characterize the relative level of power between themselves and their suppliers and customers. The most striking finding was that, despite nearly uniform complaints about the relative power of customers in the initial focus group feedback, the interviews, and the case studies, half of the

respondents to the questionnaire felt that they had a relatively even balance of power with their core customers. And although 17% felt that they had considerably less power than their core customers, 17% felt that they had considerably *more* power (see Table 20 below for a summary of the findings). This suggests that efforts put into the relationship with core customers do in fact help balance out the power. In an indirect way these findings are also consistent with the industry trajectory and the Mediated supply-network notion of variable power balances: this range of answers is what could be expected of a momentary picture of an industry with changeable power dynamics.

Equally interesting is the relative power of suppliers: half of the respondents felt that their typical suppliers had considerably more power than they did. Overall the balance of power felt nearly as unfavourable with suppliers as with customers. These findings are consistent with the supplier variables noted earlier (notably the relatively small scale of materials purchased limits buyer power; and the relatively high power of suppliers of key components).

Table 20
Power Relationships

	>>>Power	>Power	=Power	<Power	<<<Power
Core Suppliers	17%	17%	17%	33%	17%
Typical Suppliers	50%	—	—	33%	17%
Core Customers	17%	—	50%	17%	17%
Typical Customers	17%	—	33%	17%	33%

Governance

The Mediated type of supply network suggests that collaborative relationships, as part of the foundation for portfolio development and management, should be the dominant mode of governance, backed up by coopetitive relationships used to access

specialist skills or resources. As noted above, this is consistent with a collective-learning approach to knowledge management as part of developing collaborative relationships. These collaborative and collective approaches are also part of developing the strong relationships that are an important part of managing the power dynamic. Because a single firm can be a supplier, a customer, and a competitor these relationships are carefully delineated.

Respondents were asked to identify types of relationships that they have with their suppliers, customers, and other firms within the industry (intraindustry; generally a competitor), and how frequently they use these forms of governance. A follow-up, open-ended question allowed for other forms of relationships or general comments but the only contribution was a note clarifying the role that location and tax policy played in the organization's relationships (see Table 21 below for the findings on relationships with each group).

Looking at the findings from the focus group, long-term sales agreements are clearly the most common type of trading relationship (83% use them frequently or occasionally). This is the most basic form of a collaborative relationship (i.e., one limited to a "focal function," in this case sales). Product development relationships are the next most common: half of the firms use them frequently or occasionally; 83% use them at some time. Licensing agreements are also reasonably common: they are used occasionally by 67% of respondents; 84% use them occasionally or rarely.

Table 21

Types and Frequency of Trading Relationships with Suppliers, Customers and Intraindustry Trading Partners

Type of Trading Relationships	Suppliers				Customers				Intraindustry			
	Freq.	Occ.	Rare	DNA	Freq.	Occ.	Rare	DNA	Freq.	Occ.	Rare	DNA
Joint Research	—	50%	33%	17%	17%	33%	17%	17%	—	—	50%	50%
Long-term sales agreements	50%	33%	—	17%	83%	17%	—	—	—	17%	33%	50%
Product development	33%	17%	33%	—	17%	33%	17%	17%	—	—	50%	33%
Marketing agreement(s)	—	33%	33%	33%	50%	—	17%	33%	—	17%	50%	33%
Licensing agreement(s)	—	67%	17%	17%	33%	—	33%	17%	—	33%	17%	33%
Joint Venture(s)	—	17%	67%	17%	—	33%	50%	17%	—	17%	50%	33%
Minority ownership	—	—	33%	67%	—	17%	33%	50%	—	—	33%	67%

Finally, marketing agreements, joint ventures, and minority ownership are the least common type of trading relationships at the supplier level, but they are conspicuously more common with customers: half of the respondents said that they frequently used marketing agreements, second only to long-term sales agreements. Joint research and product development are also used frequently or occasionally by half of the respondents.

The range and frequency of different types of trading relationships reinforces the importance of purpose-driven alliances or collaborative trading relationships in the device industry. However, there is an apparent conflict in their relative use: the respondents indicate that most of these alliances are used rarely or occasionally, yet the background research on each of the top tier of device firms turned up lengthy lists of known alliances. This contradiction between information sources could reflect a limited level of awareness of the range of alliances used by the firm among the respondents (remembering that there were numerous complaints about the internal barriers to information flow), or they may reflect a difference in interpretation in the frequency of options offered (that is the interpretation of 'frequently' 'occasionally' 'rarely' may vary between respondents).

The Mediated supply network also anticipates some level of coopetitive trading relationships, and these were also found: intraindustry relationships are present in two thirds of the respondent's firms. Although at best occasional, and more typically rare, the types of relationships suggest that the focus is on access to specialist skills or resources: the most common types of relationships cited are joint research, product development, and joint venture.

Finally, the Mediated supply-network mode suggests that noncore purchases will be made through communicative governance mechanisms in which there is more

frequent switching of partners. The respondents were asked to characterize the relative longevity of their relationships with their suppliers and customers (see Table 22 below). The only category of trading relationship that typically lasts less than a year are those with “typical” (i.e., noncore) suppliers, and even that is a small proportion of the respondents at just 17%.

Customer relationships are strikingly long term, with one third of trading relationships with core customers lasting more than 10 years, and 50% lasting more than 5 years. This is likely to be more than a structural phenomenon: if the reason for the durability of these relationships was due to the customer base being finite or fixed, there would not be 50% mobility over a 5-year period. Relationships with typical customers last longer than relationships with even core suppliers, indicative of the downstream emphasis. These findings were augmented by comments, which noted that “the most important relationship is with physicians and hospital management.” Overall these responses reflect the emphasis on relationship development and maintenance anticipated with a Mediated supply network.

Table 22
Longevity of Trading Relationships

	Short: < 1 Year	Medium: < 5 years	Long: 5+ years	Very Long: 10+ Years	Don't Know
Core Suppliers	—	67%	33%	—	—
Typical Suppliers	17%	50%	33%	—	—
Core Customers	—	50%	17%	33%	—
Typical Customers	—	50%	33%	17%	—
Intra—Industry	—	17%	—	—	83%

Role of SCM

A frequent refrain from SCM managers in general and from a variety of sources in the present work is that SCM is not valued highly enough within the

organization; in firms with a clearly high level of commitment to SCM the comments allowed that there had been “a big improvement” and a “big change” in the attitude towards SCM. The respondents were asked to assess the relative importance of a range of strategic variables (see Table 23 below).

Despite the respondents being within the SC function in their organizations, 100% cited product quality as a critical strategic variable. A strong product portfolio came second with 80% citing it as critical and the remaining 20% deeming it to be very important. The only other factor seen as critical by more than half the respondents was customer relationships (60%). And all of the respondents saw product-development abilities as either critical (40%) or very important (60%). Comments such as “product performance and quality are paramount” and “it’s all about the product—quality, pricing, and availability” reinforced these findings. This unanimity of perspective is striking, particularly in the context of the ranges of answers to other questions.

Table 23
Importance of Strategic Variables

	Critical	Very important	Important	Somewhat Important	Not Very Important	Don't Know
Good relations: Suppliers	20%	40%	40%	—	—	—
Good relations: Customers	60%	40%	—	—	—	—
Good relations: Regulators	40%	40%	20%	—	—	—
Strong product portfolio	80%	20%	—	—	—	—
Strong product-development abilities	40%	60%	—	—	—	—
Strong support activities, esp. Marketing	—	100%	—	—	—	—
Strong support activities, esp. SCM	40%	40%	20%	—	—	—
Strong support activities, esp. Operations Mgmt.	20%	60%	20%	—	—	—
Product Quality	100%	—	—	—	—	—

Marketing was ranked as being overall the most important of the support activities (100% thought that it was very important though none thought that it was critical). By contrast 80% thought that SCM and Operations Management were either very important or critical (with a distinct tilt in favour of SCM).

Finally, although all of the characteristics offered were seen as being at least “important,” the lowest in overall importance was good relationships with suppliers: 20% felt that they were critical, 40% very important, and 40% important—a striking though consistent contrast with the relative importance of customers, which all of the respondents ranked as being either critical or very important.

Another measure of the importance of a function within an organization is the presence of individuals from that area at the higher levels of the organization. The respondents were asked for the highest level at which SCM was specifically represented (included in Table 24, Industry Sources for Hired-in SC Expertise, under Industry, below). A person whose brief specifically includes SCM can be found at executive (40%) or board (20%) level in 60% of the respondent’s firms. Another 40% have SC representation at the senior-manager level. However 40% have no SC representation above line-manager level.

The respondents were also asked if SC expertise had been brought into the company recently, and if so when and at what level. There appears to be a fairly continuous spread across the time frames, with reasonably even numbers hired at all levels over the last 12 months, last 2 years, and last 3 years (see Table 24 below). There is, however, a somewhat heavier weighting at the lower levels (line management and operational) in the last 3–5 years, whereas the more senior levels (executive and board) are weighted towards the last 2–3 years. This would suggest a “trickling up” of SC focus.

Table 24
Recent Hiring in of SCM Expertise

Level	Last 12 mos	Last 2 years	Last 3 years	Last 4-5 Years	5+ Years
Board	20%	20%	—	—	—
Executive	20%	20%	20%	—	—
Sr. Mgmt	20%	—	20%	20%	20%
Line Mgmt	20%	—	20%	40%	—
Operations	20%	20%	20%	40%	—

Industry

There were a number of indications in earlier interviews that firms in the device industry were trying to shorten their SCM learning curve by hiring experts from fields in which SCM is (or is seen as) more “advanced” than in the device industry. This implies an increasing sense of importance of the SC function. The respondents were asked if their firms had “hired in” SCM expertise from other industries, and if so, which industries and at what levels.

All of the respondents’ firms had hired SCM expertise from other industries at the operational level; 80% have also done so at the line-management and senior-management level. At the executive level 60% have brought in expertise, while 40% have done so at the board level. The major source for hired in personnel is the electronics industry (40% of the executives, senior managers, and operations personnel; 20% of the board members and the line management), followed by general manufacturing (20% at all levels). The only other industries that were cited were engineering and automotive (20% at the line-management level), and food (20% at the operations level; see Table 25 below).

Table 25
Industry Sources for Hired-in SCM Expertise

Level	%	Electronics	Engineering	Auto	Food	FMCG	Other MFG
Board	40%	20%	—	—	—	—	20%
Executive	60%	40%	—	—	—	—	20%
Sr. Mgmt	80%	40%	—	—	—	20%	20%
Line Mgmt	80%	20%	20%	20%	—	—	20%
Operations	100%	40%	20%	—	—	—	20%

Interestingly, electronics is the biggest source of hired-in expertise followed by other manufacturing. Electronics has some similarities to the device industry—especially the fast cycle and technology-based aspects; it is also an industry with an increasing amount of overlap with the device industry, as more and more devices incorporate electronic components (for example, for monitoring purposes). On the other hand engineering, the originating field of the device industry, contributed expertise only at low levels.

Given the link between industry trajectory and SCM strategy, the implications for sourcing expertise from another industry are worth considering. As has been noted, the strategies learned in one industry may not be right for another. In one of the case firms there was a clear internal difference as to the adoption of a “lean” manufacturing approach: the advocate for the “lean” approach came from the auto industry—in which “lean” is standard; those resistant to it came from other industries.

7.4 Summary

Table 26, below, provides a summary of the alignment between the Creative trajectory (as derived from McGahon), the Mediated supply network (as developed in this work) and the device industry (based on the follow up work with the focus group). Although the survey did not cover all aspects of the mediated supply network, it is clear that the findings from the industry validate the proposed SC type.

Table 26

Summary of the Alignment Between the Creative Trajectory the Mediated Supply Network

	CREATIVE TRAJECTORY	MEDIATED SUPPLY NETWORK	DEVICE INDUSTRY SURVEY / FEEDBACK
General Characteristics			
Core Assets	- Threat of obsolescence - Short product life cycle - Need for continuous renewal	- Short PLC - Core asset creators have highest power/status	- Strong product portfolio critical (80%) or very important (20%) (S) 100% id product quality as critical
Core Activities	- Core activities provide stability for industry leadership - Secondary to assets, but important for commercialization - Prepare environment for launch of new projects - Expand & develop over time	- Management of trading relationships - Commercialization of assets - Collection of modular activities	100% id strong marketing as v. important 80% id strong SCM and ops mgmt as very important or critical 60% have hired in SCM expertise at ops or exec level in last 3 years; 20% at all levels in last 12 months
Five Forces			
Buyer Power	- Overall ↑ or ↓ in buyer power depends on buyer preferences - New /innov products have high	- Buyer preferences determine relative power - Important to manage info to	50% say equal power with core buyers, 34% less and 17% more; 33% equal with typical

	- value to buyer, ↓ buyer power - Value of product can depend on experience / use of product - Buyer preferences unpredictable - Buyer feedback on new products unreliable	- buyer to balance power - Long term relationships help offset asset volatility and bridge periods between innovation	- customers; 50% less and 17% more - All respondents use intensive information sharing systems w/ buyers (collaborative information or incentive alignment)
Supplier Power	- Suppliers involved with core assets have high status / power - Suppliers to core activities try to develop specialized expertise to ↑ value - Key suppliers try to ↑ power by ↑ switching costs (can include internal researchers).	- Core asset partners have high power - Control of access to specialist skills/knowledge gives power	50% say less power than core suppliers, 17% equal, 34% more
Substitutes	- Constant threat of competitor innovation - New ways to commercialize innovation may attract creative talent - New ways for buyer to access a similar / equivalent experience		
Rivalry	- Intense competition - Intensity leads to secretive environment to avoid imitation - Constant threat of competitor innovation	- Information sharing very circumscribed - Secretive - Various alliances w/ some competitors in focal fields to manage innov and maximize assets	50% use lowest level of information sharing (log synch); 33% next lowest (info sharing).

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- | | |
|--------------|--|
| New Entrants | <ul style="list-style-type: none">▪ Entry barriers: product development skills; network of support activities; scale needed to amortize failure risk across a portfolio; access to suppliers/ buyers▪ Control of access to buyers be a barrier to entry |
|--------------|--|

- | | | |
|-------|--|---|
| Other | <ul style="list-style-type: none">▪ Industry boundaries easy to define, except for small, entrepreneurial firms▪ Norm is constant change▪ Asset creators are valued more than support activities▪ Leading group of firms is small and stable▪ Growth rates and market share are volatile▪ 4 stages: Fragmentation (long); Shakeout (short); Maturity (long); Decline (short).▪ Large scale projects that have long development times▪ Portfolio of assets at different levels of maturity | <ul style="list-style-type: none">▪ Trust is based on competence and reliability▪ Power comes from high added value; high status (esp. from innov or exceptional Q); and/or control of access. |
|-------|--|---|
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II. Strategy

Knowledge

- KSF= innovation
- Protect IP w/ KM and patents
- Create max. opportunities for learning w/out high risk
- Use collective learning and collaborative relationships w/ trading partners
- Control knowledge flows, for confidentiality and relationship management
- Good communications links with buyers important for relationship mgmt, even if info not v. reliable.
- 83% use collaborative learning w/ core customers; 67% w/ core suppliers
- As above (low levels)
- As above
- Good relations with buyers are critical (60%) or v. imp't (40%)

Power

- Use relationship management to manage trading partners
- Alignment of incentives, incl. motivation and risk&benefit sharing, to manage buyer power
- Relational contracts to counter buyer power
- Keeping trading relationships as symmetrical as possible
- 17% use incentives with core buyers:
 - All use product training, product samples and seminars; 67% use product development workshops, printed materials and giveaways
- 50% felt power about equal with core customers; 17% with core suppliers

Governance

- Use a variety of governance mechanisms
 - Use a modular approach
 - KSF is mediating variety of relationships w/ trading partners
 - Use a variety of relationship types
 - All use long term sales agreements with customers; 83% use joint ventures; 67% use joint research, joint product development, and marketing
-

-
- Vertical integration and deep alliances for control
 - Alliances can include competitors to manage innov or maximize return on assets
 - Emphasize long-term trading relationships, esp. w/ core agreements; 66% licensing agreements; and 50% minority ownership.
 - 84% use joint ventures and licensing agreements; 83% use joint research, long terms sales agreements and joint product development; 66% use marketing agreements; and 33% minority ownership with suppliers.
 - 67% use marketing agreements and joint ventures with intra-industry trading partners (competitors); 50% use joint research, long term sales agreements, product development, and licensing agreements; 33% use minority ownership
 - 50% have 5yr+ relationships with customers (core or typical); 33% with customers
-

However, as noted above, this exercise serves primarily to broadly confirm one of the proposed types, not to fully test the theory. The most obvious limitation of the focus-group questionnaire is the small scale. Another limitation is that many of the firms are subsidiaries of multinationals so the respondents may not have a good sense of the larger picture. A third limitation is inherent in the membership of the respondent group, which came from the SC function, and the segmented nature of the device industry means that the level of knowledge or awareness of the other segments may be less than it may seem. Nonetheless, the findings validate the fit between the Mediated supply-network type and an industry on the Creative industry trajectory, the high-technology medical-device company.

The device industry is a complex industry that exists in a state of constant change. Trying to balance conflicting relationships while managing a portfolio of assets in varying stages of development under constant threat of obsolescence is challenging. The device industry sees itself as a laggard in the area of supply-network management, and is actively working to “catch up.” The Mediated supply-network type gives structures that address those challenges and can help to shape the strategic choices as the industry moves along the Creative trajectory.

CHAPTER 8:

CONCLUSION

8.1 Introduction

This research set out to explore an apparent paradox: the dichotomy between theory and practice in the adoption of strategic SCM, with the further aim of contributing to the limited theoretical underpinnings of the field. Using a grounded-theory methodology, the high-technology medical-device industry and its use of SCM was examined in detail at both the operational and strategic levels using several forms of research. The following section summarizes the findings in terms of the role that strategy and industry play in the use of SCM, with links to the extant literature and theory, an essential element in emergent theory work (Eisenhardt, 1989). Validation of these findings is outlined in section 8.3, and their contributions to theory and practice are reviewed in section 8.4. Limitations of the research are discussed in section 8.5, and finally some thoughts for future work are outlined in section 8.6.

8.2 Research Summary

The individual findings of the research have been presented, analyzed, and discussed in chapters 4, 5, and 7. Here some of the major themes of the findings are summarized. In particular the role of strategy and the role of industry emerged as being important elements in the understanding of strategic SCM. These findings are then linked to the some of the relevant SC literature.

8.2.1 Role of Strategy

The first most important step in SCM implementation is to begin at the strategic level (Cook & Hagey, 2003), but there is only limited evidence that this has actually happened and considerable evidence that it has not. “Strategic” choices tend

to be at the Operations Strategy level, or Design level of SCM—e.g., designing production systems to achieve corporate goals such as JIT or flexible manufacturing—(Ahmed, Montagno, & Firenze, 1996) rather than at the goal-setting level. It has been argued that there is an absence of links between strategic theory and supply strategy, and that this lack has inhibited the ability of SCM to achieve its potential (Handfield, 2005).

In the course of the research it became clear that SCM is not “one-size fits all”: different approaches are appropriate in different situations—and the dominant paradigm of increasing integration with trading partners is not only difficult but is sometimes *inappropriate* strategically. This is a finding that has been noted previously (notably by Cox, e.g., Cox, 1999; Cox, 2001; Cox & Watson, 2004), but not developed. The importance of understanding the strategic requirements of the competitive environment, with all of the elements of knowledge, power, and governance in play, has been demonstrated by the present research and crucially, viable alternatives to the integrated paradigm have been developed.

8.2.2 Role of Industry

This research has argued that the development of supply-management strategy must factor in the role of industry. The importance of industry characteristics in SCM has been demonstrated through the findings from the device industry, as both a counterfinding to previous research, and in the validation of practice.

Frohlich and Westbrook (2001) in a widely cited study (more than 80 citations on Science Direct) sought to understand the relative benefits of integration with customers and suppliers. Their “arcs of integration” show a strong benefit to greater integration with both suppliers and customers. Applying these arcs to the device industry suggests that it should be less profitable or successful than others: the

industry is inward looking on the arcs scale (the second lowest in terms of profitability), and when it does move outward it moves primarily toward a customer-facing mode (the least profitable approach). However the device industry is actually highly profitable. In discussing potential future work the authors acknowledge that other sectors could provide “different insights.” It turns out that the industry sector used to develop the arcs model is fabricated metal products, machinery, and equipment manufacturers—for which the Integrated SC model is indeed appropriate. That the present work demonstrates that an industry following a different approach to SCM can be profitable demonstrates the relevance of an industry perspective.

The role of industry is evident in the experience of the device industry, which frets that it is “behind” in SCM practices; one manager hired-in from another industry noted that the device industry now is “where the food industry was in the 1980s.” There are numerous examples of what appear to be “poor” SC practices. And SC managers express views that range from resignation to exasperation at their “second-class” status within their organizations.

However the present work suggests that perhaps their analysis is misplaced. First, SC practices have evolved considerably since the 1980’s and it is unlikely that trying to replicate the path of other industries—particularly those with different competitive characteristics—would be to its advantage. More importantly, based on the present research the device industry appears to be largely taking an approach to SCM that is consistent with the requirements of their industry: focusing their efforts on the elements identified in the Mediated SC type should be both more productive and more effective than trying to emulate other industries. And finally, both the present research and the trajectory construct suggest that the role of SCM is becoming more important within the device industry: work toward the Mediated SC type will

position the SC role within the device industries to anticipate the coming changes and contribute meaningfully to the ability of the organization to compete as the industry evolves.

8.2.3 Links to Literature

Linking emergent theory to existing literature enhances the internal validity, generalizability, and theoretical level of theory building, and is particularly important when the findings rest on a limited number of data sources: further corroboration improves the robustness of the theory (Eisenhardt, 1989). The findings from this research can be linked to a range of extant SC research.

First, the Cigolini framework for identifying an SC strategy shares with the present work the idea that industry characteristics play an important role in the development of SC strategy (though the Cigolini model is tautological in its use of the type of SC to develop the SC strategy). However although the argument that an SC strategy can be inferred from the actions of a firm is a useful insight, the work itself is clearly aimed at the Design level of SCM, rather than the Strategic level.

The link between strategic theory and supply strategy that is argued in this work is affirmed by Handfield (2005), as is the need to reflect the “types of manoeuvres” between organizations in strategy development. Miles and Snow make the interesting point that “the supply chain mechanism allow[s] firms to blend strategies in ways we had previously thought was not possible. That is, supply chain networks allowed firms to make new strategic choices and then create new structural designs to implement them.” (R. E. Miles & Snow, 2006, p. 2). Although they cling to the model of integration, they note that SC structures limited to cost reduction and not aligned with management strategies are not stable. The paper also emphasizes that

knowledge flows are central to SCM strategy. Together, these works are consistent with the present research in their emphasis on strategy, knowledge, and governance.

Finally, as was noted in the literature review, the extant theoretical literature on SCM is limited. These limitations are severe enough that in 2006, as this research was nearing completion, two leading journals (the *International Journal of Operations and Production Management* and the *Journal of Operations Management*) ran special issues on the state of SCM theory. The *International Journal of Operations and Production Management* issue asked whether SCM has a sufficient theoretical basis to be considered an academic discipline in its own right. After reviewing the state of SCM theory, the reluctant conclusion was “not quite.” The guest editors note that SCM “lacks a coherent theoretical lens” and expresses concern that SCM is “a fragmented field open to the danger of a lack of generalisability” (Cousins, Lawson, & Squire, 2006, pp. 700–701). There are several elements in the three theoretical papers in the special issue that link to this research.

The first confirms the link that SCM creates between operations management and strategic management (though it limits the link to integrated trading relationships for the purpose of competitive advantage), and a “misalignment” between theory and practice (Storey et al., 2006). Though the emphasis is still on greater integration, there is recognition of changing business models bringing a wider range of governance mechanisms—with an implied modularity—into play. The notion of “decoupling” and the need to know when and where to decouple in the SC—a key element in the SC types offered here—is also noted. Finally, issues of power, knowledge, and governance are all identified in the summation of challenges for SCM. Storey (Storey et al., 2006) saw governance as being one of the biggest issues in SCM: outsourcing, cross-boundary initiatives, changing organizational structures, managing the coupling

points along the SC, and so on. He also emphasizes power as an issue, particularly the power to manage the SC, either internally or externally.

Second, Harland notes that there is “little evidence” of quantifiable benefits from SC integration, a theoretical debate that this work continues.. This is particularly notable given that Harland has worked extensively with one of the leading proponents of integration between trading partners in a SC, Lamming (eg., Harland, 2004; Lamming, 2000; Harland, 1999; Harland, 2005). In a recent paper Lamming recognizes that ‘discontinuities’ may trigger a need for different kinds of alliances- instead of integrated relationships, “dalliances” may be required (Phillips, 2006). This is entirely consistent with the segmentation approach of the Efficient and Reactive supply networks.

Finally, the Burgess et al. literature review (Burgess et al., 2006) characterizes the extant literature and suggests weaknesses that should be addressed in future theory work. It also addresses two particular concerns for SCM theory work: to move beyond the operations-management perspective and to attempt multitheory grounding, precisely as is found in this work.

The *Journal of Operations Management* issue sought to integrate organization theory with SCM, and the call for papers suggested a number of theory groups that the guest editors felt might helpfully inform the development of SCM theory; the correlation between these theory groups and knowledge, power, and governance has already been identified. It is notable that many of the papers in the special issue ended up integrating multiple theory groups, paralleling the work done here. In particular Ireland and Webb combined three theory groups to create a framework for trust and power (Ireland & Webb, 2006) while Holcomb and Hitt (2006) combined two theory groups to develop a construct for outsourcing, an element of governance theory.

Further, Ketchen and Hult (2006) wondered if there are generic SC strategies that “parallel” Porter (1980), Walker and Ruckert (1987), or Miles and Snow’s (2006) generic strategic typologies: precisely what this proposed SC typology offers. The SC types identified here are also consistent with the Ketchen and Hult’s contingency-based characterization of strategic SCM as matching the SC approach to the circumstances with a particular emphasis on agility, adaptability, and alignment. The present work aligns well with the characterization of SCM as being a “multidisciplinary, meta-theoretic research area” that needs to move beyond positivist methods and use more multimethod research techniques, and in particular to move beyond the operations-management perspective (Burgess et al., 2006).

8.3 Validation

This is first-level exploratory research, yet it can be validated in a number of ways at both the theoretical and applied levels. The links to literature, above, offer validation of the various themes of this work; other elements that tend to validate the research and/or its findings are noted below.

8.3.1 Grounded Theory

Glaser and Strauss (1967, p. 237, adapted by Douglas, 2003) identified four characteristics of “good” grounded theory: fit, understandability, generalizability and control. This contribution to SC theory clearly meets all four criteria. It “fits” both the real world and extant theory; it is understandable and provides workable SC types that address the problems and processes of SCM; it is generalizable across a range of industries and circumstances; and it allows for control at the firm level (Douglas, 2003; Edmondson & McManus, 2005).

8.3.2 Parallel Methodology

The development of a taxonomy of types of SCs was not envisioned at the outset of this exploratory work, but interestingly the grounded methodology used paralleled the methodology for taxonomy development used by Harland et al. (2001): a literature review, followed by exploratory data gathering, then more in-depth studies of the populations, then a final data gathering from the study population (Harland et al., 2001). The methodology emerged from the same roots: a complex problem and limited available research in an exploratory inductive study.

8.3.3 Refuting Theoretical Arguments

Three common grounds for refuting an argument for a theory are validity, truth, and persuasiveness (Van de Ven, 2007). In the present work good reasons have been given in establishing the claim (Freeley, 1996, cited in Van de Ven, 2007) though more evidence would confirm the relevance to a broader range of industries. The empirical evidence is relevant and consistent with itself and the other known evidence. It is also reasonably verifiable. Finally the argument is persuasive: it is “cumulative” in the bringing together of a diverse body of work into an intuitively sensible whole.

8.3.4 Industry Experience

Once the notion of different approaches to SCM is introduced it is quickly corroborated by experience. As an example, at a conference presentation on their continuing efforts to develop their SCM strategy, an executive of ICI lamented that despite a decade of serious effort, “ICI has not been able to achieve benefits from customer integration” (Cornelius, 2006).

Interestingly, ICI is a conglomerate of different industries—and thus potentially different industry trajectories. The presentation even linked the difficulties

in achieving benefits from integration with differences in the processes of different business units including

- Units that operate business-to-business versus those that operate business-to-retail: one uses BTO while the other uses BTS, and volatility is an issue;
- Trying to build internal SC structures versus having centres of excellence;
- Global contracts versus responsive SCs;
- Cost issues versus product life cycle considerations; and
- Efficient versus relational SCs.

This research suggests that trying to apply a corporate-wide approach to a conglomerate will not work if the industries are not in similar stages on the same trajectory: using an SC typology it would be clear that some of their business groups could successfully use an Integrated SC, but others call for different SC types.

Although anecdotal, it affirms the “fit” of the basic premise of the SC types: that different approaches to SCM are required for different industry trajectories.

8.4 Contribution

The findings from this investigation led to the identification of important theoretical aspects of SCM, notably the role of the theory groups of knowledge, power, and governance in SCM. Building on these theory groups, aided by models by Simatupang, Harland, and Lejeune, a link was made with McGahan’s strategic construct of industry trajectories. In turn this led to the development of a typology of four types of supply networks.

An important gap in the literature is an absence of links between organization and strategic theory with supply strategy: existing strategic models (e.g., Porter, 1980) offer generic strategies, but do not reflect the “types of manoeuvres” between organizations. Theory building has focused on elements of the SC (such as transaction

costs or markets) rather than the dynamics between trading partners (Handfield, 2005). Where there have been theories of trading relationships, they have applied under different conditions, “leaving a fragmented field open to the danger of a lack of generalisability” (Cousins et al., 2006, p. 701). And a particular limitation to the existing theories is that they do not align with established supply work (Handfield, 2005). This work fills that gap: it provides a typology that explicitly addresses the dynamics between trading partners and aligns with established work, while creating a “bridge” between Operations Strategy and Strategy Management (Storey et al., 2006). Moreover, it meets Melnyk and Handfield’s (1998, p. 311) dictum of being “simple, concise and useful.”

In the end, the reason for the apparently poor adoption of SCM was a hybrid of the reasons offered speculatively in the introduction: the prevailing wisdom is partially wrong—the integrated model of SCM is not right for everybody; in fact it is right for about half of industries. And SCM is more widespread than it appears—if you look for it, and if you allow it to be different from the integrated paradigm, you will find it.

By stepping over the “core concepts” of alignment and integration (Storey et al., 2006) and starting with a blank slate it was possible to see a broader picture, one that allows for a viable “framework,” but with enough flexibility to accommodate “best practice” and a range of strategic choices. It allows for the SC to be “managed” at a range of levels from strategic to operational, and as far up or down the SC as suits the firms’ strategic requirements.

8.5 Limitations

There are several layers of findings from this research: the role of knowledge, power, and governance in SCM, the role of the strategic level in SCM, the importance

of industry in SCM strategy, and the four types of supply networks. The supply-network types, derived through a careful combination of literature review, exploration of practice, and application of theory, address important theoretical and practical considerations. These findings have been validated through a validation exercise that demonstrated a high degree of alignment between the Mediated SC and the device industry, as well as links to literature, testing against the standards of “good” grounded theory, parallel methodology, theory refutation, and anecdotal evidence.

Nonetheless all research has its limitations, in the conduct of the research; in the findings; and in the generalizability of the findings.

8.5.1 Limitations in the Research

Although grounded methodology has been a very effective methodology for the exploration of SCM and the development of a strategy supply-network typology, it could be argued that the results would be more robust if done on a larger scale, particularly with more interviews or more cases. However Glaser argued that the sample size only needs to be “big enough” to generate theory, a goal that these samples clearly met. On the other hand, the sample size of the validation survey with the focus group could usefully have been bigger: the strongest findings would be unlikely to change with a bigger sample, but could contribute to more careful analysis and more robust findings.

Another limitation of the research was the language used in some of the survey questions. In particular there were some questions as to the quantification of “frequency.” Other issues such as how much the respondent really understood about the nature of trading relationships also arose. Because the survey in this instance was a means of gathering information anonymously and was followed up with a direct meeting, these issues and limitations could be addressed and clarified so their impact

on the findings was minimized, but would have to be considered if a larger scale replication was contemplated.

Finally, although it was beyond the scope of this work to undertake immersion in four industries, there would clearly be a benefit in having an example of each industry to confirm the fit and usefulness of the other SC types, particularly the Reactive and Efficient Segmentation supply networks.

8.5.2 Limitations in Theory

Finally, given that there will always be some divergence between theory and practice, there is the question of how the limitations of the present work affect the validity of the theory.

The theory developed here drew on a number of pieces of other theoretical work. This has the benefit of drawing on established work, but brings with it the limitation of using work that is not perfectly aligned with the present objectives and that may have relevant limitations of its own. This was true in different ways for each of the models used. The Simatupang model provided very useful knowledge-flow constructs but was originally envisioned as four aspects of knowledge flows in a comprehensive SC rather than four distinct types. The present work took for granted that a background level of logistics alignment and even information-sharing knowledge flows would be present and instead used the ideal types presented to focus on the dominant elements for different circumstances.

Similarly the Harland power model characterizes firms as having relatively high or low power but does not directly address the possibility that a firm can be in a position of relatively high power in some situations (for example in their relationships with core suppliers) and relatively low power in others (for example with core customers), or indeed within the same group of trading relationships (i.e., high power

relative to some customers and low power relative to others). Again, the typology was used to frame the constructs.

The Lejeune model of SC governance, like the Harland model, assumed that each SC configuration would represent a given SC, but in practice the configurations are more applicable to a given trading relationship rather than an SC: this research found elements of all four types within each of the SCs examined, and the challenge was to identify the most appropriate type for a given circumstance.

These limitations, however, do not materially affect the development of the present work: each model provided a useful framework or construct through which to evaluate the SC implications of knowledge, power, and governance, functioning here as a catalyst and a tool rather than an end in themselves.

The test of the relative importance of the theoretical limitations is in the validation exercise for the derived theory. In comparing the areas of alignment and convergence and the areas of divergence, it is clear that the proposed Mediated SC type aligns well with practice in the device industry. Although the other SC types have not been tested against industry practice, the solid theoretical foundation and the alignment with existing theory elements suggest that any limitations will similarly be of degree, not kind.

8.6 Future Work

Fisher (1997) attributes the poor SC performance to the lack of a framework that managers can use to determine what approach to SCM is most appropriate. Storey et al. (2006) argues for a “contingent” approach of matching SC characteristics to product strategy, rather than following “best practice.” This work bridges these views. Developing the research on a theoretical level will involve testing the other three supply network types against industry, as well as more detailed development of

the different stages of each type. On a practical level, the supply types need only minimal recasting to make them immediately accessible and useful for practitioners. Linking the theoretical and practical elements with more robust gathering of information on actual practice would be highly desirable as a means of both validation and as a means of empirically establishing best practice.

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APPENDIX 1:

OPERATIONAL SC TOOLS AND TECHNIQUES

Table A1.1

Examples of Operational SC Tools

Information Tools	On-line connections (internet, EDI, etc.) for inter-company transfer of information in standard formats
Gather, transmit and share data	Automated ID systems (bar codes, RFID, etc.) to monitor movement of goods through the logistics system and to final sale (POS).
Create and direct flow of information	Integrated databases to share information on forecasts, inventories and production orders.
Co-ordination and Control Tools	JIT
Manage flows	Metrics: line item fill rates, average order cycle time, relative timeliness of deliveries (early/late), backorder levels, order-size constraints, delivery times and flexibility; also vendor rating systems and quality certifications
Monitor operations	SC cost accounting Logistics focused cost accounting (such as activity based costing)
Organization Tools	Interface managers who co-ordinate with SC partner(s), and facilitate information transmission.
Support cross-company communication and co-ordination	
Quality Systems	Six Sigma TQM

Table A1.2

Examples of SC Techniques for Operations Strategy

Configuration of the SC (physical structure)	Design for SCM: approaches for better product and process design Warehouses network redesign: decoupling points at the interfaces between members of the SC Transportation Fleet Design Retailing Systems Redesign Facilities Network Redesign
Management of the SC	Lean Manufacturing Lean Supply Chains Agile Supply Chains Logistic Category Management Distribution Requirements Planning (DRP) Transport Optimization Physical Distribution Continuous Replenishment Vendor Managed Inventory Reserving Upstream Stock Reordering Policies
Planning Systems	MRP DRP ERP DSS Advanced Planning and Scheduling Systems (APS) Capacity Requirements Planning (CRP) Capacity Control

APPENDIX 2:

CASE INTERVIEW GUIDELINES

1. Organization Structure and Processes

- Organization chart
- Major changes/restructurings
- For key departments (e.g., R&D, manufacturing, QC, process development):
- How are they planned/managed?
- How are they factored into the SC?
- What SC issues do they face/raise?
- Regulatory authorities and their impact

2. Trading Relationships

- Sourcing options
- Types used and relative weight of each (i.e., prevalence of that form of sourcing)
- Evolution of relationships (esp. where they have moved from one level to another, i.e., from contracting to alliance).
- Level of integration with trading partners
- Balance of power between trading partners

3. General Operations

- General:
 - Importance of SC for customer, firm
 - Which nodes in the value chain are considered as part of the SC?
 - Mapping of SC (i.e., distribution and number of production and distribution sites & area/market served by them)
- Supply Chain
 - Structure
 - Management
 - Evolution
 - Tools and Techniques
 - Tools and techniques used
 - Relative weight (i.e., which tools & techniques are particularly important; which are peripheral)
 - Emerging v. fading (i.e., which tools and techniques are coming in/becoming more prevalent and which are declining in use)
 - Evolving issues
 - Strategy
 - Links to overall strategy
 - Planning cycle
 - Evaluation
 - Process
 - Metrics

APPENDIX 3:

CASE STUDY INTERVIEW TEMPLATE

1. Organization Structure and Processes

- Organization chart
 - Major changes / restructurings
- For key departments (e.g., R&D, manufacturing, QC, process development):
 - How are they planned/managed
 - How are they factored into the SC
 - What SC issues do they face/raise
- Regulatory authorities and their impact

2. Trading Relationships

- Sourcing options
 - Types used and relative weighting of each (i.e., prevalence of that form of sourcing)
 - Evolution of relationships (esp. where they have moved from one level to another, i.e. from contracting to alliance).
- Level of integration with trading partners
- Balance of power between trading partners

3. General Operations

General:

- Importance of SC for customer, firm
- Which nodes in the value chain are considered as part of the SC
- Mapping of SC (i.e., distribution and number of production and distribution sites & area/market served by them)

Manufacturing Process:

- Primary
 - Specific production issues
 - Use of outside contractors
- Secondary

4. Supply Chain

- Structure
 - Management
 - Evolution
- Tools and Techniques
 - Tools and techniques used
 - Relative weighting (i.e., which tools & techniques are particularly important; which are peripheral)
 - Emerging v. fading (i.e., which tools and techniques are coming in/becoming more prevalent and which are declining in use)
 - Evolving issues
- Strategy
 - Links to overall strategy
 - Planning cycle
- Evaluation
 - Process
 - Metrics

APPENDIX 4:

EVALUATION OF FIRMS FOR CASE SELECTION

Medtronic

Medtronic is the largest of high-technology medical-device company, specializing in heart and vascular disorders, with 50% of revenue coming from defibrillators and pacemakers. An engineering-based firm, growth has been driven by innovation and R&D first, and acquisitions second. Medtronic is seen as having a good pipeline of emerging products.

Table A4.1

Annual revenue	\$9.1bn				% relevant: 100%
Sales by region	NA: 61.9%	Eur: 29.5%	Asia 1.4%	RoW 7%	
Manufacturing locations	NA: 16/57%	Eur: 9/32%	Asia: 3/4%	RoW: 0	28 total; 12 in clusters in NA, 3 in Eur, 1 in Asia

Significant Strategic Events

Founded: 1949

First international distribution agreement: 1960

First international facility: 1967; manufacturing and distribution in Holland

Acquisition of major international distributors: 1970

Regional HQ established: Latin America (Brazil) 1971; Europe (initially France-1972; then Brussels- 1991; and finally Switzerland- 1997).

Direct entry to Asia: Japan (1970s)

Competitor acquisitions begin: 1985

Supply Chain Management

The company has an explicit focus on SCM in terms of insuring the availability of components and materials.

Medtronic has been involved in three intraindustry SC initiatives:

The Cardiovascular Alliance, introduced by Medtronic in 1998, joined Medtronic with hospitals and physicians in long-term contractual agreements that reflected both pricing and product innovation.

In 1999 Medtronic signed agreements with Novation (leading SCM company in healthcare) to supply spinal and cardiac-care products through national healthcare alliances. Agreements were based on public competitive bid process

In 2000 Medtronic became a founder member of GHX

Table A4.2

EVALUATION CRITERIA	WEIGHTING	MEDTRONICS
Size—large or small	+	√ (large)
“Pure play”	+	√
SC focus	+	√
Strategic events	+	√
Globalization	+	√
Major organizational change in last 3 years	—	X

Baxter

Baxter specializes in complex systemic conditions, such as haemophilia, kidney disease, cancer, and immune disorders. Although predominantly a medical-device company, the company is expanding into areas of pharmaceuticals and biotechnology, following the convergence trend. Baxter has a policy of manufacturing locally, and more than half its staff and sales are outside the home region.

Table A4.3

Annual revenue	\$8.9bn				% relevant: 40% (est)
Sales by region	NA: 30.7%	Eur: 3.6%*	Asia 2.9%	RoW 62.7	*Germany only
Manufacturing locations	NA: 13/41%	Eur: 8/25%	Asia: 7/22%	RoW: 4/12 %	32 total; 4 in clusters in NA, 3 in Eur, 1 in Asia

Significant Strategic Events

Founded: 1931

First international facility: 1954; office in Belgium

First competitor acquisition: 1959

Major acquisition: American Hospital Supply Corporation (1985); a failure, the various pieces are divested in the 1990s

Strategic refocus: spin off of Allegiance to focus on technology and global expansion

First plant in Asia: 1995; China

Significant acquisitions: 1998–2002

Global Supply Chain Management

Baxter is a founder member of GHX. The company went through an intensive period of SCM investment in the mid-90’s, and is currently doing so again.

Table A4.4

EVALUATION CRITERIA	WEIGHTING	BAXTER
Size- Large or small	+	√ (Large)
‘Pure play’	+	X
Evidence of explicit SC focus	+	√
Strategic events	+	√
Globalization	+	√
Organizational change	-	X

Siemens Medical

Siemens Medical Solutions contributes about 10% of Siemens corporate earnings, specializing in diagnostic and therapeutic systems and devices, as well as clinical and administrative IT systems, maintenance and support services, and consulting. It is particularly difficult to evaluate Siemens Medical, as the company breaks out very little information on this group.

Table A4.5

Annual revenue	\$7.4bn				% relevant: unk
Sales by region	NA:	Eur:	Asia	RoW	Information not available
Manufacturing locations	NA: 2/25%	Eur: 4/50%	Asia: 2/25%	RoW: 0	8 known; actual total may be greater.

Significant Strategic Events

It is particularly difficult to get information about Siemens Medical. The group is one of the smallest divisions within Siemens, and information about sales, operations, etc. are typically compiled. Also, it has been noted that Siemens corporate has been known to oblige Siemens Medical to take actions based on the strategic requirements of the parent company, even when they are not necessarily in the best interests of the division.

Global Supply Chain Management

Although Siemens manufactures a range of medical devices, the largest segment of its medical technology area is large computer-tomography systems, which do not fit into the medical-device category. The firm uses efficient SC practices such as restructuring of production and delivery processes as part of its aggressive cost-cutting exercises (which are designed in large part to offset the higher costs of manufacturing in Europe). The VP of logistics specifically competes “by organizing the entire supply chain as intelligently as possible” (Franz Grasser 2002; Industry Week).

Table A4.6

EVALUATION CRITERIA	WEIGHTING	SIEMENS
Size—Large or small	+	√ (Large)
“Pure play”	+	X
SC focus	+	√
Strategic events	+	?
Globalization	+	?
Organizational change	-	X

Stryker

Stryker is a leader in the orthopaedic implant and equipment market, and a strong player in the endoscopy, physical-therapy services, and specialty medical-bed markets. More than 90% of the company’s business comes from implantables. The company, which has been paying down debt expects to generate excess cash in 2005, anticipates driving growth through acquisition and some expansion of manufacturing facilities.

Table A4.7

Annual revenue	\$3.6bn				% relevant: 95%
Sales by region	NA: 64.3%	Eur: 18.2%	Asia 8.7%	RoW 8.7%	
Manufacturing locations	NA: 6/66%	Eur: 3/33%	Asia: 0	RoW: 0	9 total; 3 in clusters in NA, 2 in Eur, 0 in Asia

Significant Strategic Events

Founded: 1941
First acquisition of competitor: 1979
Direct entry to Asia: Japan (1993)

Supply Chain Management

Stryker organizes its buyers in the same manner as it organizes its sales teams: by product line. Buyers are dedicated to a particular product line and are responsible for all of the components for that product line. The buyers coordinate all aspects of the buying process for that product line with the relevant engineers, as well as with marketing and production. They also control inventory levels and maintain the company’s relationships with suppliers.

Table A4.8

EVALUATION CRITERIA	WEIGHTING	STRYKER
Size—Large or small	+	√
“Pure play”	+	√
SC focus	+	√
Strategic events	+	X
Globalization	+	√
Organizational change	-	X

Guidant / Johnson & Johnson

Guidant and Johnson & Johnson (JNJ) agreed to merge in December, 2004. However, as the merger has not yet gone through, and given that JNJ often leaves such businesses relatively intact, the firm has not been removed from the top 10 list. [2006 update: the Guidant merger is proceeding, but with Boston Scientific instead of JNJ].

The company specializes in cardiovascular devices.

Table A4.9

Annual revenue	\$3.6bn				% relevant: 95%
Sales by region	NA: 68%	Eur: 19.9 %	Asia 8.9%	RoW 2.9%	
Manufacturing locations	NA: 4/80%	Eur: 1/20%	Asia: 0	RoW: 0	5 total; 2 in clusters in NA, 1 in Eur, 0 in Asia

Significant Strategic Events

Founded: 1994

First acquisition of competitor: 1997

First strategic divestiture: 1999

Direct entry to Asia: Japan (1993)

Supply Chain Management

Guidant is highly vertically integrated in a number of key areas, particularly areas of where cost, supply, or quality is central. Outside suppliers are kept to a minimum number and must meet a variety of technology, quality, delivery, and value-added tests to become a supplier—but these relationships can be terminated by either side on short notice.

Table A4.10

EVALUATION CRITERIA	WEIGHTING	GUIDANT
Size—Large or small	+	√ (large and small)
“Pure play”	+	√
Evidence of explicit SC focus	+	X
History of strategic events	+	X
Globalization	+	√
Major organizational change in last 3 years	-	√

Boston Scientific

Boston Scientific specializes in less invasive technologies, with a particular emphasis on avoiding surgery. The firm has an aggressive growth strategy, doubling R&D over the last five years and participating in more than 100 strategic alliances in the last three years.

Table A4.11

Annual revenue	\$3.6bn				% relevant: 95%
Sales by region	NA: 55%	Eur: 19.3%	Asia 15.6%	RoW 9.7%	
Manufacturing locations	NA: 7/64%	Eur: 2/18%	Asia: 2/18%	RoW: 0	11 total; 6 in clusters in NA, 1 in Eur, 1 in Asia

Significant Strategic Events

Founded: 1979
First acquisition of competitor: 1980
First overseas manufacturing facility: 1987, Denmark
Subsidiaries established: 1988, France and Japan
Company goes public: 1992
Acquisitions that quadrupled workforce: 1995
Restructuring of international operations: 1996–1997 (established regional management organizations in Asia/Pacific (Singapore), India, Latin America (Buenos Aires) and Central Europe; Paris established as European HQ; manufacturing facilities in Belgium and Denmark closed and production moved to Ireland.
Alliances and investments in smaller firms: more than 100 between 2001–2003

Supply Chain Management

In 2000 Boston Scientific approved a three-fold global operations strategy, including a plant network-optimization initiative, a manufacturing process-control initiative and a supply-chain-optimization initiative. The supply-chain-optimization initiative consisted of procurement and inventory-management programs (to reduce inventory levels, lower inventory holding costs, and reduce inventory write-offs). Interestingly, the company did not have any significant expenses associated with these initiatives.

Boston Scientific has supply chain expertise at both the senior-executive and board level. At the executive level, the Senior VP of Corporate Operations, Jim Taylor, reports to the President and is responsible for corporate operations, supply chain management, quality assurance, and corporate procurement. Before Boston Scientific he was VP of Global Technology at Nestle Clinical Nutrition and Corporate VP of Manufacturing Operations and Strategy at Baxter.

At the Board level, in May of 2002 a new Director position was added. The new Director, Ursula Burns, is President of the Document Systems and Solutions Group at Xerox Corporation and a corporate Senior Vice President. Before that she led Xerox’s Worldwide Business Services and Corporate Strategic Services and was responsible for worldwide manufacturing, logistics and supply chain operations.

Table A4.12

EVALUATION CRITERIA	WEIGHTING	BOSTON SCIENTIFIC
Size—Large or small	+	X (medium)
“Pure play”	+	√
SC focus	+	√
Strategic events	+	√
Globalization	+	√
Organizational change	-	X

Abbott

Abbott Laboratories is a leading “health care” company that defines its principal business as “the discovery, development, manufacture and sale of a broad line of health care products.” Abbott does not fully segregate its diagnostic and device segment; the numbers and information below relate as nearly as possible to the medical device portion of the business, which is in turn approximately 17% of total turnover.

Table A4.13

Annual revenue	\$3.0bn				% relevant: 60% (est)
Sales by region	NA: 63.8%	Eur: 10.4%	Asia 4.6%	RoW 21%	
Manufacturing locations	NA: 7/46%	Eur: 6/40%	Asia: 1/6%	RoW: 1/6%	15 total; 5 in clusters in NA, 2 in Eur, 1 in Asia

Significant Strategic Events

Founded:1888
 First international affiliate: 1931, Montreal
 Asian JV: 1962, Japan (still the largest operation outside the US); 1977, Japan (TAP)
 Spin-off of core hospital products business: 2004, Hospira

Supply Chain Management

As a founder member of the Global Healthcare Exchange (GHX) Abbott is very involved with e-commerce trading channels. The company uses a variant of activity-based costing (which they call activity-based compensation) to encourage customers to deal with them either through abbott.com, EDI or GHX, by “compensating” them (i.e., sharing the savings) for the reduced cost of the transaction.

The supply-chain-management system integrates manufacturing, product availability, and customer use information, as well as customer service. It is also integrated with crisis-management planning (natural disasters, accidents, and strikes). Abbott customer service monitors CNN: extra supplies started to arrive at Oklahoma City hospitals within 10 minutes of the explosion; calls to New York hospitals to identify product needs started before the second plane hit the World Trade Center, By the time the second plane had hit delivery trucks headed for New York had already been diverted to Pennsylvania and New Jersey. Within 6 hours of the grounding of aircraft in the US, all of Abbott’s scheduled air shipments had been put on trucks. (World Trade Magazine)

Table A4.14

EVALUATION CRITERIA	WEIGHTING	ABBOTT
Size—Large or small	+	√ (Large)
“Pure play”	+	X
SC focus	+	√
Strategic events	+	√
Globalization	+	√
Organizational change	-	X

Smith and Nephew

Smith and Nephew are a UK company that has in the last year been listed on the NYSE. The company has three “global business units”—orthopaedics, endoscopy and wound management.

Table A4.15

Annual revenue	\$2.1bn				% relevant:
Sales by region	NA: 73.7%	Eur: 34.5%	Asia 14.5*%	RoW %	*includes RoW
Manufacturing locations	NA: 5/83%	Eur: 1/16%	Asia: 0	RoW: 0	6 total; 3 in clusters in NA, 1 in Eur, 0 in Asia

Significant Strategic Events

Company founded: 1856
 First international contacts: 1906, Canada
 First international offshoots: 1921, Canada; South Africa (1931), New Zealand (1953), Sweden (1979), Germany and Holland (1981) and Spain (1984) would follow.
 Major strategic acquisition: 1986, Richards Medical Company, which put the company in the top group of U.S. orthopaedic firms

Purchasing of distributors: Italy (1988); Portugal (1998); Germany (1995); Puerto Rico (1996); Switzerland (1996)

Divestiture and Restructuring: sale of consumer products division to focus on advanced medical devices.

Failed merger: Announcement of merger with Centerpulse (2003), but the deal fell apart and rival Zimmer bought Centerpulse.

Supply Chain Management

Smith & Nephew has a policy of vertical integration, for quality, regulatory, and cost reasons. Each business unit purchases raw materials, components, finished products and packaging materials from certain key suppliers.

Table A4.16

EVALUATION CRITERIA	WEIGHTING	SMITH AND NEPHEW
Size—Large or small	+	√ (small)
“Pure play”	+	√
SC focus	+	X
Strategic events	+	√
Globalization	+	X
Organizational change	-	X

St. Jude Medical

St. Jude Medical specializes in cardiovascular devices, including both mechanical and tissue heart valves and other cardiac implants. It is an engineering-driven company, with relatively fewer acquisitions, alliances, and mergers than many of the other top tier companies.

Table A4.17

Annual revenue	\$1.9bn				% relevant: 100%
Sales by region	NA: 58.4%	Eur: 24.1%	Asia 10.7%	RoW 6.7%	
Manufacturing locations	NA: 6	Eur: 1	Asia: 0	RoW: 1	8 total; 4 in clusters in NA, 0 in Eur, 0 in Asia

Significant Strategic Events

Company founded: 1976

First acquisition of competitor: 1994 (Pacesetter, Siemens cardiac rhythm business)

Purchase of international distributor: 2002–2003. Japan

Supply Chain Management

No information

Table A4.18

EVALUATION CRITERIA	WEIGHTING	ST. JUDE
Size—Large or small	+	√ (small)
“Pure play”	+	√
SC focus	+	X
Strategic events	+	X
Globalization	+	√
Organizational change	-	X

Zimmer

Zimmer specializes in reconstructive and spinal implants and orthopaedic surgical products. Their strategic priorities are “new geographies, new products and new markets” through rapid commercialization, accelerated internal innovation, acquisition & measurable execution targets. They expect future growth to come from minimally invasive procedures, spinal technology, and orthobiologicals.

Table A4.19

Annual revenue	\$1.9bn				% relevant: 70%
Sales by region	NA: 63.5%	Eur: 19.2%	Asia 17.1%	RoW 0	
Manufacturing locations	NA: 8/88%	Eur: 1/11%	Asia: 0	RoW: 0	9 total; 6 in clusters in NA, 1 in Eur, 0 in Asia

Significant Strategic Events

Company founded: 1926
First exports: 1929, Scotland
First import/distribution agreement: 1931, Germany
Export department established: 1967
Acquired: 1969, by Bristol-Myers
Divested: 2001
Merger/Acquisition: 2003: Centerpulse; effectively doubled the size of the company

Supply Chain Management

Zimmer actively promotes a supplier diversity program, in which they seek to identify small, disadvantaged, minority owned, women owned, hubzone, veteran owned and service disabled veteran businesses as suppliers. They specifically identify this as being desirable in a global business community, and as being part of better relations with employees, customers, suppliers and investors.

Table A4.20

EVALUATION CRITERIA	WEIGHTING	ZIMMER
Size—Large or small	+	√ (small)
“Pure play”	+	√
SC focus	+	X
Strategic events	+	√
Globalization	+	√
Organizational change	-	√

Biomet

Biomet makes products for musculoskeletal treatments, including reconstruction, surgical instruments, arthroscopy products, spinal, craniomaxillofacial and dental implants, and associated supplies. Biomet was founded in 1977 and all four founders are still involved. It has had a very sound financial growth history.

Table A4.21

Annual revenue	\$1.6bn				% relevant: 100%
Sales by region	NA: 69.4%	Eur: 23.9%	Asia -	RoW 6.6%*	* includes Asia
Manufacturing locations	NA: 8/57%	Eur: 6/43%	Asia: -	RoW: -	14 total; 7in clusters in NA, 1 in Eur, 0 in Asia

Significant Strategic Events

Company founded:1977
First international presence; first acquisition: 1984
Stock buy-back: 2001–2002

Supply Chain Management

No information

Table A4.22

EVALUATION CRITERIA	WEIGHTING	BIOMET
Size—Large or small	+	√ (small)
“Pure play”	+	√
SC focus	+	X
Strategic events	+	X
Globalization	+	X
Organizational change	-	X

Bard

Bard specializes in vascular, urology, oncology, and specialty surgical products, and pioneered single-use products for hospitals. They are either the market leader or second in most of their business lines.

Table A4.23

Annual revenue	\$1.4bn				% relevant: 70%
Sales by region	NA: 71%	Eur: 18%	Asia 5%	RoW 5.6%	
Manufacturing locations	NA: 9/64%	Eur: 3/21%	Asia: 7%	RoW: 7%	14 total; 5 in clusters in NA, 1 in Eur, 0 in Asia

Significant Strategic Events

Company founded: 1907

Company goes public: 1963

First acquisition of a competitor: 1966

First international plants opened: 1974, South America and Japan

Restructuring of European operations: 1987

Strategic refocus to global Disease State Management, including divestment of the cardiac business and acquisition of several businesses: 1997

Launch of Corporate Healthcare Services, covering account management, supply chain services and “business enhancement services” (support for customer business needs for use, operating effectiveness, etc.: 1997

Supply Chain Management

In 2000 Bard established an integrated e-commerce and consolidated supply chain system through an outsourced logistics service subsidiary of Owens & Minor (a major medical supplies distributor). In 2001 Bard joined Novation’s supply chain provider Marketplace@Novation, which has approximately 100 participating manufacturers and distributors, and is powered by Neoforma, which also powers GHX.

Table A4.24

EVALUATION CRITERIA	WEIGHTING	BARD
Size—Large or small	+	√ (small)
“Pure play”	+	√
SC focus	+	√
Strategic events	+	√
Globalization	+	X
Organizational change	-	X

Varian

Varian specializes in diagnostic imaging, radiation therapy (66% of world market) and x-ray tubes. In addition to its own products it manufactures x-ray tubes for OEMs. They also offer software products and devices to optimize the use of their products

Table A4.25

Annual revenue	\$1.0bn				% relevant: 80%
Sales by region	NA: 60%	Eur: 23%	Asia 15%	RoW 2%	
Manufacturing locations	NA: 9/64%	Eur: 3/21%	Asia: 7%	RoW: 7%	14 total; 5 in clusters in NA, 1 in Eur, 0 in Asia

Significant Strategic Events

Company founded: 1948

Company segments into three separate, publicly listed companies: semiconductors, instruments, and medical systems: 1999

Supply Chain Management

The MD of Varian has introduced a program of “Eco-Design and Supply Chain Management” in the UK operation, which emphasizes working with suppliers and customers on improving product design, with an eye to being ecofriendly.

Table A4.26

EVALUATION CRITERIA	WEIGHTING	VARIAN
Size—Large or small	-	√ (small)
“Pure play”	+	X
SC focus	+	√
Strategic events	+	√
Globalization	+	√
Organizational change	-	X

APPENDIX 5:

INTERVIEW AGENDA

Donal Moloney, DePuy

Joe Heffernan, Boston Scientific

Organization structure; where supply chain fits in the organization

Supply chain management in the device industry:

- What is the primary focus?
- What are the upstream and downstream interfaces like?

How are information flows managed?

- Who controls the flows
- What are the mechanisms

How symmetrical is the power in trading relationships?

- How is power structured (e.g., contracts, incentives, dominance)?
- Has or does the balance of power change?

What are the main elements of governance decision making?

- How and where are governance decisions made?
- What are key factors in making a governance decision?
- Has or does the type of governance change?

APPENDIX 6:

CLASSIFICATION OF MEDICAL DEVICES

Table A6.1

Classification of Medical Devices Across Organizations

Classification System	Relevant Users	Relevant Code (s)	
ISIC: International Sectoral Industrial Classification (activity based)(v.3)	OECD, UN	3311 (2912)*	Medical appliances and instruments
SIC: Standard Industrial Classification	FDA	3841 3842 3843 3844 3845	Surgical & medical instruments and apparatus Orthopaedic, prosthetic, & surgical appliances and supplies Dental equipment and supplies X-Ray apparatus and tubes Electromedical and electrotherapeutic apparatus
SITC: Standard International Trade Classification (product based).	UN (Comtrade)	774 872 899.6 741.83*	Electrodiagnostic and radiological med. dev. Instruments and appliances Appliances worn / carried implanted Lab heating / cooling equipment
NAICS: North American Industry Classification System	Canada, Mexico, USA	334510 334517 339111 339112 339113 339114 339115	Electromedical and electrotherapeutic apparatus Irradiation apparatus Medical equipment and supplies Surgical & Medical instruments Surgical appliances and supplies Dental equipment and supplies Ophthalmic goods

APPENDIX 7:
AGENDA FOR FOCUS GROUP MEETING

IMDA Steering Committee Meeting
Thursday, 14 October 2004

1. Project Overview: understanding and describing the use of supply chain management industry level.
2. Industry: medical devices, a diverse industry which is seen as having particular potential as an adopter of SCM.
3. Approach
 - Year 1: background research in SCM, industry selection
 - Year 2: empirical research, including 1-2 case studies
4. IMDA
 - A year of research into Med Dev TBD:
 - what would be interesting for IMDA to know about MedDev industry (have Eucomed & Advamed)?
 - what data would be interesting to have that isn't already available?
 - Warnings? Suggestions? Advice?
 - Benefits
 - Greater understanding and insight into the context within which the industry is operating.
 - Greater understanding of the state of SCM for the industry and opportunities for leveraging SCM to greater advantage for the industry.
 - Level of interest- Collaborate? Participate? Cooperate? Passive?

APPENDIX 8:

INFORMATION SOURCES: MEDTRONIC CASE

Arthur D. Collins, Chair and CEO*
Minneapolis, MN

Art Collins replaced Bill George as Chair and CEO of Medtronic in 2002, following a planned 2-year succession. They had worked together for 10 years when Art joined Medtronic as EVP and President of Medtronic International. Together, Art and Bill developed Medtronic's long-term strategy and vision together. Art has an MBA from Wharton and was also a consultant at Booz, Allen, & Hamilton before he joined Abbott in 1978.

**Not interviewed: information gathered through published interviews and articles only*

Ron Frisbie, VP CRM Manufacturing and Supply Chain
Minneapolis, MN

In 2004 Ron led a Inventory Improvement challenge with student consultants at Carlson Consulting, looking for ways to reduce the "bullwhip" effect within vertically integrated suppliers in the medical-devices industry, which is projected to save 12% in inventory investment and 23% increase in service levels (product outages).

Ron joined Medtronic 2 years ago. He came from Ford, where among other things he was part of the team that won a Best Plant award (1993) for a comprehensive, integrated approach to organizing the production and supply chain systems. This initiative targeted suppliers, in-house operations and customers. With suppliers, the Total Supplier Improvement Group (set up in 1992; reduced supplier in-house defects by 66% and quality rejects of delivered parts by 25% within a year). Internally, they inaugurated Ford's Flexibility Enabling Manufacturing System, which allowed participants access to real-time data for detecting and correcting both quality and throughput problems. With customers, a "liaison engineer" was assigned to each major customer, acting as a customer "champion," working with the customer to improve processes and product applications, material-handling practices, throughput improvement and even scrap reduction.

Marc Van Corven, VP Supply Chain EMEA (Europe, Middle East, Africa)
Geneva

Marc was trained as an Industrial Engineer, and has 10 years of IT experience and 10 years in logistics as a COO. He came to Medtronics from GE Industrial. He describes the EMEA region as both the most complex Medtronic region, operating in 18 languages and the strongest growth market.

Gerry Kilcommins, VP Operations and GM Medtronic Vascular
Galway

APPENDIX 9:

MEDTRONIC CASE FINANCIALS

Table A9.1

	2004	2003	2002	2001
Net Sales	9087	7665	6410	5551
Cost of Goods Sold	2253	1890	1652	1410
R&D	851	749	646	577
Selling, General & Admin	2801	2372	1962	1685
Operating Earnings	2796	2341	1524	1549
Net Earnings	1959	1599	984	1046

(dollars in millions)

Table A9.2

Global Sales

Region	2004	2003	2002	2001
United States	6159	6279	5162	4255
Europe	1847	2264	1592	1424
Asia Pacific	859	710	653	618
Other	222	172	178	218
Total	9087	7665	6410	5551

(dollars in billions)

Table A9.3

Sales by Product Group

Product Group	2004 Sales		2003 Sales		2002 Sales		2001 Sales	
	\$m	%	\$m	%	\$m	%	\$m	%
CRM	4238	46	3630	47	2943	46	2658	48
Neurological & Diabetes	1611	18	1356	18	1024	16	644	11
Spinal, ENT & SNT	1765	19	1346	18	1012	16	834	15
Vascular	842	9	774	10	902	14	928	17
Cardiac Surgery	631	7	557	7	519	8	487	9

(dollars in millions)

APPENDIX 10:

MEDTRONIC TIMELINE & GENEALOGY

1949: Medtronic founded to repair electronic hospital equipment

1950: Medtronic became representative for several medical equipment manufacturers.

1950s: Medtronic began to customize equipment for regular hospital customers, then began to manufacture custom equipment (including defibrillators and cardiac monitors)

1960: Medtronic gets exclusive production and distribution agreement for Chardack-Greatbatch implantable pacemaker.

Distribution agreement with Picker International for all international markets (except Canada)

1967: First international facility opened, at Schiphol Airport, Amsterdam, and a manufacturing centre in Kerkrade.

1968: Acquisition of sales agent in Canada.

Alliance with Alcatel (France) to develop nuclear –powered pacemakers

1970: Contract with Picker not renewed.

Acquisition of major distributors.

1971: Latin American headquarters established in Sao Paulo, Brazil

1972: European headquarters established in Paris, France (moved in 1991 to Brussels and again in 1997 to Switzerland)

1970s: Direct sales operation in Japan established.

Manufacturing facilities opened in Puerto Rico, Canada, and France

1985: Acquisition of Johnson & Johnson Cardiovascular Division (tissue heart valves and cardiopulmonary equipment)

Acquisition of Versaflex Delivery Systems (angioplasty and guiding catheters)

Acquisition of Bio-Medicus (centrifugal blood pumps)

1986: Acquisition of Vitatron (Holland) (pacemakers)

1987: Research centre opened in Holland

Education centres for training physicians and sales staff opened in US, India, and Japan

1990: Acquisition of TUR (Germany) (pacemakers)

Acquisition of Cardiorhythm (arrhythmia diagnosis)

Acquisition of DLP (surgical cardiac cannulae)

1990s: Numerous minority stake holdings in medical technology companies.

Alliance with Novartis

- 1999: Merger with Xomed (ENT stents, catheters, endoscopes, guidance systems, etc.)
Distribution agreement with Pall Corporation (cardiac filtration products)
Alliance for research and development/minority stakeholding with Carmel Biosensors (combination of living cells and microelectronics for biosensors)
- 2000: Joint marketing agreement with Cephalon for programmable spinal infusion system in UK, France, and Austria
Acquisition of Cyberonics (vagus nerve stimulation technology for epilepsy)
Acquisition of PercuSurge (guidewires and catheters to capture embolic debris)
- 2001: Acquisition of Contegra Pulmonary Valved Conduit (paediatric heart valves)
Acquisition of Minimed and Medical Research Group (external programmable insulin pumps & glucose monitoring systems)
Acquisition of Pascal Medical (Sweden) (portable pressure-pulse generators)
Acquisition of VidaMed (needle system for prostate treatment)
- 2002: Acquisition of Paceart (from GE Medical Systems Information Technologies) (database systems for implantable cardiac devices)
Distribution agreement for Ventrica (bypass graft connectors) in Europe
Strategic agreement with Abbott to use Abbott's immunosuppressant drug on Medtronic drug-eluting stent
Acquisition of Spinal Dynamics Corporation (artificial cervical discs)
- 2003: Licensing agreement with Collagenex Pharmaceuticals (impacts compounds/protease inhibitors) for technology applications worldwide.
Licensing agreement and minority stakeholding in Endobionics (microsyringes for delivery of agents into arterial membranes)
Distribution agreement in Europe with GI-Yamanouchi European Partnership (Wyeth and Yamanouchi) for recombinant human bone morphogenetic protein
Acquisition of TransVascular (delivery mechanisms for cells, genes, and drugs to the vascular system)
Licensing agreement with Yamanouchi (Japan) for development, regulatory processing, sales, and marketing of recombinant human bone morphogenetic protein worldwide.
Acquisition of Vertelink (minimally invasive spinal-surgery products)

APPENDIX 11:

BARD FINANCIALS

Table A11.1

	2004	2003	2002	2001
Net Sales	1656	1433	1273	1181
R&D	111	87	61	
Selling, Gen. & Admin	521	448	376	
Net Earnings	302	168	155	143
Net Sales	1656	1433	1273	1181
R&D	111	87	61	

(dollars in million; Source: SEC 10K filings)

Table A11.2

Region	2004	2003	2002	2001
United States	1156	1020	929	
Europe	316	259	215	
Japan	84	73	64	
Rest of World	99	81	69	
Total	1656	1433	1273	

(dollars in billions)

Table A11.3

Product Group	2004 Sales		2003 Sales		2002 Sales		2001 Sales	
	\$m	%	\$m	%	\$m	%	\$m	%
Vascular	393	24	307	21	259	20	251	
Urology	493	30	451	32	390	33	361	
Oncology	343	23	283	23	212	24	199	
Surgical Supplies	313	19	272	19	229	18	205	
Other		4		5		5		

(dollars in millions)

APPENDIX 12:

BARD TIMELINE & GENEALOGY

Significant Strategic Events:

1907: Company founded
1963: Company goes public
1966: First acquisition of a competitor
1968: Listed on stock exchanges
1974: First international plants opened: South America and Japan
1975: Invests heavily in kidney dialysis membrane
1978: Major recall hurts sales badly
1978: Tax change in industry: rate increased from 40% to 48%
1978–1980: Sells kidney dialysis membrane business (after heavy losses) and other underperforming product groups in “refocus” strategy. Also looks for acquisition candidates.
1982: Cost pressures from third parties and government
1984: Government and private sector put caps on reimbursement, leading to serious decreases in medical device and pharmaceutical profits.
1985: WSJ notes that Bard was “once regarded as a second rank hospital supplier” but now was the first choice of 2/3 of heart surgeons for its Gruntzig catheters, which contribute 40% of the firms profits.
1986: Significant batch of new top-management appointments
1987: Stock drops by 50%: in 1985 Bard had 70% of the angioplasty market; by 1987 that had dropped to 45%, with Eli Lilly holding 45%.
1987: Plant in Malaysia opened
1987: Restructuring of European operations
1989: Significant number of new top-management appointments
1991: Significant number of new top-management appointments
1993: Proposed healthcare reforms lead to cost cutting moves in healthcare purchasers and result in a squeeze on medical device companies. It is expected that single-product, medium-sized companies (\$250–\$350m/pa) will do best. A round of M&A is set off.
1994: Bard is suspended from taking federal contracts because of guilty plea and pays highest (to date) criminal penalty fine (\$61m)
1994: Buys Angiomed in Germany, and consolidates German operations there
1995: Back on the list for U.S. contracts; FDA monitoring lifted
1995: Significant batch of new top-management appointments
1995: Stents take off, rejuvenating angioplasty market. The leaders now are Boston Scientific, Guidant, and Cordis (77%), Medtronic (7%) and Bard (6%).
1996: Bard has no group purchasing deals, but does have deals with some healthcare chains
Strategic refocus to global Disease State Management, including divestment of the cardiac business and acquisition of several businesses: 1997
Launch of Corporate Healthcare Services, covering account management, supply chain services and “business enhancement services” (support for customer business needs for utilization, operating effectiveness, etc.): 1997

APPENDIX 13

SURVEY

Note: This survey was administered through the on-line survey agent SurveyMonkey. The following provides the questions and approximates the format of the actual survey, but is not an actual representation of the on-screen appearance. In questions presented in table format, each cell would have offered a drop-down menu of the answer choices noted below the table. Open ended questions were accompanied by a text box in which respondents could enter their answer or comments.

1. Welcome

This study is being conducted by researchers at the School of Business Studies, Trinity College Dublin. It is part of a larger research project on supply chain management in the medical device industry.

All responses to this survey are entirely confidential. There are no individual identifiers, and neither Survey Monkey nor the researchers will know either the identities of the respondents or the organizations they represent. All results will be used in aggregate and nobody outside our research group will have access to the collected data. However, we will make the overall results available to the IMDA Supply Chain group in the form of a summary report.

This aspect of the research is looking at the nature of trading relationships- an important aspect of supply chain management in all industries, but particularly in those where trading partners may be buyers, suppliers and competitors of each other. In addition to the IMDA group, this survey will be given to professionals at various level of medical device firms, in several countries.

The survey is very short: there are 12 questions, in 3 sections (that's 5 screens, including this welcome, and a thank you at the end). The success of our research depends on receiving fully completed questionnaire forms. Therefore, we would like you to answer all the questions in this questionnaire. If you don't have the answers, a 'Don't Know' option has been added.

The results will be gathered by the website, and the composite data made available to the researchers. The final project report will be completed in March, but the results of the survey may be made available to the IMDA Supply Chain group prior to that.

We really do appreciate your participation, and welcome any additional comments or suggestions (some of which have already been incorporated into the survey).

2. Trading Relationships

The medical device industry is known for using many types of alliances and trading relationships. These questions are designed to help us understand more about your trading relationships. Please use the box at the end of this section to add any comments that might improve our understanding.

If you have multiple relationships with your trading partners, please answer for each type of relationship. Intra-industry refers to companies whose primary business is similar to yours (that is, a firm that may also be a competitor).

1. Which of the following types of trading relationships / alliances do you use, and how frequently do you use them?

	Suppliers	Customers	Intra-Industry
Joint Research			
Long term sales agreements			
Product development			
Marketing agreement(s)			
Licensing agreement(s)			
Joint venture(s)			
Minority ownership			

Choices: Frequently, Occasionally, Rarely/Never, Does Not Apply, Don't Know

2. Are there other forms of alliance(s) that you use that are not listed above? if so, please describe, indicate how often you use them and how important they are to your organization.

3. How long do your trading relationships typically last:

	Typical Longevity
Core suppliers	
Typical suppliers	
Core customers	
Typical customers	
Intra-industry alliances	

Choices: Short term- less than a year; Medium- less than 5 years; Long- more than 5 years; Very long- more than 10 years; Don't Know

4. In your trading relationships, what is the relative balance of power between you and:

	They typically have...
Core suppliers	
Typical suppliers	
Core customers	
Typical customers	
Intra-industry alliances	

Choices: Considerably more power; Somewhat more power; About the same amount of power; Somewhat less power; Considerably less power

5. How much information do you share with your trading partners?

	Information Shared
Core suppliers	
Typical suppliers	
Core customers	
Typical customers	
Intra-industry alliances	

Choices: As much information as is needed to complete the transaction (price, quantity, product requirements, etc.); Enough information to facilitate the process (using tools such as JIT, EDI, VMI, etc.); Information to encourage the other party to cooperate (performance metrics, incentives, etc.); As much information as is necessary for us to create better systems or products together.

6. Which of the following incentives do you use to encourage your trading partners to work with you? Please check all that apply. If there are others, please note them in Question 7.

	Use	Importance
Information materials (printed, DVD, etc.)		
Product samples		
Give-aways (not product samples)		
Product discounts		
Product training		
Meetings / Seminars on-site/locally		
Meetings / Seminars in 'destination' locations		
Product development workshops		
Other (specify below)		

Choices- Use: Never/rarely; Occasionally; Often; Most of the time / always; Don't Know

Choices- Importance: Low; Medium; High; Essential; Don't Know; Does Not Apply

7. Please note any other forms of incentives that are important to your relationships with your trading partners.

3. Your Organization

8. What are the most important strategic variables for the success of your firm?

	Relative Importance
Product quality	
Strong product portfolio	
Strong product development abilities	
Good relationships with suppliers	
Good relationships with customers	
Good relationships with regulators	
Strong support activities, especially marketing	
Strong support activities, especially operations management	
Strong support activities, especially supply chain management	

Choices: Critical; Very important; Important; Somewhat important; Not very important; Don't Know

9. What is the highest level person in your organization whose brief specifically includes supply management?

- Board
- Executive
- Senior manager
- Manager
- Other (please specify:_____)

10. Has your organization brought in people with supply management expertise from other industries specifically to improve the supply management capabilities in your organization? If so, from what industry? If the relevant industry is not listed, or if you have brought in expertise from multiple industries at the same level, please indicate which in the next question.

	Brought in?	From?	How recently?
Board			
Executive			
Senior Management			
Line Management			
Operational			

Choices- Brought in: Yes; No; Don't Know
Choices- From: Electronics; Engineering; Automotive; Food; Consumer Goods; Retail; Other Manufacturing; Don't Know
Choices- How recently: Last 12 months; Last 2 years; Last 3 years; Last 3-5 years; 5+ years; Don't Know

11. If your company has brought in outside expertise from an industry not listed above, please note what industry(ies), how recently and at what level.

12. Please add any comments that will help us to understand your trading relationships. If there are areas which you feel have been overlooked, please note those as well.

