Outlining a Future of Supply Chain Management - Coordinated Supply Networks

by

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Abstract

This thesis explores the use of different approaches and structures to facilitate coordinating a set of strategic business partners across multiple tiers of a single supply chain – defined as the supply network. The study is based on a deductive model of three dimensions of coordination, corresponding to the information, material, and financial dependencies between organizations in a supply network. This segmentation allows separate exploration of coordination structures at the level of information systems, logistics and operations, and financial allocation across organizations within the supply network.

The research methodology entailed the use of the Delphi technique, soliciting input via in-depth personal interviews from academic, industry, and consulting experts in supply chain management. This method is selected because of few current examples in industry, lack of hard data and absence of structured frameworks in the field.

For each of the coordination dimensions, the structures and mechanisms to efficiently coordinate a supply network were identified, described, and categorized. The result is a structured spectrum of coordinating approaches that illustrates the managing of dependencies within the supply network. Trends and consensus in the responses are identified from the data to provide insight into future developments in the field. Illustrative examples of such coordination structures are discussed to demonstrate the inner working of coordinating mechanisms, and to identify the key issues, requirements and obstacles in achieving coordination across multiple tiers.

Thesis Supervisors:
Charles H. Fine Title: Chrysler LFM Professor of Management
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Thanks for always being there…you made this so much easier!

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Chapter 1 Introduction

1.1 Thesis Objective

The objective of this thesis is to explore how information, material, and financial flows of mutually dependent business partners in supply chains can be optimally coordinated across multiple tiers.[1] Even though different forms of coordination like information integration and collaboration with business partners are a well-accepted concept by companies in various industries at a strategic level, such efforts at present do not achieve coordinating operations of companies across *multiple* tiers of a supply chain.

Coordination efforts at present are mostly dyadic, and rarely span across more than two adjacent partners in a supply chain. Unlike these dyadic coordination efforts, multi-tier coordination initiatives would allow identifying mutually advantageous opportunities and reducing redundancies in the supply chain that would otherwise not have been considered.[2]

A limited number of strategic business partners of the same supply chain – defined as the supply network[3] – could potentially improve their competitive advantage by creating new entities and processes that would enable coordination spanning multiple participants of the supply network.[4] Such 'holistic' coordination attempts could manifest themselves through the creation and control of alternative governance structures in supply networks in charge of coordinating operations of multiple partners.[5] This thesis attempts to determine different approaches and map entities required to achieve such coordination. It intends to provide a comprehensive overview of such, rather than choose any one particular approach.

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[1] Coordination is to be interpreted as the managing of mutual dependencies, as is the case of information, material, and financial flows between companies of a supply chain. It does not refer to constraint based mathematical optimization where a single, "best" solution is found.

[2] Such as identifying and reducing redundant inventory, ordering, and planning processes.

[3] Supply network in the context of this thesis refers to a selected set of strategic business partners from multiple tiers in the supply chain which have a meaningful and non-substitutable relationship. The argument for the term 'network' rather than 'chain' is presented in Section 4.3 on page 64.

[4] Dyadic refers to two-way efforts to collaborate with partners that are immediately adjacent in a supply chain, without any intermediaries. Therefore, these initiatives exclude efforts that involve participants across more than two tiers in a supply chain.

[5] The term 'holistic' in the supply chain context refers to coordination considering companies of multiple tiers in a supply chain.

1.2 Motivation

The author, while working with James B. Rice, Jr. and Charles H. Fine at the Massachusetts Institute of Technology (MIT), performed research to determine recent trends in supply chain integration with a focus on supply chains in the agriculture-food, high technology, and consumer packaged goods industries. It was observed that effective supply chain integration and collaborative initiatives with business partners to coordinate supply chain operations have become a critical factor of competitive advantage – a principle generally agreed upon by leaders in academia, consulting and industry.

This observation is consistent with research findings at Michigan State University by Bowersox et al. [1] illustrating correlation between logistics and supply chain excellence and bottom-line performance, specifically when customer, supplier, and relationship integration is pursued.

Interest in supply chain management with focus on external trading partners has increased steadily since the 1980s when companies began to see the benefits of collaborative relationships [2]. Increased focus on highly integrated supply chains and wide-ranging collaboration initiatives has been driven in part by the following ongoing trends, observed most explicitly in the high technology and apparel industries:[6]

- *Increased globalization of demand and supply* given that the volume of all goods and services traded in all industries accounts for 45% of the world gross domestic product in 1995, as opposed to 25% in 1970 [3]

- *Ever more demanding customers* as buying products anytime, anywhere, cheap and fast becomes the standard expectation of customers in Internet based distribution channels suggested by Fontanella [4] and Anderson and Lee [5]

- *Shortening product cycles* that demand faster responsiveness of supply chains in addition to decreasing the likelihood of achieving *long-term* competitive advantage as discussed by Fine [6]

- *Proliferation of product variety*, which requires the handling of large number of SKUs[7] and corresponding information [7]

[6] The term 'integration' in supply chains refers to the degree of information sharing, workflow coordination, and synchronization in the supply chain as illustrated by Lee and Whang [22], discussed in Section 2.3 on page 25.

[7] SKU stands for stock keeping unit. A company usually assigns a unique SKU number to every different product configuration for track keeping.

- *Time based competition* as discussed by Stalk, illustrating the exceptional advantage created from providing products in a more timely and affordable manner than competitors [8]

- *Demand Driven Business Models* allowing companies to produce only what is demanded – a move from a push to pull systems reflected by initiatives like just-in-time, efficient consumer response, and Kanban based operations as observed by Hewitt [9][8]

Driven by these trends, companies with internal fragmented functional areas have responded by integrating their supply chain operations form the inside out as illustrated by Christiaanse and Kumar [10].

Companies in the 1970s operated largely based on the theories developed at the beginning of the century by Taylor [11], which suggest performance improvement initiatives concentrated on the optimization of individual tasks. This resulted in separate and primarily isolated operating procurement, warehousing, manufacturing, sales and inbound/outbound transportation functions. Coordination with suppliers and customers was left to market forces.

In the late 1980s and 1990s, large industrial manufacturers started to integrate isolated functional silos within their companies by implementing materials requirements planning systems (MRP), manufacturing resource planning (MRPII), distribution resource planning (DRP) and consequently enterprise resource planning (ERP) systems throughout the 1990s.

Many companies had difficulties identifying measurable benefits from the wave of ERP implementations. Research by James and Wolf [12] suggests that most benefits could have been achieved without the information technology (IT) investment. Concurrent to the implementation phase of these supply chain software tools, large industrial companies started to actively explore the potential benefits from efficient coordination with adjacent trading partners.

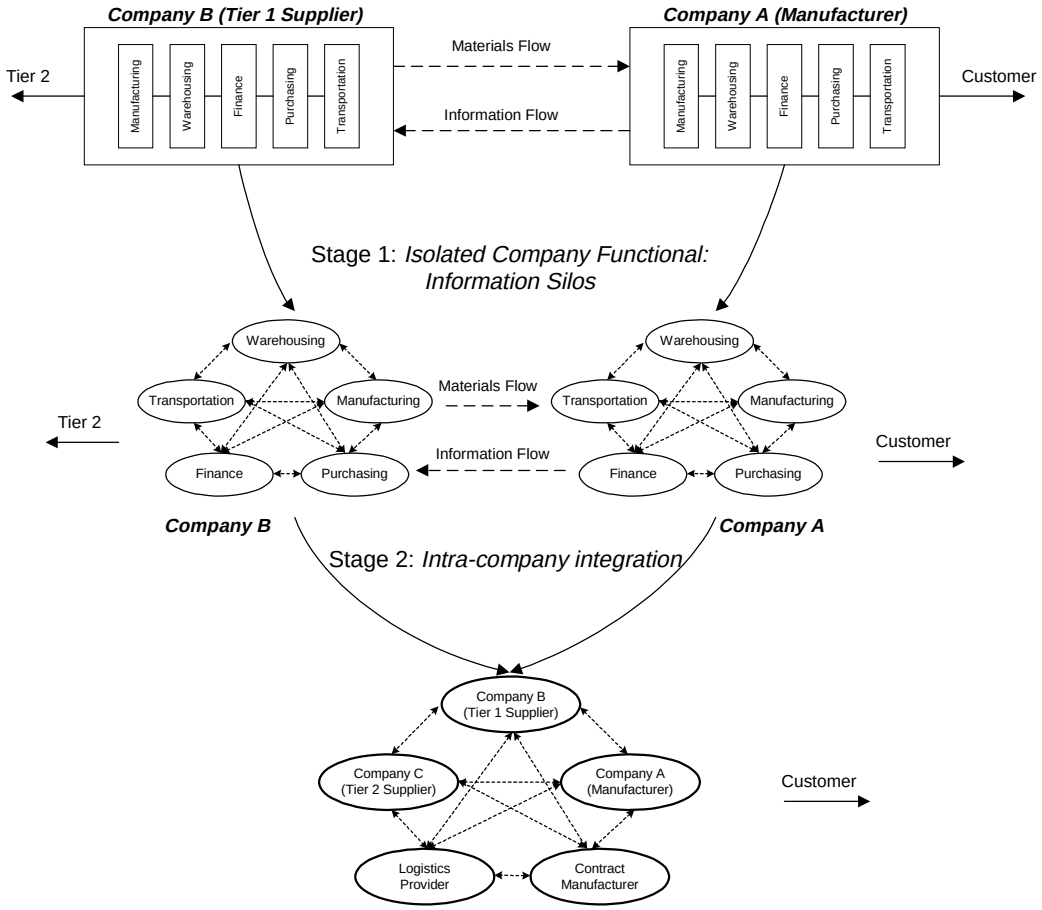
Inter-firm coordination is increasingly an imperative for competitiveness as discussed by Hayes et al. [13]. The first sophisticated tool to facilitate sharing large amounts of information was the introduction and adoption of electronic data interchange (EDI), an electronic based ordering system used by medium to large size companies.[9] At present web-based technology is gradually replacing EDI in the long run.[10]

[8] A Kanban operation – based on the Japanese word for "sign" – is a pull system, which uses fixed lot sizes to move material through manufacturing in a synchronized manner.

[9] Due to the large investment requirements of EDI technology, this remained an option used primarily by major industrial companies.

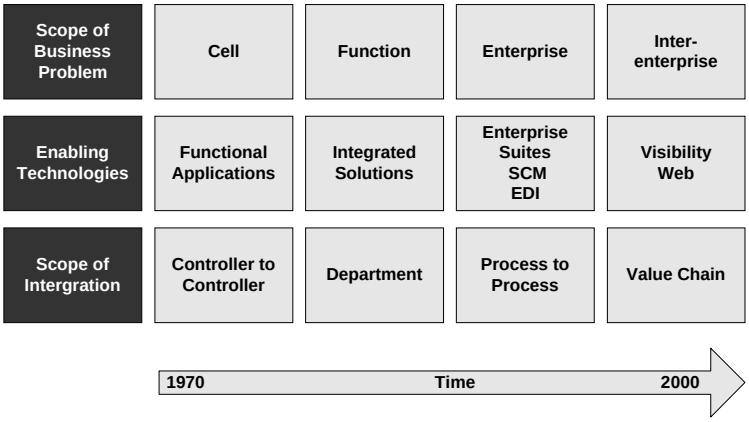
[10] Electronic transactions are still primarily done through EDI despite the rapid development of new Internet based technologies.

Most recently, leaders in the business community as well as experts in the supply chain field in academia have started envisioning gaining simultaneous visibility, collaboration, and coordination across multiple strategic partners of the entire supply chain – or supply network – leading to the evolution of tightly integrated supply networks illustrated in Figure 1-1. This evolution builds on the advancement of supply chain technology illustrated in Figure 1-2, by the creation of operating ties among supply chain participants and through the use of inter-organizational forms discussed by Christiaanse and Kumar [14].



Source: Author, with selected concepts from Benchmarking Partners, 1999.

Figure 1-1 The Supply Chain Integration Process



Source: Avicon.

Figure 1-2 Evolution of Supply Chain Technology

Recognizing that market pressures would further drive companies to explore methods of coordinating and optimizing operations beyond their four walls, the Integrated Supply Chain Management program (ISCM) at MIT decided to explore how companies could move from selected collaboration initiatives to broader multi-tier supply network coordination.

The objective of this research became to identify requirements, obstacles and frameworks to structure thinking on how to facilitate coordination in supply networks. This thesis does not attempt to explore mathematical or quantitative models of how such supply networks might be optimized.

The approach to study this is based on interviewing experts in the field from academia, consulting and industry. This approach would allow to (1) determine what structures might facilitate such multi-tier coordination among supply network participants, (2) map the possible structures that might facilitate such, and (3) identify evidence of future competition among separate – internally coordinated – supply networks as suggested by Gattorna and Berger [15] and Cookson and Delattre [16].

1.3 Research Approach

Malone and Crowston [17] suggest that the field of coordination is in its infancy with most research to be done in identifying and analyzing coordination structures. Based on limited hard data in the field of multi-tier coordination in supply chains, it is critical to use an adequate research approach to understand and develop a vision of this unidentified future state.

A practical method to achieve this is the Delphi methodology, a method for technical and strategic evaluations, and forecasting based on expert judgment of knowledgeable individuals [18]. The Delphi technique is widely considered effective in situations where

no hard data exists and the primary source of information is well informed learned opinion as shown by Dalkey [19].

For this, thought leaders in supply chain management from academia, consulting, and industry were interviewed. A non-predisposing, open-ended questionnaire was developed and discussed with candidates in a series of personal interviews. The results were then synthesized and shared back with respondents in a controlled feedback manner. The Delphi methodology typically suggests two, to a maximum of three, iterations.

Prior research suggests that the first iteration, which poses the problem in broad terms, is the most comprehensive iteration in the process [20]. Given to the time period of this thesis and the time requirement to interview 31 experts in the field only detailed findings from the first iteration are presented.[11] A complete overview of the research methodology is presented in Chapter 5.

1.4 Thesis Structure

The structure of this thesis is shown in Figure 1-3. The thesis is organized as follows:

In Chapter 2, a literature review exploring state of the art supply chain integration efforts with business partners, including selected collaboration efforts to provide the reader with an overview of the building blocks of multi-tier coordination in addition to the benefits and impediments associated with such efforts, is presented.

In Chapter 3, a review of supply chain coordination approaches from the economic theory standpoint is presented. This section further analyzes how governance structures and control distribution in such supply networks affects achieving coordinated operations.

In Chapter 4, the concept of the supply network is developed based on recent trends and the emergence of virtual organization models. In addition, research results exploring supply network versus supply network competition are presented.

In Chapter 5, an overview of the Delphi methodology, the basis of this research is presented. This chapter provides insight to the type of data sought, by which criteria interview candidates were selected for the study, how questionnaires were developed, and the advantages and limitations of the research approach used.

In Chapter 6, the interview results and key findings are presented. This chapter includes a detailed analysis of responses, a spectrum of coordination approaches and structures, determination of trends in the data, and an assessment of answers provided.

[11] The number of candidates, 31, needs to exceed a minimum number of approximately 10-15 candidates required by the research methodology to obtain meaningful results as discussed in Section 5.4 on page 80.

In the last chapter, Chapter 7, the summary of findings of this study followed by conclusions drawn and directions for future studies in this field are presented.

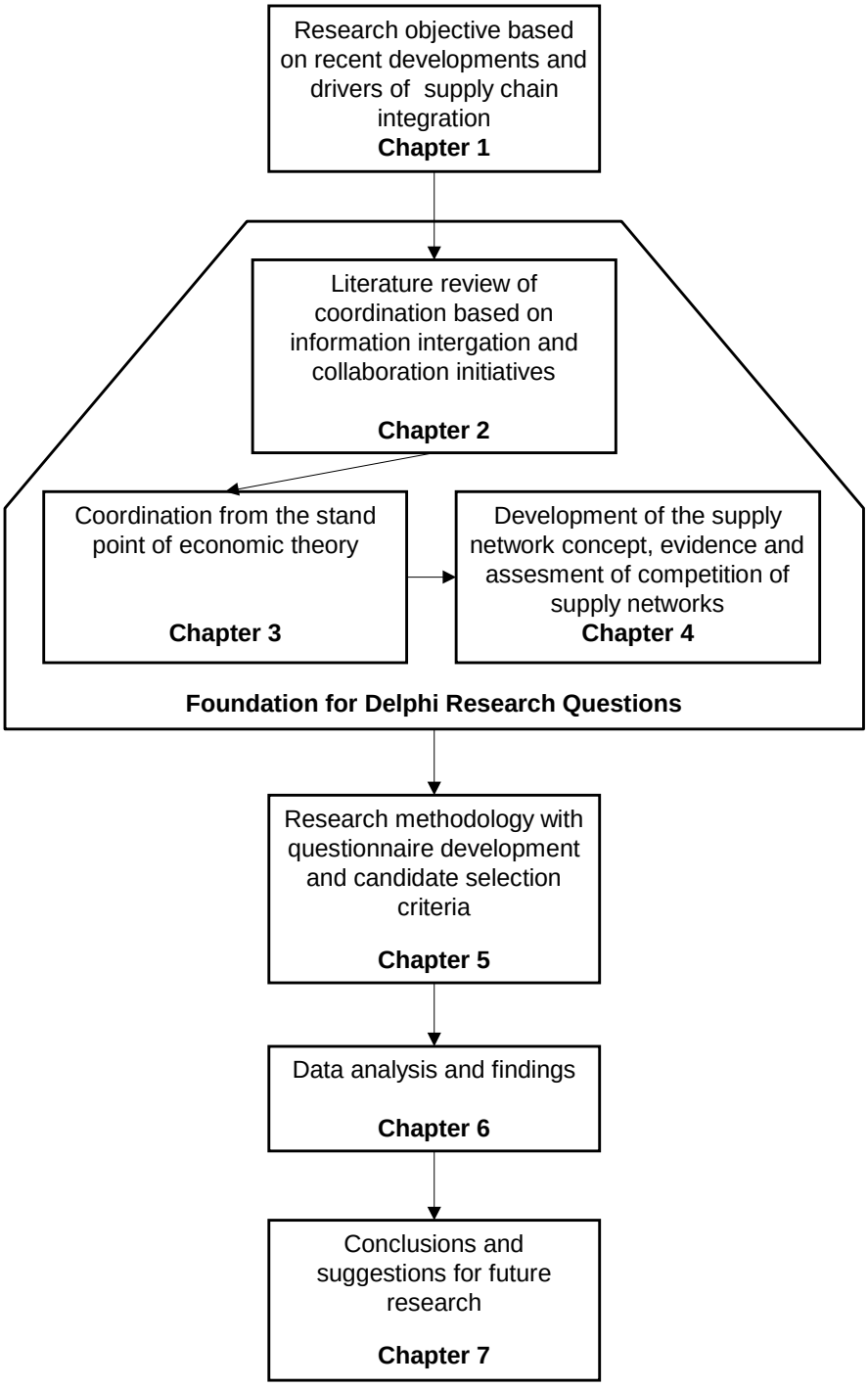


Figure 1-3 Thesis Structure

Chapter 2 Background

2.1 Introduction

In order to develop a meaningful research questionnaire aimed at determining the entities and processes that allow multi-tier supply chain coordination, it is useful to review literature that explores the building blocks of such holistic supply chain coordination – Chapter 2 –, how economic theory explains coordination – Chapter 3 –, and the supply network concept – Chapter 4.

The objective of the literature review in this chapter is to provide the reader with (1) an overview of initiatives used to achieve coordination across business partners of the same supply chain (2) identify the current state of the art of these efforts, and (3) illustrate the benefits and impediments of such coordination attempts.

2.2 Dimensions of Coordination

The meaning of coordination is broad, but a good definition applicable to the supply chain context is given by Malone and Crowston [21]. At its highest level, Malone and Crowston define coordination as:

"Coordination is managing dependencies between activities"

Supply chain management is based on the premise that a single company rarely can efficiently perform all the operations in the manufacturing process of a product from raw material to finished product. Correspondingly, the dependencies created among supply participants, require coordination activities to ensure adequate flow of information, materials and financial payments among members.

This inclusive definition of coordination comprises efforts like "cooperation" and "collaboration" which have their own connotations of managing dependencies of activities. The definition further suggests that if there is no interdependence there is nothing to coordinate while on the other hand, the higher the dependency the greater the need to coordinate.

In this thesis, building on Malone's definition, a model with multiple *dimensions of coordination* that allow achieving coordinated operations of information, materials and financial flows is presented. The first dimension of coordination is external information integration discussed in Section 2.4 to coordinate exchange of information among companies.

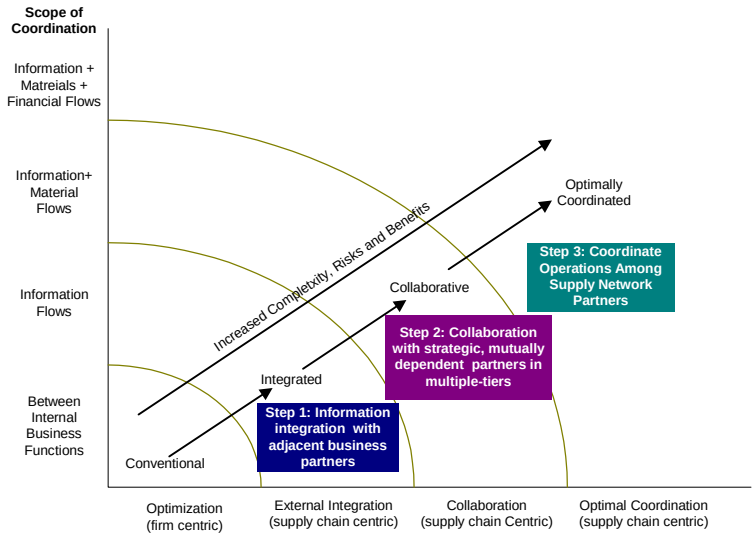
The second dimension of coordination is collaboration with supply chain partners to jointly coordinate information *and* material flows as discussed in Section 2.5. Each dimension of coordination is inclusive, i.e. each higher dimension contains elements and information from the lower dimension.

Both of these building blocks in coordination improve the sharing of information and the efficient managing of materials but do not rigorously coordinate mutual dependencies of all three fundamental flows – information, materials, and financial. In this thesis, this third and highest dimension of coordination is defined as:

> *"The attempt to most efficiently manage information, material and financial flows through a supply chain to maximize value among business partners of the same supply network"*

Such "optimal" coordination might be achieved through this layered model of coordination dimensions illustrated in the next section. It also serves as the foundation for designing the research questionnaire for research candidates in Chapter 5.

Figure 2-1 illustrates a graphical representation of the three coordination steps facilitating coordination among a set of mutually dependent and strategically important business partners.



Source: Author; Cookson and Delattre, 2001.

Figure 2-1 Steps in Supply Network Coordination

The next section discusses how the three dimensions of coordination used in this thesis and comparison to other models found in literature, drawing similarities and differences in the approaches and definitions used by other researchers.

2.3 Supply Chain Integration Models

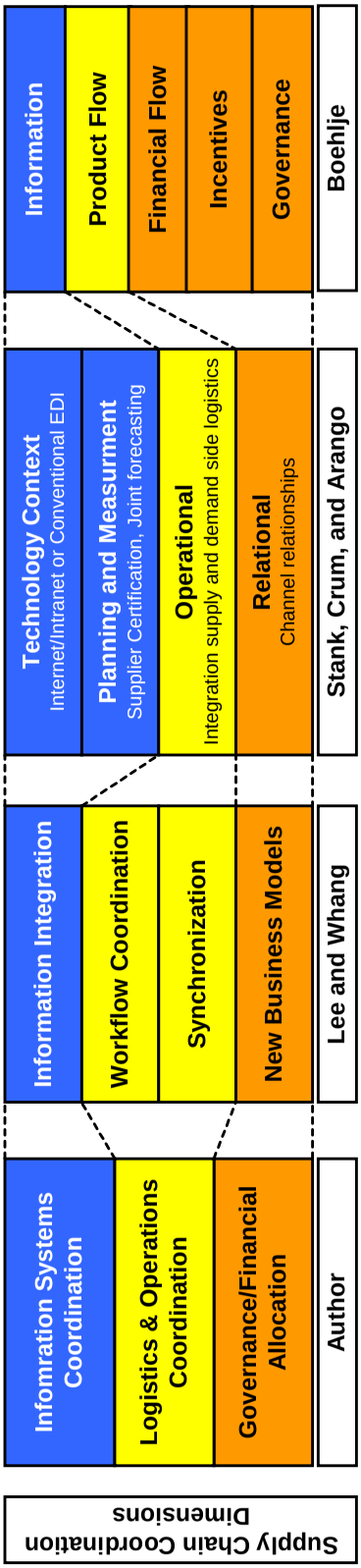
Lee and Whang [22] argue that supply chain integration has four key dimensions: information integration, workflow coordination, synchronization and new business models.[12]

Information integration refers to the degree of sharing of demand information, inventory status, capacity plans, and shipment schedules. Workflow coordination refers to streamlining workflow activities across various members in a supply chain in order to achieve efficiencies from increased order accuracy and timely shipments. Synchronization entails joint design and execution of plans for forecasting and replenishment –also called collaboration. New business models refer to how entire supply networks may jointly create new products, pursue mass customization and penetrate new markets.

The deductive supply chain integration model of Lee and Whang corresponds to the model of coordination dimensions in this thesis as follows: 1st dimension of coordination is information integration, 2nd dimension of coordination is workflow coordination and synchronization – or also called collaboration – and the 3rd dimension of coordination is through the creation of new business models.[13]

Other models of supply chain integration/coordination have been proposed by Stank et al. [23] and Boehlje [24].[14] A side-by-side comparison of the multiple dimensions of these models allows identifying parallels of the segmentation approach used by the author to analyze supply chain coordination at several layers. The dimensions in different models are related to the authors model as shown in Figure 2-2. Not all models have the same number of dimensions, but similar dimensions can be grouped to form a broader category for comparison.

[12] Based on Lee and Whang's definition, the attempt to integrate the supply chain is equivalent to the attempt to coordinate across companies.
[13] Refer to Figure 2-2 on page 26 for a graphical illustration of this relationship.
[14] Stank et al. refer to this as supply chain alignment, and Boehlje as the critical dimensions of a value chain.



Source: Author; Lee and Whang, 2000; Stank et al., 1999; Boehlje, 2000.

Figure 2-2 Models of Supply Chain Integration/Coordination

Information integration attempts to coordinate the dependency of prerequisite of constraints as described by Malone and Crowston [25], which occurs when notification – i.e. information exchange –, sequencing and tracking in a complex project is required.[15] Further discussion of the coordination dimensions is based primarily on Lee and Whang's model, and how these correspond to the three-layered model of this thesis.

2.4 Information Integration

Supply chain integration refers to both internal and external integration – i.e. joining internal company business segments and integrating with outside companies.

Internal supply chain integration is the process of joining otherwise separate activities such as purchasing, warehousing, transportation, distribution, and customer service within a single enterprise. It is arguable to what extent companies have achieved integration and coordination of internal functions.

These attempts are ongoing efforts. However, due to decreasing marginal returns several companies have increasingly focused outside the firm's boundaries to identify higher value opportunities from collaborating with adjacent supply chain partners as observed by Bauknight [26]. Bauknight argues that while internal integration provides a competitive advantage in some cases, that advantage will quickly erode over the next few years due to the rising potential from coordination of supply chain activities outside the enterprise.

Consequently, many companies have focused on external integration with partners, with emphasis on coordinating information sharing. No longer can companies compete as isolated entities that are disconnected from their supply chain partners as mentioned by Christiaanse, Kumar and Lam [27]. In order for firms to succeed in markets that are driven by the trends mentioned in Section 1.2, it is necessary for companies to create strong information linkages with their chain partners.[16] External integration, based on information sharing, is the primary building block and coordination dimension among companies to improve performance.

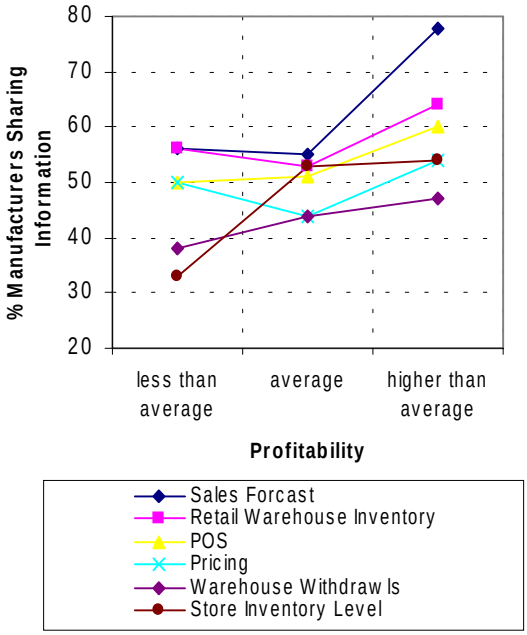
The next section discusses the rationale for the first dimension of integration through benefits associated from coordinating information flows across supply chain partners.

2.4.1 Information Sharing Benefits

The benefits of information integration are illustrated in a consumer goods industry wide study conducted by Hau Lee at Stanford University and Andersen Consulting [28]. Based

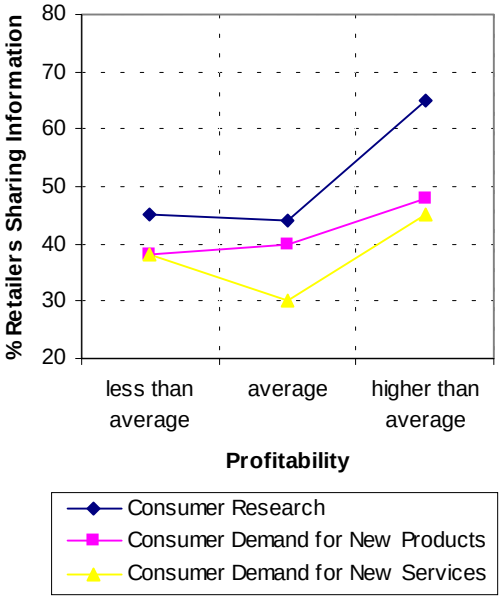
[15] In this instance, the supply chain can be thought of as a large complex project to be managed.
[16] See Section 1.2 on page 16, for the trends driving increased focus on supply chain operations.

on a survey of 100 manufacturers and 100 retailers, it was found that companies engaged in higher levels of information sharing with supply chain partners reported higher than average profits. The degree of information sharing and profits and its impact on manufacturers and retailers are shown in Figure 2-3 and Figure 2-4, respectively. A clear correlation in both the level of information sharing at retailers and manufacturers and profits is observed.



Source: Stanford - Andersen, 1998.

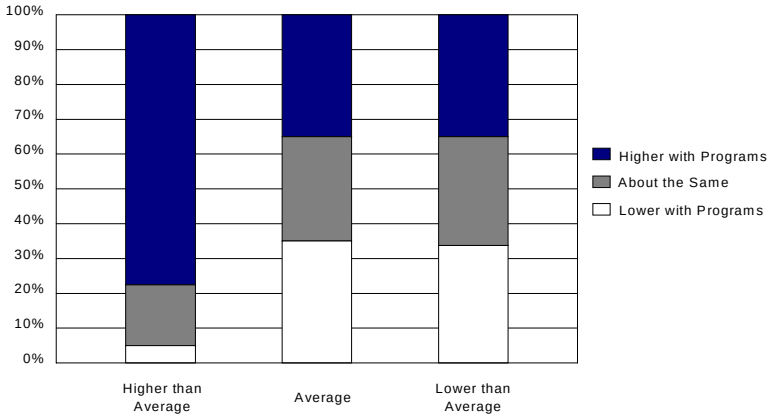
Figure 2-3 Profitability and Infromtion Sharing – Impact on Manufacturers



Source: Stanford - Andersen, 1998.

Figure 2-4 Profitability and Information Sharing – Impact on Retailers

In addition, Figure 2-5 illustrates how higher profits are linked to higher levels of joint demand and logistics planning.



Source: Stanford – Andersen, 1998.

Figure 2-5 Profits and Level of Joint Demand and Logistics Planning

2.4.2 Case Studies in Information Integration

In addition to the benefits from information sharing in the consumer packaged goods industry, innovative information integration in the supply chains of Cisco Systems and Dell Computer has substantial advantages over conventional approaches.[17] Both companies have seen their stock prices soar several thousand percent over the past decade to a large extent due to efficiency gains, cost reductions and mastering their supply chain by using extensive information integration systems. An overview of the cost savings and revenue maximizing from efficiently integrating information systems and consequently flow of information are illustrated in the two examples, respectively.

Case in Point – Cost Reduction at Cisco Systems

Cisco Systems' CFO, Carl Redfield, estimated in 1999 that Cisco's interconnected supply chain had led to $700 million in savings since 1994 [29]. These are significant bottom line savings for Cisco, approximately 12% of net income.[18]

Cisco is able to achieve such gains from connecting its customers and suppliers to an electronic-hub (e-Hub) which allows end-to-end information visibility across the entire supply chain – sharing forecasts, order information and availability of components. In addition, Cisco integrates its suppliers in the planning and forecasting process in order to minimize discrepancies in the capacity planning and production processes. By integrating suppliers early on in the product ordering process, the average order-to-delivery time for customer-configured systems has been reduced to 10 days in 2001 from 23 days in 1998.

By coordinating workflows among customers and suppliers in an electronic form that is fast and accurate, Cisco is able to achieve significant cost reductions.

Case in Point – Revenue Gains at Dell Computer

Supply chain integration through workflow coordination benefits also enhances revenues, increases market share, strengthens competitive position, and enhances the value of a company as described by Lee [30].[19]

The case of Dell Computer provides an example of how supply chain performance enhances competitiveness. In the PC industry, competition is not based on technology per se, since all manufacturers use the same technology – Intel and Microsoft. The competition centers on cost and service levels, which Dell has successfully addressed

[17] Refer to [29], [58] for comprehensive overview of cost savings at Cisco and [31], [32], [33] for revenue growth and business model of Dell.
[18] Using the average annual net income from 1994 to 1999 and allocating savings equally to each year.
[19] Revenue gains are found at any company that is growing. However, in the case of Dell, the source of competitive advantage and its revenue growth is often directly associated with the choice of supply chain model and integration with suppliers and customers.

[31]. The company's success in eating away market share from Compaq, IBM, and HP in the personal computer market is partly based on the ability of allowing customers to design, price and build systems based on their individual needs, also referred to as the 'Dell Direct Model' [32].[20]

At present, Dell has several information sharing initiatives with its suppliers in addition to joint planning and forecasting. Components are delivered in a just-in-time basis from adjacent suppliers to Dell's manufacturing plants (and those of its contract manufacturers), computers are assembled in matter of hours and a merge-in-transit operations adds monitors and other peripherals to shipments on the way to the consumer. An average order is received by the customer 4-5 days after placement [33].

Dell achieves such short built-to-order cycles by electronically linking its main suppliers and physically locating them around its plants in a configuration called a revolver[21]. Parts are ordered on a need basis only and delivered within hours by trucks on a continuous loop between suppliers and Dell, known as a "milk run", that delivers the sorted parts to the computer maker's plant for final assembly.

The aforementioned examples illustrate how closer integration with supply chain partners allow significant cost reductions and expansion in market share. It is recognized that many other non-supply chain related factors like employing innovative business models, sales force automation and superior research and development contributed to the success of these companies.

As illustrated, there are benefits from higher levels of information system coordination and information sharing between supply chain partners. However, several basic questions remain, including to what degree companies are achieving mutually beneficial integration with their partners as well as the identification the fundamental factors leading to success and failure. The next section presents the most common obstacles documented in literature affecting supply chain information and workflow integration.

2.4.3 Obstacles to External Information Integration

The preceding section presented some of the successful approaches and benefits from tighter interaction with supply chain partners. However, every attempt to closely integrate with business partners is associated with obstacles.

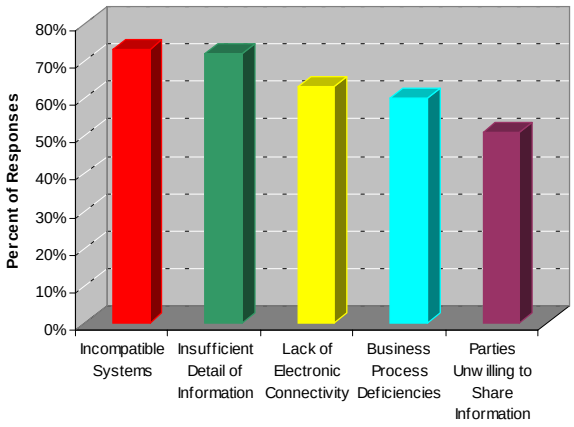
[20] Dell's market share of personal computer shipments in the US grew from practically 0% in 1986 to 19.7% in 2000.

[21] The "revolver" is a concept developed by Dell that describes the operation of its inbound materials. Supplier's warehouses are built around the company's and contract manufacturers manufacturing facilities. Request for parts are sent out several times per day to suppliers, which deliver parts in a just-in-time basis to the manufacturing facilities. Suppliers are able to sell any excess inventory to other customers from their Dell dedicated distribution centers if necessary.

An example of such incongruence was observed at the Airbus consortium, – a supply chain of multiple partners – recently restructured and now owned by EADS (80%) and BAE Systems (20%) [34].[22] Historically, the consortium members, four conglomerates from different countries, kept financial and manufacturing data hidden from one another. Each participant worked to sell to the consortium at the highest price possible.

The joint venture competed with Boeing based on competitive pricing and frequently recorded losses even as partners profited on manufacturing. With the new ownership structure, the separate management teams and forecasts have been removed, and the profit of the new entity is higher. This example demonstrates how a company based on differing incentives lacked the ability to coordinate the exchange of accurate information.

When issues of trust and unwillingness to share information are overcome, there still exist fundamental technical difficulties in sharing data and coordinating workflows across business partners.[23] A survey of 100 supply chain managers conducted by Urban Wallace & Associates illustrates that the four most common obstacles to achieving inventory visibility across the supply chain were technical problems rather than 'soft-factors'.[24]



Note: More than one answer allowed.
Source: Research conducted for Transentric by Urban Wallace & Associates, 2001

Figure 2-6 Obstacles of Inventory Visibility in the Supply Chain

A survey conducted by Forrester Research [35] of 41 executives of Global 2500 firms concludes that 90% of respondents currently use inward facing applications to buy, make, and monitor, suggesting another barrier why information sharing is not widely adopted. The study concludes that by 2003 88% expect to use outward facing applications for collaboration and fulfillment.

[22] Refer to the Glossary of Companies on page 141 for a description of EADS and BAE Systems.
[23] Lack of trust and other attempts to avoid the sharing of information are referred to as 'soft-factors' since they cannot be clearly explained and quantified.
[24] Research provided by Transentric executives.

Even though organizational, cultural, and personal impediments may stand in the way of integration, increased information sharing with partners of the supply chain are the first step in achieving synchronized supply chain operations. Such integration provides the foundation for achieving information exchange and creating visibility across the supply chain. It allows for information integration and workflow coordination, the first two levels of supply chain integration of Lee and Whang's supply chain integration spectrum.

The next step is the attempt to mutually coordinate the supply chain by collaborating with trading partners to achieve higher levels of synchronization of information *and* materials, based on the inclusiveness property of the second dimension of coordination.

2.5 Collaboration in Supply Chains

2.5.1 Introduction

Section 2.4.1 and 2.4.2 illustrated how information integration creates better visibility and coordinated flow of information in the supply chain, often accompanied by higher profits for the organizations involved. For coordination of information *and* material flows between supply chain participants, a zero-sum game needs to be transformed into a non-zero sum game. This can be achieved through mutually established collaboration initiatives. Bowersox et al. [36] present evidence of transformation of adversarial relationships into collaborative efforts as one of the fundamental trends in supply chain management.

To achieve the second dimension of supply chain integration, i.e. workflow coordination and synchronization, business partners often engage in collaboration.[25] Collaboration allows companies – either by verbal or contractual agreements – to mutually determine how to synchronize product flows, reduce inefficiencies, and share the mutual value created. Collaboration coordinates the dependency of transferring physical goods from one place to another.[26] It is a "higher" level coordination activity than information sharing and workflow coordination due to added complexity of managing products. It includes tasks such as joint planning, forecasting and running replenishment operations.

2.5.2 Collaboration Defined

As in the case of supply chain management, there are numerous definitions of collaboration and what areas in an organization it encompasses. Mentzer et al. [37] set their baseline for research in collaboration by suggesting the following definition of collaboration based on the consensus view of research participants:

[25] This corresponds to the third of four dimensions of integration by Lee and Whang [22]: information sharing, workflow coordination, synchronization, and new business models.
[26] Collaborative design is excluded since it is out of the scope of this thesis.

"Collaboration means that companies involved are working together to meet one common objective. Collaboration is characterized by the sharing of information, knowledge, risk and profits."

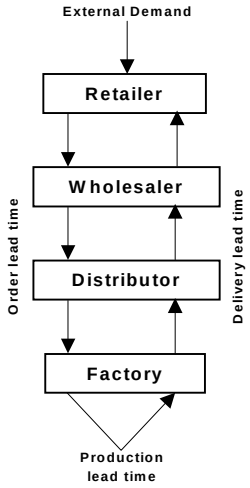
A more comprehensive definition of collaboration is given by Lotus-Benchmarking Partners [38]:

"Collaboration is closed-loop shared decision making between trading partners that is focused on the end consumer. Collaboration of trading partners on daily decisions, such as the quantity an assortment of orders, delivery dates, product design, and promotions allows aligning the efforts of two or more companies to act like one."

2.5.3 The Bullwhip Effect

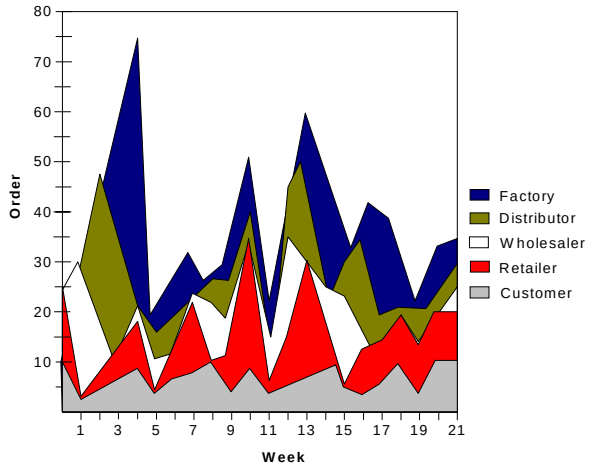
The benefit from coordination through collaboration is best illustrated by common phenomena observed when no collaboration and information sharing takes place in the supply chain. This often results in the distortion of information as it moves upstream through a supply chain from the customer to the raw materials supplier. Time delays in ordering and shipping materials – and failure of decision makers to consider these time delays – cause order variability to increase as one moves upstream in a supply chain. This phenomenon, called the "bullwhip effect", is extensively documented based on industry data by Lee, Padmanabhan, and Whang [39] and manufacturing supply chain simulation models by Sterman [40] and the systems dynamics group at MIT.

The applicability of the bullwhip effect is so common to supply chains, that it is classified as a law of supply chain management per Fine [41]. It is based on the observance that throughout many years, suppliers and retailers have observed that while customer demand for specific products does not vary much, inventory and back-order levels fluctuate considerably across the supply chain. These fluctuations become amplified the further upstream one looks; refer to Figure 2-7 for a sample supply chain and Figure 2-8 for a graphical illustration of order variability amplification.



Source: Simchi-Levi, 2000.

Figure 2-7 Beer Game Supply Chain



Source: Simchi-Levi, 2000.

Figure 2-8 Order Variability in the Supply Chain

An example of this phenomenon was observed in the US machine tool industry from 1961 to 1991.[27] While gross domestic product of the US oscillated in the range of ± 2-3% per year, automotive production oscillated in the range of ± 20%, and the machine tool industry fluctuated from ± 60-80% at times.

The root causes of the bullwhip effect have been summarized by Simchi-Levi [42] as follows:

Demand Forecasting Since there is no visibility of end user data every participant in the chain produces his/her own forecast. Errors – variability – in the forecast add up since inventory managers tend to buffer against uncertainty.

Lead-Time The increase in variability is magnified with higher lead-times. Increased lead times imply that small changes in the estimate of demand require significant changes in order quantities due to the long time for those replenishment quantities to travel through the replenishment pipeline.

Batch Ordering Batch orders, to exploit economies of scale in transportation and lower ordering costs, create periods with large orders followed by periods of no orders which introduces further swings in the ordering process.

Price Fluctuation Price discounts lead retailers to stock up on cheap goods, consequently altering the ordering pattern in the following periods.

Inflated Orders When shortage periods are expected to occur, retailers often inflate orders to guarantee enough supply, however, once they are over, retailers go back to old order quantities, which can lead to all kinds of distortion.

[27] Taken from Fine [6].

Collaboration models discussed in the following sections focus on mitigating these root causes. The distinction between dyadic and multi-tier collaboration is made.[28]

Dyadic collaboration is the collaboration between immediately adjacent supply chain partners. It is a two-company centric collaboration approach, where coordination between two entities with little consideration of other participants in the chain is done.

Multi-tier collaboration initiatives span across several tiers and various members of a supply chain. For example, such approach would incorporate Dell, Intel, AMD and AMD's supplier working jointly to determine optimal operational parameters such as inventory levels, capacity plans and demand forecasts. Such an approach would aim to coordinate operations of the entire supply chain.

The following two sections of this thesis – Section 2.5.4 and 2.5.5 – explore the dependencies and benefits in dyadic and multi-tier collaboration approaches and state of the art examples of the second building block for coordinated supply networks presented in Chapter 3.

2.5.4 Dyadic Collaboration

2.5.4.1 Current State

At present, most collaboration efforts in supply chain management revolve around two adjacent members of a supply chain that are mutually dependent – i.e. both businesses either buy or sell a significant volume to each other and view the adjacent partner as crucial for long term competitive position. Examples of such efforts include vendor-managed inventories (VMI), efficient consumer response (ECR), and more recently the use of Collaborative, Planning, Forecasting, and Replenishment (CPFR) models.

The prerequisite for such collaboration efforts includes a clear determination of potential benefits and their corresponding distribution among the business partners involved. Byrnes and Shapiro argue that it is crucial to carefully estimate the savings in advance and measuring them as they occur [43]. Only such a clear determination and distribution of pay-offs can create the necessary incentive for both parties to collaborate while ensuring fairness for the duration of the initiative.

At the highest level, the value from supply chain collaboration processes can be categorized in Table 2-1, with VMI, ECR and CPFR falling into the "Planning, Forecasting, and Replenishment" category.

[28] Dyadic means two-way, pertaining to two parts or elements.

Table 2-1 Value from Collaboration Processes

Inter-Enterprise Business Process	Value
Order Management	▪ Competitive advantage and increased revenue through reduced stock-outs ▪ Lower costs through reduced inventory
Distribution	▪ Lower cost through optimized shipping and fulfillment execution
Planning, Forecasting, and Replenishment	▪ Competitive advantage and increase in revenue through reduced stock-outs ▪ Reduced inventory levels
Sourcing	▪ Faster product introduction

Source: Benchmarking Partners-Lotus Corporation, 1999.

2.5.4.2 Vendor Managed Inventory

Vendor Managed inventory (VMI) was developed in the late 1980s in an effort to reduce inventory and stock-outs at retail stores. In a VMI configuration, tasks traditionally performed by a retailer – like stocking and ordering product – are managed by the supplier of the product. The first highly visible VMI model was between Wal-Mart and P&G in the diaper product category in the late 1980s. Another example of a long ongoing VMI initiative is Frito-Lay, in which drivers/salespersons stock the store shelves for small retail customers to keep the shelves full, the product fresh and paperwork to a minimum [44].

Benefits from VMI are created through reduced costs and improved service. Lower costs are achieved through better demand visibility – reducing the need for large buffer stocks –, smoothing of uneven orders, and increase the percentage of low-cost full truckload shipments. Increased service from VMI occurs through coordination of replenishment orders and deliveries across multiple customers that allow inventory balancing across the customer's distribution centers.

Waller et al. [45] evaluate the effect of key variables in VMI through numerous simulation models. Results show that even with large demand variability VMI considerably reduces cycle stock and modestly reduces safety stock. It was further determined that the VMI adoption rate among retailers has no effect on the potential benefits of VMI, i.e. a retailers decision to adopt VMI can be made without concern for the suppliers relationship with other customers. Finally, Waller et al. illustrate that VMI allows the manufacturer to reduce excess capacity usually required to buffer demand uncertainty.

In another study, Clark and Hammond [46] conclude that VMI programs have been shown to increase inventory turns from 50 to 100% percent over those achieved before implementation, even when the retailer and manufacturer were already using EDI before.

Other benefits of VMI initiatives such as increases in productivity, increased customer satisfaction, and reduction in distribution, operation costs, and inventory levels are documented in a KPMG study [47]. The results are listed in Table 2-2.

Table 2-2 Benefits from VMI

Inventory Levels	**Consumer Satisfaction**
▪ Customer Inventory Levels (40% reduction typical) ▪ Manufacturer Wholesaler Inventory (30% reduction typical) ▪ Average Carrying Cost Reduction	▪ Fill Rate (98% feasible) ▪ Higher Product Freshness
Distribution/Operations Costs	**Productivity**
▪ Improved Truck Utilization ▪ Number of shipments ▪ Reduction in Paper Work ▪ Reduction in Returns ▪ Personnel Costs	Reduction of: ▪ % Time Negotiating Price, deals and Following up on Invoice Deductions ▪ % of Sales People's Time Dealing with Replenishment ▪ % Inventory Manager's Time Spent Operating VMI Program

Source: KPMG, 1996.

Several VMI failures have been observed. In the case of Spartan Stores – a US based cooperative grocery wholesaler – the company decided to halt the program after 12 months due to lack of benefits caused by the vendors limited ability to forecast orders and manage promotion planning. Similarly, in 1995 K-Mart cut its VMI program from 300 to 50 suppliers due to numerous vendor departments not achieving target service rates. It was observed that in most cases vendors lacked forecasting capabilities. The effectiveness of VMI is often criticized by stating that it simply shifts the burden of carrying inventory to suppliers instead of reducing it in the system as discussed by Bowman [48].

Similar initiatives to VMI such as just-in-time II (JIT II) apply the same concept of allowing the supplier to manage inventory and ordering to the procurement side of a company.[29]

2.5.4.3 Efficient Consumer Response

Efficient Consumer Response (ECR) started in the early 1993 as a voluntary group in the grocery industry to use technology and strategic alliances to reduce costs. The ECR movement is based on the principle of just-in-time inventory management as discussed by Drayer [49]. It aims to expand the benefits observed form quick response initiatives – i.e. operating based on a demand signal – by broadening the scope to include product

[29] JIT II was developed by Bose Corporation in Massachusetts. In this model, an 'in-plant' representative employed and paid by a supplier works in the procurement department of Bose, ordering components for Bose.

promotions and introductions. ECR has four key areas: (1) efficient replenishment, (2) efficient promotion, (3) efficient introduction, and (4) efficient assortment.

One of the most successful models of ECR was built by P&G throughout the 1990s. The company reports 6-9% in bottom line cost savings from the initiative, distributed as follows: 40% logistics, 40% promotion, 10% assortment, and 10% product introductions [50]. Since the early 1990s, Proctor & Gamble's market share has increased, prices decreased, and margins increased due in part to the success of ECR [51].

The practices of ECR lay the foundation for collaborative, planning, replenishment and forecasting, a more data intensive and technology intensive form of building collaborative business relationships discussed in the next section.

2.5.4.4 Collaborative, Planning, Forecasting and Replenishment

Collaborative Planning, Forecasting and Replenishing (CPFR) is a recent initiative aimed at creating common language standards and standardized processes to facilitate inter-company coordination. It was introduced in 1995 by an industry group led by Wal-Mart, Benchmarking Partners, Warner Lambert, SAP, and Manugistics through the Voluntary Interindustry Commerce Standards Association (VICS) in an attempt to standardize collaborative processes across companies.[30]

A research note from the Gartner Group [52] shows that only recently manufacturers and retailers in the consumer packaged goods industry have enthusiastically responded to CPFR. Gartner estimates that by the end of 2001, most Type A enterprises – enterprises that are technology-driven and risk using innovative technology to gain a competitive advantage – will participate in 2-5 CPFR pilots with channel masters focused on dyadic collaboration initiatives.

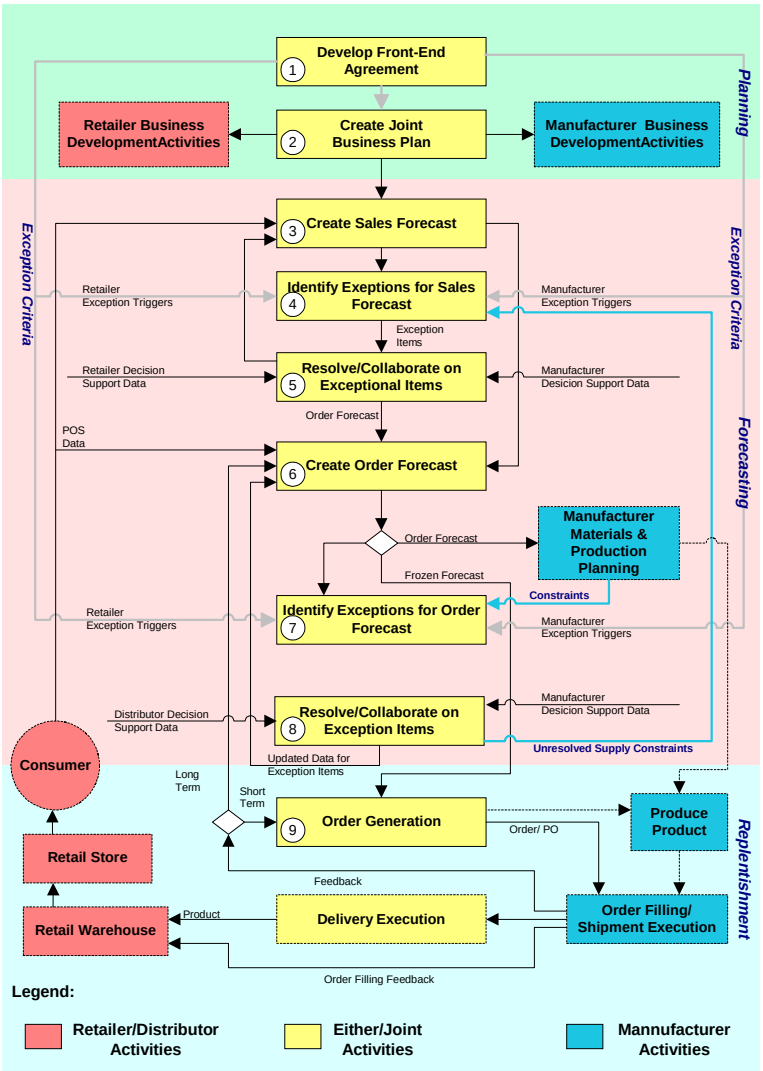
CPFR is particularly adequate in industries where inventory comprises a significant portion of total logistics costs – automobile, high-tech and retail industries– and where demand levels are stable. A research study based on U.S. Commerce Department reports by Ireland and Bruce [53] illustrates that retail chain sales for the year 2000 was projected to reach $3.2 trillion, supported by holding $372 million in inventories. Including wholesalers and consumer packaged goods manufacturers the inventory figure is estimated at $1.1 trillion across the entire retail chain. Based on CPFR pilots, reductions of 10% in inventory across companies in the chain are often feasible. A 10% reduction in inventory represents a net present value of $300 to $400 billion to the industry members.[31]

Figure 2-9 presents a detailed flowchart illustrating information and product flows in a generic CPFR collaboration process. The process model is segmented into three stages.

[30] Refer to Section 2.5.5.2 on page 43 for a discussion of VICS.
[31] Using the net present value method with a conservative cost of capital at 10% p.a.

The first stage is planning, and involves Steps 1 and 2. The second stage is forecasting, and involves Steps 3 through 8. The last stage, replenishment, consists of Step 9.

Color is also used to indicate which trading partner is leading a particular process activity. Retailer/Distributor-led activities are shown in red. Manufacturer-led activities are in dark blue. Shared activities are indicated by yellow.[32] In the model, "distributor" is used as a generic term to describe a business that doesn't manufacture its own products but purchases and resells product. This definition is meant to include retailers. The process and data format is clearly defined for each stage of the iterative process with standard exception triggers built into the system to cope with disrupting promotions or other special considerations in the forecasting process.



Source: Voluntary Interindustry Commerce Standards association, 1998, Author.

Figure 2-9 CPFR Process Flow Chart

[32] For black and white thesis copies: activities in red are primarily on the left side of the diagram, activities in yellow in the middle, and activities in blue on the right side.

Ireland and Bruce [54] present a summary of the benefits form three CPFR pilots in the retail sector. Their research findings are summarized in Table 2-3.

Table 2-3 Benefits from Three CPFR Pilots

Pilot	Description	Results
Nabisco and Wegmans	First-phase pilot managed 22 Planters Nuts SKUs at Wegman's DC. Utilized spreadsheet and e-mail. Second phase pilot managed 20 Milk-Bone SKUs. Used Manugistics Networks software.	Nut category sales grew 16.3%. Private-label nut sales grew at 15.7%. Planters Nuts sales grew 53.9%. Days of inventory on hand decreased by 2.5, or 18%. Pet-snack category sales grew 7%. Private-label sales grew at 31%. Milk-Bone sales grew 8%.
Kimberly Clark and Kmart	2,100 stores, 14 distribution centers (DCs), and 15 SKUs. Utilized Kmart-developed Internet site	Store in-stock levels improved. Adjusted DC replenishment logic. Reduced overall inventory required. Improved joint focus on specific goals through front-end agreement.
Wal-Mart and Sara Lee Branded Apparel	23 branded underwear items in 2,400 stores. Collaborated via spreadsheets.	Sales up 45% (comp. Sales up 35%). Inventory up only 12%. Market share up 10%. Retail turns up 30%. Retail weeks-on-hand down 23%. Gross margin return on inventory investment up 49%. In-stock up 2.7%

Source: Ireland and Bruce, 2000.

In all three cases substantial improvements in item-availability, inventory turns, and increased sales were observed. Specifically, Nabisco and Wegmans chose the Planter's line of products due to the high degree of promotion and variety of the product line. These two factors create considerable variability and persistently produced disparities in the forecasts of trading partners.

Nabisco used Manugistics software to automate forecast comparisons between both companies. In addition to the scalability of CPFR into larger categories and other product lines, Nabisco is looking at synchronizing the downstream transportation and distribution crucial for ensuring timely replenishment as illustrated by Walton and Princi [55].

2.5.4.5 Summary

The literature reviewed in the dyadic collaboration space focuses on the characteristics and benefits of these efforts without providing a good insight to which entities and governance structures would allow coordination across participants in multiple tiers of a

supply chain. Most collaboration efforts reviewed are software based, and attempt to optimize information and materials flows across two companies.

Examples illustrated are dyadic collaboration efforts – i.e. the sharing of information and decision-making is exclusively between companies in adjacent tiers of a supply chain. Such coordination and attempts to optimize are "local" in nature – they focus on one link at a time in a supply chain.[33] The problem then resembles network flow problem, where individual flow optimization of individual lanes in the network results in a sub-optimal outcome for the larger system. In order to achieve a global optimum, sub-optimal conditions need to be enforced at some links.

It is plausible that as in the case of providing visibility and coordination among internal functional silos in companies in the late 1980s created improvements in operational efficiency, creating visibility and optimization processes among several supply chain members can increase the overall supply chains ability to identify inefficient operations.

Initiatives to collaborate across multiple partners of a supply chain like sharing information such as sales forecasts, capacity planning, production schedules, and collaborative logistics networks have recently evolved. These multi-tier collaboration efforts are discussed in the following section.

Ireland and Bruce [56] observe that many of these supply chain management initiatives have primarily addressed supply side relationships. Demand side interactions are left untouched and disconnected from the supply chain. In order for multi-tier coordination to take place, these demand side relationships and functional processes need to be integrated as well.

2.5.5 Multi-Tier Collaboration

2.5.5.1 Current State

The traditional focus on the competitive advantage of single firms is no longer sufficient. Christopher [57] argues that due to an increasing number of value and cost conscious customers competitive advantage is not determined by a firms individual effort anymore.

More specifically, this advantage becomes dependent on the entire supply chain, with its corresponding inter-organizational forms – i.e. partnerships, collaboration, and effective use of electronic exchanges. However, widespread sharing of information and collaboration across supply chain partners in various tiers *simultaneously* is still in its infancy.

[33] A node in the network can be thought of as a company and a link as the relationships or collaborative effort between two adjacent companies.

To make this point it is useful to look at arguably one of the most tightly integrated supply chain spanning three-tiers in the US, employed by the networking gear manufacturer Cisco Systems. Cisco Systems primarily integrates with customers electronically – through Cisco Connection Online (CCO) – and suppliers – through manufacturing connection online (MCO) – through web-portals. The company manages all financial transactions for these exchanges through its enterprise system, which frees partners form low value administrative tasks.

Cisco's strategy is characterized by deep information sharing, and the company ensures that all suppliers are working off the same forecast signal and share inventory and purchase orders [58]. In many instances orders are directly routed to contract manufacturers and shipped to customers from the contract manufacturer's, bypassing Cisco altogether.

Despite high levels of integration, the interconnected network still experiences erratic inventory stocking as observed at Cisco in November of 2000. In an attempt to meet surging demand, Cisco aggressively stocked up high-speed communications and networking products from PMC Sierra and Applied Micro Circuits to ensure component availability and hedge against possible supply shortages.

Customer orders in the first fiscal quarter– August-October 2000 – were much slower than expected due to a general downturn in information technology infrastructure spending in the last months of 2000 and first quarter of 2001.[34] Cisco's raw materials inventory rose 335% in the first quarter – from $145 million to $631 million –, and total inventory increased 59% while revenues only increased by 14%.[35] The company was left with excess inventory for the 2nd quarter while its suppliers were hurt by considerably lower orders.[36]

This example illustrates that even highly collaborative chains with some multi-tier collaboration attempts often experience erroneous movements of materials that sub-optimize the supply network. A lack of predetermined coordination mechanisms among business partners allowed too many components to flow downstream in the chain and depreciate at 15% per month.[37]

In less technologically sophisticated chains, like in the consumer retail goods multi-tier collaboration is not clearly identifiable at present. Most attempts to create multi-tier coordination are based on the developing building blocks such as industry standardization efforts – Section 2.5.5.2 –, third party hosted exchange and collaboration providers – Section 2.5.5.3–, and collaborative logistics providers – Section 2.5.5.4.

[34] Fiscal year ending in July.
[35] Source: "Cisco Slams Chip Stocks", article on cnnfn.com, 11/07/2000.
[36] Source: "Cisco Inferno Hits Techs", article on cnnfn.com, 02/07/2001.
[37] This arguably was a forecasting error with a wrong hedging strategy but it illustrates the point of unnecessary positioning of product in the supply chain. 15%/month conservative depreciation estimate of inventory used in PC industry.

2.5.5.2 Industry Standardization Efforts

Most coordination models rely on establishing of common communication standards, through either private networks or industry-developed standards. Numerous industry standard-setting bodies exist, three of which are particularly interesting in their impact on inter-organizational business coordination. (1) Uniform Code Council in the consumer goods sector, (2) RosettaNet in the information technology, electronic components, and semiconductor manufacturing industries, and (3) the Voluntary Inter-industry Communications Standards Committee in the general merchandise sector.

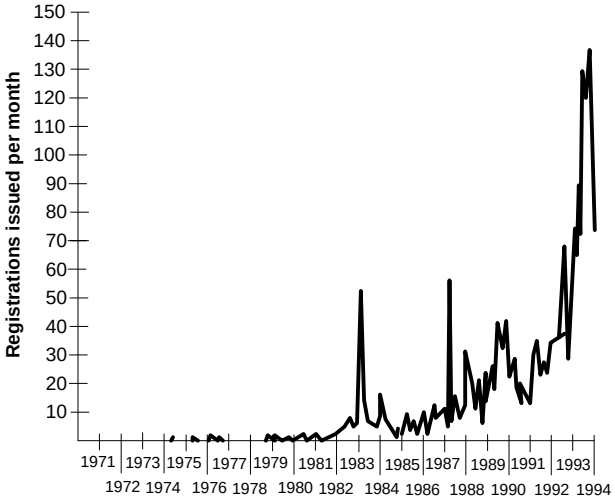
Uniform Code Council

The Uniform Code Council (UCC) evolved out of an informal association in the grocery industry to assign uniform product codes (UPC) to manufacturers in the early 1970s.[38] The use of UPC codes has allowed to, accurately, identify and track products through supply chains, as well as for retailers and manufacturers to obtain accurate point of sales information.

The UCC cannot coordinate by itself, it only sets the communications formats to more effectively track and manage products and inventory in the supply chain; actual adoption depends on influential businesses as illustrated by Abernathy et al. [59].

A standards adoption example in the apparel industry illustrated in Figure 2-10 shows that adoption of UPC codes proposed by the UCC depended largely on large companies in the retail industry requiring manufacturers to use bar codes. In 1983, K-Mart began to demand UCC requirements for manufacturers followed by Wal-Mart in 1987. As seen in Figure 2-10, in both instances registrations jump considerably, overcoming the tipping point to widespread adoption by all industry members.

[38] A UPC bar code consists of ten digits. The first five digits are assigned to individual companies and the second five for product identification.



Note: Apparel UPC Registrations, monthly data.
Source: Abernathy et al., 1999.

Figure 2-10 Example of Adoption Rate of Standards: UPC Codes

RosettaNet

RosettaNet is a self-funded, non-profit consortium of major information technology, electronic components, and semiconductor manufacturing companies working to create and implement industry-wide open electronic business process standards.[39] Over 300 companies representing over $1 trillion in annual revenues currently participate in RosettaNet's standards development, strategy, and implementation activities.

The organization develops Partner Interface Processes (PIPs) that define business processes between trading partners. These are specialized system-to-system XML-based dialogs. Each PIP specification includes a business document with the vocabulary, and a business process with the instructions of the message dialog.

PIPs are classified into seven clusters: (1) partner, product and service review, (2) product information, (3) order management, (4) inventory management, (5) marketing information management, (6) service and support, and (7) manufacturing. Each cluster provides specific capabilities to exchange information, configure and manage transactions.

Among those members reporting readiness of internal business process alignments with selected PIPs are Avnet, Cisco Systems, Compaq Computer, Federal Express, NEC Technologies, Netscape, Solectron, and UPS. Trading partners that have reported readiness and are exchanging PIPs in pilot or production mode include Intel and Arrow

[39] Refer to www.rosettanet.org for a complete set of standard processes.

Electronics, Hewlett-Packard and SAP, 3Com and CompUSA, and Ingram Micro with CompUSA.[40]

Voluntary Inter-Industry Communications Standards Committee

Similar to the UCC and RosettaNet, the objective of the Voluntary Inter-Industry Communications Standards Committee (VICS) is to encourage the use of standards and protocols to lower the cost of coordination among business partners by standardizing communications protocols and formats. VICS, created in 1986 by a group of supplier, manufacturer, and retailing executives, establishes cross-industry standards that simplify the flow of product and information in the general merchandise retail industry for retailers and suppliers alike.

The VICS is responsible for creating the CPFR Committee and the creation of CPFR voluntary guidelines to explain the business processes, supporting technology, and change management issues associated with implementing CPFR.

2.5.5.3 Supply Network Software/Internet Based Exchanges

There are two categories among software vendors to facilitate multi-tier coordination: (1) supply network application software, and (2) electronic exchanges in several variants and ownership structures.

Supply Network Software

Forrester Research concludes that the vast majority of current supply chain applications do not connect supply chain partners [60]. It projects the increased use of what it defines as 'extended relationship management' (XRM) applications to connect companies across multiple tiers of the supply network.[41]

Forrester attributes the increasing importance of extended relationship management is based on three drivers: (1) As firms outsource more of their business, managing relationships with multiple tiers becomes important. Shared data infrastructure avoids the costs of linking up one at a time, (2) channel master driven solutions become more expensive and make less sense as multiform collaboration rises, and (3) fulfillment will be driven by collapsing multiple manual processes into single online activities.

Current examples of XRM are: (1) Business to business collaboration communities – Atlas Commerce's eHub to coordinate commitments of interdependent suppliers in the injection-molding process of HP and four tiers of suppliers, (2) Multi-tier sell-side systems – Seagate's use of software from Comergent that allows re-sellers to see real-

[40] Source: UCC Press Release, Santa Ana, California, 02/02/2000.
[41] Forrester defines XRM as: "Collaboration between multiple independent firms to manage supply and demand".

time price and availability form distributors, and (3) Three tiered channel management systems – Miller Electric uses InfoNow to connect local distributors to the end customer.

There are also numerous hosted software providers that provide visibility including companies like Tilion, Inc., which provides an infrastructure service for collecting, analyzing, and distributing information of e-commerce transactions and Transentric, which provides visibility of all inventory in a company's supply chain, both in-transit and in-storage [61].[42]

Electronic Exchanges

There are numerous forms of electronic exchanges established to facilitate supply chain coordination. Anderson and Lee [62] explain how new business models such as electronic marketplaces – industry vertical marketplaces, private exchanges and horizontal aggregators – can be used as mechanisms to create a synchronized supply chain. This thesis does not intend to cover business-to-business (B2B) exchanges in depth but to provide a brief overview of dyadic collaboration and eventual multi-tier coordination facilitated through these.

Electronic exchanges aiming to provide capabilities above the transactional level include i2's tradematrix and CPFR hosted solutions by Syncra Systems. i2's tradematrix deals with the common difficulty of manufacturers and retailers to set up several individual CPFR relationships by allowing a company to collaborate with all its partners in the same business environment. As an example, this collaboration approach would be anchored around a retailer in the food industry who would suggest that its suppliers also join. A six-step process defines the collaborative process with each supplier as presented by Kuglin and Rosenbaum [63]:

1. The supplier generates a statistical forecast and new product introduction information and sends it to the retailer.

2. The retailer reviews the demand forecast and exceptions. At this point, the retailer can see new product introductions and supply-demand mismatches.

3. The retailer modifies or updates the forecasts and sends them back to the supplier. Here the retailer indicates, for example, where higher than anticipated demand due to promotions is expected.

4. The seller sends back the supply-plan information and offers alternatives for exceptions. The supplier has completed the demand/supply matching process and is able to report what it is able to produce and deliver.

5. The retailer reviews the supply-plan and looks for exceptions.

[42] For more details about Tilion and Transentric refer to the Glossary of Companies on page 141.

6. The retailer sends back the updated demand information. If thee are items that cannot be supplied, the retailer has the option to update the demand information and order substitute products.

This process is repeated with other suppliers. This type of exchange allows a primarily collaborative effort around sharing forecasts and planning data. Such approaches are recent and it is not yet clear if more than adjacent companies of a supply chain are simultaneously engaging in such collaboration efforts. Transaction oriented B2B exchanges – such as Transora[43], WWRE[44], and Covisint[45] – are in the development phase and currently limited in their ability to offer collaboration environments to participants.[46]

The impact of B2B exchanges on supply chains is discussed by Wise and Morrison [64]. Wise and Morrison observe that, first, current exchanges are auction or transactional based, disrupting the supply chain as opposed to long-term collaboration relationships. Second, they tend to benefit buyers, as visibility and buyer power is aggregated. Finally, some B2B exchange business models take a large portion of the value created by the service, often making it only marginally attractive for companies to join.

Minahan [65] points out that web-based B2B exchanges have proven satisfactory for the purchasing products like MRO supplies, office supplies and computer equipment due to the standard characteristics of such products. However, Minahan determines that web-based services are still ill suited for sourcing inputs that are more complex since such purchases require substantial cross-collaboration throughout the purchasing process.

At present electronic exchanges are going through a consolidation phase, the product of lack of adoption, low volume, and unclear business model viability. It has not been fully proven that supply chain coordination and inventories can be as quickly and dramatically improved as B2B companies propose. [47]

In addition, actual execution further downstream in the value chain requires collaboration in the transportation space, as it is the case of collaborative logistics initiatives. Collaborative logistics networks are nothing new, as they have existed since the 1980s when manufacturers, distributors, and shippers have attempted to optimize truckload operations. As part of one of the more mature collaboration initiatives that span across multiple supply chain participants, collaborative logistics are being dramatically reinvented due to advances in information technology and therefore discussed in the next section.

[43] Transora is an electronic exchange in the consumer-packaged goods industry backed by P&G, Unilever, amongst 52 others. Transora is not in operation as of 05/2001.
[44] The World Wide Retail Exchange is an electronic exchange in the mass merchandise retail industry backed by Kmart, Target, Ahold, and 50 others.
[45] Covisint is an electronic exchange in the automotive industry owned by GM, Ford, DaimlerChrysler, and Renault/Nissan.
[46] Transora and WWRE have announced plans to offer CPFR capabilities to participants in the future.
[47] Source: The Wall Street Journal, "P-to-P, B-to-B – R.I.P.?", Section B1, April 4, 2001.

2.5.5.4 Collaborative Logistics

Collaborative logistics networks like Nistevo and i2's freightmatrix provide participants with online management of contracts, tacking of shipments, and the ability to manage exceptions through execution and sharing capacity with other members through exchange.[48] These initiatives are limited to exclusively coordinating the transportation aspect of logistics.

The savings of collaborative logistics alliances are documented in a Omni Consulting Group study on the private, Internet based freight and logistics alliance managed by Nistevo [66]. Participating companies of this 12 member alliance include General Mills, The Pillsbury Company, Land O' Lakes, Graphic Packaging Corp, and other consumer packaged goods companies.

The study determines that improved asset visibility, improved use of assets and economies of scale can produce efficiency gains of 12.3% for participating organizations. These efficiency improvements come from automating the process of posting shipments (3%), smoothing of demand by reducing uncertainty (4%), and improved asset utilization of their logistics execution (5%).

Both dyadic and multi-tier collaboration initiatives presented in Section 2.5.4 and Section 2.5.5 have shown tangible benefits if executed correctly. Multi-tier collaboration exhibits greater complexity due to the number of partners involved. While many benefits have been achieved from collaboration initiatives, there have been many failures between individual firms like Spartan Stores, and industry wide collaboration efforts like DAMA and impediments to establishing successful collaboration efforts with supply chain partners.[49]

2.5.5.5 Summary

Multi-tier initiatives found in literature are limited, primarily software focused and mostly in development or pilot mode. The initiatives generally do not allow identifying trade-offs among multiple supply chain participants in the coordination process.

Firms often realize that establishing either type of collaborative partnership can be difficult, especially if based on a long time history of adversarial relations. These impediments to coordinate through collaboration are discussed in the next section.

[48] This type of multi-company collaboration spans vertically and horizontally across multiple supply chains and is not limited to collaboration between members of the same supply chain.

[49] DAMA stands for Demand Activated Manufacturing Architecture, and is discussed in Section 2.6.1 on page 49.

2.6 Impediments to Collaboration

The majority of the literature reviewed focused on the characteristics of successful collaborative relationships without providing a good insight to how relationships are developed, maintained, and properly executed over the long run in addition to the specific pitfalls that companies face. Firms often realize that actually establishing partnerships can be very difficult, especially if based on a long time history of adversarial relations.

Impediments of collaboration were classified into two general categories: separate economic entities and operational barriers.

2.6.1 Separate Economic Entities

Since companies in a supply chain are separately owned economic entities, there are limitations to the processes and initiatives available to coordinate across supply chain members.[50] Given this ownership structure, the vast majority of managers' perspectives are limited to maximizing company profitability and efficiency gains.

Fine [67] points out that there is an inherent tension over which party will perform what value added activities in the supply chain. This causes some members in the chain trying to perform some functions currently done by another business partner, which results in each company trying to take away some business from each other. Fine uses Procter & Gamble and Wal-Mart as an example of two mutually dependent supply chain partners that struggle for their part of the value chain to be the one that adds the most value, and receive the most profits accordingly.

Most inter-company coordination takes place by virtue of imposing collaboration procedures and of coercion by the controlling party – this topic is covered in depth in Section 3.3.1. Bowman [68] illustrates that consumer-facing companies – like major original equipment manufacturers (OEMs) or retailers – are often the business partners that drive the chain and determine the terms of collaboration. In order to form a truly collaborative relationship these channel-masters would have to cede some of their control to other parties.[51]

Often members of collaborative initiatives remain reluctant to share sensitive business information with partners. This lack of trust is often the single biggest barrier to collaborative relationships. Further, the effects of instability in supply chains due to the bullwhip effect discussed in Section 2.5 magnify the lack of trust as discussed by Sterman [69]. With high order variability, downstream firms find their suppliers to be unreliable. On the other hand, suppliers find their customers ordering patterns volatile

[50] There are some exceptions such as cooperatives in the food industry and partial ownership of supply chain partners like in a Japanese Keirestu. Refer to Section 6.2.1, on page 85 for more detail.
[51] The term 'channel master' is discussed in Section 3.3.1 on page 58.

and unpredictable. This can cause trust to rapidly break down despite collaborative initiatives in place.

Finally, there is evidence that companies also tend to resist industry wide collaboration initiatives in many instances as exemplified by Taylor and Terhune [70]. The example in point is the Demand Activated Manufacturing Architecture (DAMA) collaboration initiative in the apparel industry funded in part by the US government in 1996. This industry wide effort attempted to facilitate collaboration among US apparel manufacturers to become more competitive with lower-cost manufacturers in Asia. The effort failed in the prototype phase four years after introduction due to the lack of trust among companies as well as the interest of companies in gaining an edge rather than level operating conditions.

2.6.2 Operational Barriers

Companies and managers willing to look past their self interests still find themselves facing difficulties in implementing collaboration efforts. As shown by Byrnes and Shapiro [71], in a case study of operating ties of the Xerox Company and its major customers, implementing a new standing order system for coordinated replenishment actions required organizational changes in over half the company.

The initiative was successful, however, a large number of changes overcome included: assigning new roles to regional operations managers, reconfiguration of regional warehouses, procurement and the creation of long-range purchase agreements, and the change of manufacturing schedules to draw efficiencies from the new, more stable demand pattern. Such changes are time consuming to implement in large companies and require a great deal of internal coordination and commitment within a company.

In many cases, companies have several suppliers and customers for which collaborative initiatives are maintained. For example, P&G maintains collaborative initiatives with all its major customers, which include mass retailers like Wal-Mart, Kmart, Target and Ahold N.V.

Collaboration like CPFR in this arrangement becomes time consuming and expensive to maintain. The time it takes to establish such relationships often exceeds the time employees stay with a firm, making it difficult to achieve continuity in the management of a relationship as discussed by Mentzer et al. [72]. This time constraint and narrow focus of managers on their own functional areas often creates inability to see how collaboration with others – both inside and outside the company – can improve operational performance.

At a February 2001 MIT ISCM conference attended by industry participants, consensus view was that collaboration efforts often create vast amounts of data that are troublesome to handle. In some instances, the data is at the wrong level of aggregation or format due to different systems software of supply chain partners.

The increased opportunity of collecting information through web enabled technologies causes information overloads that are difficult to deal with which creates due to the problem of copious amounts of data that cannot be managed in a time efficient manner. In addition, there exist multiple security and compatibility issues since there are many isolated solutions and no single data format standard.

Overcoming these barriers to inter-firm coordination will depend in large part on the adoption rate and successful implementation of common language standards like XML, and the facilitation of maintaining multiple collaborative relationships in automated web-based environments.[52]

2.7 Summary

Information integration and collaboration are two coordination dimensions for establishing the electronic connectivity and win/win based relationships from which to conduct simultaneous coordination of information, material, and financial flows across multiple business partners. The benefits and impediments of these initiatives were illustrated by examples in industry.

From the literature review in this chapter, it has been illustrated that current collaborative initiatives are primarily based on information sharing with some successful efforts in collaboration between two partners in adjacent tiers of a supply chain. Most initiatives are based on implementing software packages that enable better visibility, establish communications standards, and automate the process of exchanging information among companies. While sharing and coordination of information flows yields observable benefits, these were generally lower than measurable benefits found in collaborative initiatives that included the coordination of both information and logistics processes.

No clear evidence of successful multi-tier coordination efforts geared to coordinating information, material, and financial flow across multiple partners simultaneously were identified in the literature review.

The next chapter, Chapter 3, presents a preliminary analysis of the economic theory of how firms coordinate activities in the context of supply chains and explores the creation, evidence, and properties of the supply network principle in addition to research on the supply network and competition thereof.

[52] An example of such a system is i2's Tradematrix, which is designed to facilitate multiple collaboration initiatives among several partners in a web-based environment.

Chapter 3 Governance and Control in Supply Chains

3.1 Introduction

Chapter 2 illustrated two dimensions of coordination based on information integration and workflow coordination, and synchronization through collaboration with supply chain partners in linear supply chains.

The objective of this chapter, Chapter 3, is to examine the traditional mechanisms that affect the third dimension of coordination by examining the effect of governance structures on coordination in the supply chain from an economic standpoint.

For this, the efficient boundary of the firm, governance structures, and control distribution in supply chains is discussed to understand: (1) transaction costs analysis and how it determines firm size, (2) how governance structures coordinate the supply chain, and (3) the distribution of control observed in open market based supply chains and its impact on coordination.

3.2 Governance Structures

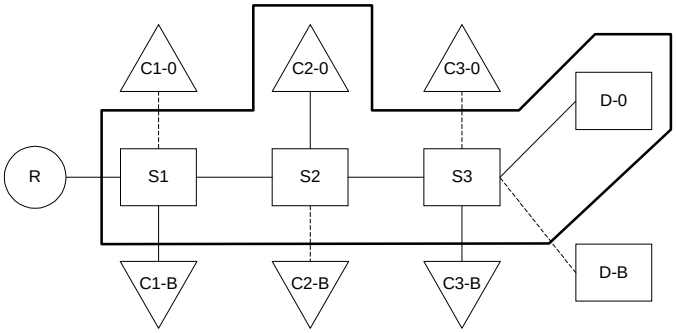
3.2.1 The Efficient Boundary of the Firm

Grossman and Hart [73] define the firm as consisting of those assets it owns or over which it has control. No distinction between ownership and control is made and ownership is defined as the power to exercise control. The power to exercise control makes it more likely for the firm to be able to coordinate activities.

In the context of supply chain dependencies, if a firm could improve the coordination of supply chain related activities by vertically integrating and gaining the associated control, what are the reasons for not buying all suppliers and operating as one entity? Analysis by Williamson [74] illustrates that there are increasing costs of coordinating organizations that are more complex, incentives are degraded upon transferring a transaction from

market to hierarchy, and bureaucratic costs are increased.[53] In most instances, vertical integration is not even feasible due to technological or financial constraints.

If the firm is viewed as a technological entity, then the natural and efficient boundary will be determined principally by technological economies of scale and scope as observed by Williamson [75]. The efficient boundary is then the inclusive set of core plus additional stages for which own supply can be shown to be the efficient choice as shown in Figure 3-1.[54] Williamson [76] further argues that the efficient boundary of the firm may not exclusively be determined by economies of scale and scope in technology but also by other organizational issues relaxing his initial theory to include soft factors.



Note: Refer to footnote for legend.
Source: Williamson, 1985.

Figure 3-1 Efficient Boundary of the Firm

Transactions costs analysis, initially developed by Coase [77], suggests that transactions will be organized in the firm when the costs of doing so are lower than the cost of using an open market. Coase [78] characterizes the firm as an incomplete contract with four transactions costs, two *ex ante* and two *ex post* of the contract date: (1) contingencies that are not foreseeable at the contracting date, (2) even if all contingencies can be identified it might be impossible to write them into a contract, (3) the cost of monitoring the contracts, and (4) the costs of enforcing contracts.

Williamson [79] illustrates three determinants of transaction costs: specificity of assets deployed, environmental uncertainty, and frequency. Asset Specificity is discussed in Section 3.2.2. Environmental uncertainty refers to variations in demand and uncertainties in the relationships with supply chain partners. Frequency refers to how often transactions occur. He consequently argues that firm size in the supply chain is based on

[53] Hierarchies and markets are discussed in Section 3.2.2 on page 55 and Section 3.2.3 on page 55 respectively.
[54] Legend: core production stages are rectangles S1, S2, S3. Raw materials represented by circle R. Component supply represented by triangles, C1-B, C2-B, C3-B if the firm buys components, C1-0, C2-0, C3-0 if the firm makes its own components. Distribution represented as squares, D-B if firm uses market distribution, and D-0 if the firm uses its own distribution. Solid lines between units represent actual transactions and dashed lines a potential transaction. The efficient boundary of the firm is the solid closed curve.

minimizing these transaction costs. This is achieved by two governance structures: *hierarchies* and *open markets*.

3.2.2 Hierarchy

Efficient flow of product and delivery at lowest cost requires that firms decide how to coordinate the supply chain vertically. Transactions costs analysis provides a foundation framework for examining supply chain governance: hierarchy – i.e. vertical integration – and open markets – i.e. market exchange. Hierarchy refers to the ownership of production inputs, meaning the degree ownership and subsequent control over the production capabilities.

The degree of vertical integration or hierarchy as governance choice in supply chains depends largely on asset specificity as illustrated by Overboom [80]. Asset specificity refers to the degree to which an asset can be redeployed to alternative uses and by alternative users without sacrifice of production value per Williamson [81]. There are four main types of asset specificity determined by Williamson [82]:

- *Site specificity*. Is observed when firms and plants are located in close proximity in order to minimize transportation and inventories. Since these assets are immobile, the setup/relocation costs are high.

- *Physical asset specificity*. Refers to plant, machinery, and technology that are specific to a transaction.

- *Human asset specificity*. When employees require substantial training and "learn by doing", the cost of autonomous contracting over an employment relation increases, making common ownership of successful stages more desirable.

- *Dedicated assets*. Involves making investments in dedicated assets on the behalf of a particular buyer.

Tirole [83], based on several empirical regression analysis studies, concludes that vertical integration and long-term contracts are more likely the more specific the investments are. Higher levels of asset specificity increase the need for hierarchical governance due to the limited number of suppliers willing to commit large capital investments for a trading partner.

3.2.3 Open Markets

In supply chains, coordination with suppliers and customers occurs primarily based on market forces. Governance through open markets refers to the process of buying production inputs or services in an open market rather than procuring them internally. Sourcing through open markets often results in competitive prices due to market

competition among suppliers. In addition, it allows spreading risk with suppliers, taking advantage of economies of scale and focusing on core competencies.

Undesired characteristics of market governance in supply chains are tied primarily to human behavior in this environment. Whipple et al. [84] illustrate that *bounded rationality* and *opportunism* often lead to less than optimal transactions.

Bounded rationality states that there is a limit to how much information humans can accurately process, which means that decisions are principally made with incomplete knowledge. This means that often not all suppliers can be realistically considered in a transaction. The second factor, opportunism, occurs when people act in their self-interest at the expanse of another. In a market environment, due to imperfect information and market like mechanism such behavior is common.

Malone [85] argues that new capabilities for transmitting information faster and less expensively can lower the coordination costs between firms. This leads to more market transactions –i.e. more outsourcing – but at the same time closer coordination across firm boundaries.

The two governance structures illustrated – hierarchies and open markets – are also reflected by two schools of thought in supply chain software design.[55] On the one hand are centrally managed constraint based optimization applications from i2 and Manugistics. These are based on a hierarchical design, where optimal parameters are enforced throughout the nodes that can be controlled in the company and supply chain.

On the other hand, are independently managed networks with distributed decision making there are applications that seek each participants own requirements such as software to procure materials and services as developed by Ariba and CommerceOne.

The appropriateness of each governance structure is a question of strategy, and it depends on several factors like product architecture, product strategic importance, market availability, and supply base capability as discussed by Fine [86].

3.2.4 The Make/Buy Decision

The hierarchy and open market governance structures discussed in the previous section give rise to the make/buy problem in supply chain management. In fact, supply chain management can be thought of as a series of outsourcing – i.e. make/buy – decisions.[56] Fine and Whitney [87] argue that make/buy is a core competency, and that outsourcing creates dependency on either capacity or knowledge or both. The ability to continually think through the make/buy decision illustrates that neither extreme of market based or hierarchical governance may be the best solution in the long-run.

[55] From personal interview with Lou Pelsuo at Surgency in February 2001.
[56] This concept is credited to James Masters at MIT.

Through advancements in information technology and outsourced manufacturers and service providers, companies do not necessarily have to own the assets to control the production of a product. This expands the make/buy problem to more than a binary decision, introducing hybrid governance structures based on long-term contracting. Anderson and Narus [88] argue that options for managing supply chain relationships are perhaps better seen as a continuum from market exchange to hybrid-integrative governance rather than a two-option characterization.

3.2.5 Hybrids

Between the two governance extremes of hierarchies and open markets lies an intermediate option, often referred to as hybrid integrative. Williamson [89] refers to this as "credible commitment". Such arrangements include contractual agreements that are reciprocal in nature, i.e. a supplier might guarantee certain product availability for a higher price or provide product for lower price in exchange for a long-term purchase commitment.

The "credible commitment" is fragile, but can be protected by the following methods suggested by Whipple et al. [90]: (1) establishing a detailed contract with punitive responses as well as flexibility of modifying the agreement once the environment changes, (2) per-qualifying suppliers, (3) requiring certain levels of technological sophistication, and (4) use of joint cost reduction programs to the share savings with suppliers.

Whipple et al. analysis' suggests that ECR relationships in the grocery industry are best managed by such a hybrid structure when conditions of high asset specificity and high information application exist.[57] Other forms of hybrid governance include strategic alliances, joint ventures, and cooperatives as observed by Boehlje [91] in the food sector.

When governance of the supply chain is by hierarchy there is no supply chain partner to coordinate with, since by definition, hierarchy means ownership. Therefore, coordination with supply chain partners occurs either through an open market or hybrid governance structures.

The key question is what inter-organizational entities and processes allow the adequate coordination in the supply chain, in view of multiple options possible the hybrid space.

3.3 Control in Supply Chains and Effect on Coordination

In a strictly economic approach, Grossman and Hart [92] argue that what a company does not own it does not control, however, it can still exert control based on its market size. In

[57] Information application refers to both the content – quantity and accuracy – and level of sophistication – e.g. real time – involved in the exchange process.

the context of supply chain management, ownership and control are not necessarily unified, i.e. there are numerous examples of companies that command a large volume of sales in a channel implicitly controlling terms of trade of other supply chain members despite not owning the assets.

In open markets, coordination is largely influenced by influential companies. Chandler [93] argues that many of the labor intensive, fragmented industries such as textiles, apparel, furniture, and some food processing supply chains are driven by the mass retailers who initiated to coordinate the flow of goods from suppliers to consumers.

The next section discusses distribution of control found in supply chains that operate through open markets and its effect on coordination. Section 3.3.1 discusses the current distribution of control in open market based supply chains and the benefits and shortcomings from centralized control in achieving optimal coordination of the supply chain. Section 3.3.2 presents di-polar control distribution in agriculture chains and its effect on coordination.

3.3.1 Single Pole Control

The Gartner Group [94] defines a channel master as the following:

> *"A channel master is an enterprise within a supply chain that has compelling control over the sales of a product."*

As a result, a channel master has influence over enterprises that depend on it for large part of their business within that supply chain, in addition to owning the brand awareness among consumers.[58] Being the most influential member in a supply chain, a channel master often dictates the technology platforms and business processes used between itself and its partners.

Cooke [95] argues that new supply chain communities – or networks – need an impetus to collaborate, which can only come from the channel master in the chain. These channel masters have the influence to force suppliers to participate in on-line supply chain communities and to establish these networks. Refer to Table 3-1 for a selected list of channel masters.

In addition, AMR Research [96] projects that channel masters that dominate through distribution or manufacturing excellence like Ingram Micro and Cisco Systems are likely to emerge in the future. Both companies have dominated in the past through creating innovative business models by electronically integrating with suppliers and customers.

[58] There are exceptions where components in a finished product are at least or more important as the final product itself, as can be the case of Intel processors in personal computers. In such cases, several channel masters might coexist in the same chain.

Taylor and Terhune [97] cite that based on their experience with *Fortune 500* companies, collaboration succeeds when driven and enforced by a small number of channel master enterprises. These channel masters wish to maintain or expand their competitive position while at the same time reducing "community" costs.

Table 3-1 Representative Channel Masters

Company	Supply Chain	Rationale
GM, Ford, Daimler Chrysler	Automotive Manufacturing	Top 3 automakers command 73.7% of annual vehicle sales
Coca Cola, Pepsi, Cadburry-Schweppes	Beverages and Soft Drinks	Top 3 manufactures account for 80.1% of soft drink market
Dell Computer	Computer Manufacturing	Commands the largest share of desktop PC sales in the US
Cisco Systems	Networking Gear Manufacturing	Leading manufacturer that owns the electronic infrastructure of the supply chain, and customer mind
Wal-Mart	Mass-Retail	Biggest customer account of most CPG companies, requires vendors to operate through RetailLink[59]

Source: Author.

The presence of a clearly defined channel master effectively centralizes control in the supply chain towards the channel master end, crating advantages and disadvantages associated with this.

Advantages of Centralized Control

This section presents examples of how centralization of control facilitates optimally coordinating certain supply chain operations.

Hewitt [98] argues that coordination can effectively be replaced by control. This entails having flow in the supply chain be delegated by fewer points in the system. As an example, when a channel master requires a supplier to operate a JIT II system, it centralizes control from a formerly four-step, four-people to a two-step, one-person process. The result is a more cost effective and coordinated process as seen at the Bose Corporation.[60]

Malone [99] illustrates that as communication costs fall, companies decentralizing decision-making must seek a balance between empowerment and control. However, Malone also argues that it becomes desirable to bring remote information together. With more information and a broader perspective, centralized decision makers can make better decisions than isolated ones, and for many kinds of decisions, companies can derive substantial benefits form centralization.

[59] RetailLink is based on Wal-Mart's privately technology – formerly EDI based – to share business sensitive information with its suppliers.

[60] There are several other considerations that need to be evaluated in a JIT II approach such as information security concerns, excessive dependency on partners and future growth rate of both companies involved.

A different attempt to coordinate information, material and financial flows centrally around one entity in the supply chain is proposed by Ulrich [100]. Ulrich argues that the adoption of a holistic governance structure – a legal entity owned by supply chain partners would allow members to access information of the whole supply chain. Initiatives enabled through this centralized model could include joint planning, raw material management, waste treatment, and conservation measures.

Disadvantages of Centralized Control

Disadvantages in a channel master centric supply chain coordination approach stem from creating one-sided coordination, which is often not optimal for adjacent suppliers. The equitable distribution of profits is not granted, often leading to worsening relationships or arms length interaction. Mis-trust towards the channel master and fear of exploitation often does not induce cooperative behavior among suppliers.

In many instances, distributed decision making can be advantageous as illustrated by Malone [101]. In his study of how IT affects centralization and decentralization in the organization, Malone concludes that as communication costs fall, there comes a point at which connected, *decentralized* decision makers are more effective. This comes from the premise that these decision makers can combine far ranging information with local knowledge, energy, and creativity.

3.3.2 Di-Polar Control

Several supply chains in the agriculture industry are characterized by a dual concentration of control, downstream at the customer end – i.e. a retailer – and all the way upstream at an influential supplier.

Even though most agriculture/fiber chains are characterized by relatively low value products, some food and fiber chains with high value specialty items can potentially be compared and categorized as high-tech chains since they exhibit similar performance goals – high speed to market, emphasis on low inventory level, and pull driven operation.[61] Examples include specialty food producers like high-end veal – Peter's Farms in the Netherlands –, extra strong wool fiber producers of Merino wool, and specialty food producers.

Some of these chains are information technology intensive due to the high value nature of the product and the importance of responsiveness in the chain. Champion and Fearne [102] illustrate that the distribution of power in agri-chains in many instances is becoming increasingly polarized in two places, i.e., at the retailer end which has the greatest level of knowledge about the customers needs, and at the plant/animal breeder who holds a high level of control over the quality and production process of the product.

[61] By creating strong brands, the consumer implicitly requires the retailer to carry certain manufacturers products.

Specific factors that create this di-polar control structure is the recognition by end-users of the quality of the product, as well as the ecological origin and ethical factors of the production process.

Coordination of the chain in such an environment is often complicated through commodity markets between upstream and downstream supply chain participants. In the past, this has deterred from vertical coordination in these chains as illustrated by Champion and Fearne [103].

3.4 Summary

This chapter reviewed economic theory relevant to supply chain coordination and illustrated how governance structures act as natural coordination mechanisms in supply chains. Based on open market force governance, single pole and di-polar control distributions were identified and the implications on coordination discussed.

The next chapter, Chapter 4, introduces the concept of supply chains as supply networks and presents research results from an add-on study conducted to explore the proposition in literature of supply chain versus supply chain competition.

Chapter 4 Supply Chains as Supply Networks

4.1 Introduction

This chapter presents the concept of supply chains as supply networks and how competition can take place in such an environment.

For this, factors driving the formation of tightly integrated supply networks are presented in Section 4.2. Properties of supply networks are presented in Sections 4.3, 4.4, 4.5, and 4.6. Research on the proposition of competition among supply networks is presented in Section 4.7. Finally, Section 4.8 summarizes the three dimensions of coordination used for the coordination model in this thesis.

4.2 Drivers

Historically companies have tried to increase supply chain responsiveness and address inadequacies in supply by backward integrating and gaining control of upstream suppliers by acquisition.[62] In the context of transactions cost analysis discussed in Section 3.2.1 there are clear limitations to vertical integration. Williamson [104] observes that vertical integration should be very selective and that more integration is not always better than less. A Gartner research note [105] suggests that advantages inherent in vertical integration are disappearing, as one enterprise alone cannot be sufficiently large, financially independent and organizationally capable in a market with technologically complex products.

Bowersox et al. [106] conclude that there is a trend towards vertical integration to become more responsive at present, but it is accomplished through 'virtual' integration. Bowersox et al. define virtual integration as becoming as responsive as owning all the assets in the chain without having to actually own all the pieces.

There are four fundamental drivers for creating a tightly integrated network of qualified suppliers for non-commodity products and services:[63]

[62] Ford Motors in an attempt to secure supply for its Model A went on a vertical integration spree in the 1940s in which the company ended up owning rubber plantations to secure raw materials for tires.

[63] Attributed to Edmund Schuster. It is assumed that for commodities, it would still be beneficial to maintain arm's length relationships to obtain the lowest possible price.

- *Quality* is often an important factor for companies to seek a closer relationship with a supplier or customer. As an example, Lockheed Martin certifies suppliers on multiple levels based on increasingly stringent quality measures. Lockheed benefits from better quality suppliers while preferred suppliers benefit from reduced inspections, preferred procurement status, and increased visibility to Lockheed units [107]

- *Price* is always a crucial decision factor for procuring materials and services. Exclusive agreements and long-term contracts can often lock-in lower prices than in an open market environment

- *Capacity* plays a role in capacity constraints industries. By having a deep relationship, better allocation of supply can often be obtained

- *New Product Development* drives closer integration and coordination with supply chain partners. As an example, Chrysler encourages and jointly develops new ideas and components for their vehicles with suppliers. An estimated $1.2 billion have been saved in cost cutting efforts – these cost savings from improved designs are shared with suppliers, creating higher value for all parties involved [108]

If these factors were equal for all suppliers, there would be little incentive to create long-term commitments and integrate with supply chain partners – every company would likely obtain the best deal through open market purchases. The current business environment suggests the opposite, all four factors varying considerably from one company to another, making it desirable to seek the highest qualified businesses and engage in longer-term relationships.

4.3 Supply Network or Chain?

A chain is only as strong as its weakest link. This is rather simplistic statement conveys a strong notion of why the supply chain of a product is often disrupted: operational inadequacies of one participant in the chain. The slowest transfer point determines the responsiveness of the entire chain as observed by Goldratt and Cox [109] and Hewitt [110]. This creates the need to consider a set of companies or supply network as opposed to a single company in making supply chain design decisions.

Rather than a *chain*, the term *network* is more accurate since a growing number information and material flows in supply chains are not linear and sequential anymore. In the case of information sharing, some OEMs route orders directly to contract manufacturers.[64] Likewise, many contract manufacturers ship products directly to

[64] Such as Cisco Systems and Ericsson.

customers. In some instances, products from other suppliers are merged by a third party logistics provider in transit to the customer.[65]

In literature several acronyms of supply networks like supply webs, value nets, value webs, intelligent trading networks, demand satisfaction communities, and collaborative business communities are used to connote special characteristics of such networks, with most meanings in accordance with the following definition adapted form Taylor and Terhune [111]:

> "*A supply network is a collection of mutually dependent and strategic supply chain partners that share proprietary information and make joint decisions in order to better coordinate and synchronize demand fulfillment to the customer.*"

4.4 Supply Network Properties

Murphy [112] argues that with the advent of the Internet old ways of operating supply chains – in a linear, sequential fashion – are no longer appropriate since due to the lack speed and responsiveness to customer pull signals. Rather, "intelligent-webs" that use high speed and real-time communications to link partners in a networked structure are evolving to satisfy consumer demand in a highly responsive manner.

Bovet and Martha [113] further elaborate on the characteristics of supply networks by noting that linear supply chains have arm's length, sequential relationships while value nets are collaborative and systemic.[66] Such value nets are pull-oriented systems, with the customer at its core.

Bovet and Martha present Miller SQA – a unit of furniture retailer Herman Miller that offers simple, quick and affordable furniture solutions – as a responsive supply network. Miller SQA is highly integrated with its supply chain partners, with information being transmitted to suppliers 4 times a day and just-in-time (JIT) delivery. Information flows between customer and suppliers of Miller SQA to achieve end-to-end integration and very short order-to-delivery cycle times. The visibility created is across the network is so extensive that the company only needs to hold as little as one or two days worth of inventory.

Kahl and Berquist [114] illustrate that the Internet is a robust platform that allows companies to transition from simply connected linear supply chains to becoming electronic business communities that are coordinated. In such an environment, the inter-connectivity is process oriented – rather than being transaction focused. Product introduction cycles are reduced, information is less prone to distortion, and better visibility in the supply chain allows more cost economical resolution of conflicts.

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[65] As observed in Dell's merge in transit operation where computers and monitors from separate suppliers are matched en route to the customer by UPS.

[66] Bovet and Martha [113] use the term value nets similar for what has been defined as the supply network in this thesis, even though not analogous.

Poirier and Bauer [115] argue that the most progressive stage of supply chain evolution is the one of full network connectivity, where all business functions across trading partners are interconnected. Finally, Cokins [116] argues that each trading partner in a supply chain has a stake in a high level of productivity and performance by all other participants in the chain. By working together in a collaborative way, trading partners eventually behave as a virtual extended enterprise.

4.5 Supply Network Trends

A report by Forrester Research projects that supply chains will be replaced by supply networks in the near future.[67] The report argues that by 2004 linear manufacturing value chains will be replaced by networks of manufacturing specialists that cooperate. The corresponding specialization allows firms to excel in core manufacturing and to participate in multiple networks as needed.

The majority of evidence of the supply network model is the evolution of virtual organizations, for which most examples center on Cisco Systems, and its electronically linked suppliers and customers. Other examples of virtual organizations mentioned frequently in literature are Ericsson and Dell due to their heavy outsourcing of manufacturing, logistics and customer service. The concept of virtual organizations is introduced in the next section.

4.6 Virtual Organizations

4.6.1 Definition

Current examples of tightly connected supply chains that can be characterized as supply networks are company centric virtual organizations. Jägers et al. [117] point to limited empirical evidence of this organizational model based on the lack of a concrete theoretical model and research is based primarily on qualitative examples. In most examples classified as being "virtual", the most influential member sits at the center of the network, and integration and collaboration efforts are built around them. IBM-Benchmarking Partners [118] provide the following definition for a virtual organization:

> *"In a virtual extended corporation, functions formerly handled within one company are shifted to multiple external trading partners, connected and coordinated to perform a process as if they were one company."*

Have et al. [119] suggest a similar definition:

[67] Source: "Global eCommerce Will Crush Today's Brittle Supply Chains, Predicts Forrester Research", Forester Research Press Release, September 11, 2000.

"The virtual organization is a dynamic alliance between organizations that bring in complimentary competencies and resources and that are collectively available to each other, with the objective of delivering a product or service to the market as a collective."

4.6.2 Driving Forces

The primary reasons for the emergence of virtual organizations based on research by Jansen et al. [120] illustrates that organizing processes in such network organization are driven by two factors:

- An increased need for flexibility, in addition to which the necessary core competencies can only be obtained by collaborating with external partners illustrated by Prahalad and Hamel [121]

- Efficiency gains by sharing resources with other partners, to enhance risk spreading and risk reduction

in addition to:

- The use of information technology is correlated with both decreases in firm size and vertical integration as illustrated by Brynjolfsson [122]

IBM-Benchmarking Partners [123] argue that the emergence of virtual extended corporations is most evident in the high tech sector with companies focusing more intensely on their core competencies. System manufacturers such as Dell and Cisco have transitioned the majority of their manufacturing to contract manufacturers that are increasingly responsible for order fulfillment. In the distribution space, Ingram Micro has dominated similarly by tight coupling with suppliers and customers.[68]

Further, Cookson, and Delattre [124] conclude that increasingly original equipment manufacturers are outsourcing product, sub-assembly, and component manufacturing to Tier 1 suppliers, therefore becoming virtual manufacturers. Such outsourcing allows OEMs to focus on product innovation, brand management, and customer management.

4.6.3 Characteristics

In the supply chain context, virtual organizations resemble a coordinated approach to managing information, material and financial flows among members. Jägers et al. [125] create a framework to identify the characteristics of virtual organizations based on the following observations:

[68] Source: "The Innovators will Control the Supply Chain", AMR Research, May 26, 2000.

- *Boundary Crossing and Complementary Core Competencies.* The increased need for flexibility, driven by mass-customization, can only be guaranteed by small and flexible organizations. Co-operation and collaboration needs to take place in the form of a network type of virtual organization that allows the pooling of core competencies and combination of working methods utilized by participating parties

- *Geographical Dispersion.* Falling communications costs result in lesser importance of the physical location of work[69]

- *Changing Participants.* At the front end the customer perceives that the business is being carried out by one single organization, whereas in reality the rendering of service occurs through a network of organizations, that periodically changes

- *Participant Equality.* Increased dependence in virtual organizations leads to greater equality in participant relations, and a culture based on the sharing of skills and information replaces the older control based culture. Often one organization will assign itself as the 'enterprise lead' and will function as a project leader

- *Electronic Communication.* Jägers et al. conclude that information and communication technologies (ICT) are the necessary prerequisite catalyst for a virtual organization. This agrees with the requirements found in the majority of literature sources reviewed. The possibilities of virtual organizations grow larger as a result of ICT

4.6.4 Obstacles

Obstacles in building virtual organizations are closely related to a supply network arrangement between trading partners. The following four impediments were identified as frequent impediments in establishing virtual organizations:

- The reduction in the ability to source through open markets or ability to pursue more profitable business propositions in the short run. When possible, companies prefer to have several suppliers for the same product in order to avoid a possible 'lock-in' by the supplier

- Higher levels of outsourcing increase the complexity of coordinating the supply network, as more information flows, activities and processes need to be managed

- The higher the number of activities outsourced for each manufacturing or supply chain function, the larger the number of organizations splitting the margin for the same activity

[69] However, other factors such as transportation and warehousing do vary significantly with location and have to be considered.

- The question of legal liability in virtual corporations has not been yet specifically addressed. This includes the ownership of inventory in the network and the extent of legal liability of each supply network participant

4.6.5 Evidence

The trend towards participation in virtual supply chain integration is expected to continue according to a study by Canhers In-Stat Group [126]. The report projects that by 2004, $823 billion will flow through virtual supply-chain integration networks in the United States, up from $43.4 million in 2000. Participation in these networks is projected to grow from 25,000 businesses today to approximately 280,000 by 2004.

Recent examples of companies attempting to become more 'virtual' organizations by shifting some traditional responsibilities to integrated supply chain partners include Ericsson's decision to outsource all it cell-phone manufacturing to Flextronics International in January of 2001. In a similar manner, Lucent Technologies is planning transfer ownership of several manufacturing plants to its main contract manufacturers like Solectron in 2001/02 in an effort to focus on research & development and sales.

4.7 Supply Chain vs. Supply Chain Competition

4.7.1 Overview

In view of evidence of virtual organizations, Christiaanse and Kumar [127] argue that tightly integrated supply networks will compete against other supply networks to satisfy highly volatile, global, customized demand patterns. Christiaanse and Kumar conclude that sequentially organized supply chains are no longer adequate in this type of environment. Based the development of modern information technologies such as the Internet, Intranets, Extranets, intelligent agents, electronic markets, web-based procurement, and broadband communications the traditional constraints on supply chains are disappearing.

Similar propositions have been made by a wide variety of researchers in academia, consulting, and industry arguing that the focus of competition in the future will shift from company versus company to supply chain versus supply chain – see Appendix A for selected propositions.

Despite extensive frequency of this proposition in literature, the majority of sources do not offer further insight as to how this statement should be interpreted or offer any current examples of this incidence.

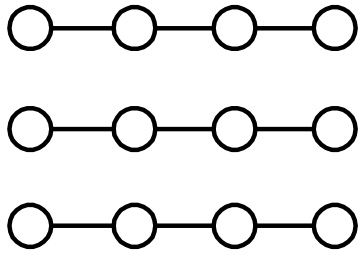
4.7.2 Supply Network Competition

To explore the interpretation and implications of these propositions, we first look at the literal meaning and proceed to refine the understanding built on questionnaire based research conducted as an add-on to the Delhi study.[70]

By definition, supply chains *do* compete against other supply chains to a certain extent since no company can successfully compete alone, it can only be successful as part of a broader supply chain.[71] As illustrated in Figure 4-1, for m-number of n-tier supply chains, in the case that all sets of m-chains were completely disjoint at each tier n in an industry, the statement would literally be true.

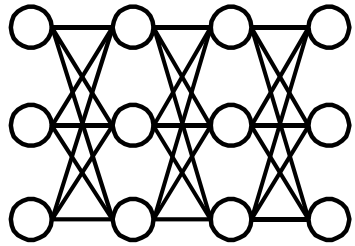
On the other hand, the proposition is false by definition when all companies compete in all different supply chains in an industry. This occurs if in every chain m, at every tier n a firm sold goods to every tier n+1 company as seen in Figure 4-2. This could be the case of modular and commodity products that can cost efficiently procured from multiple members in an open market.

The distribution of flows and relationships observed in industry is generally in between these two extremes as seen in Figure 4-3, with some disjoint and other overlapping chains. Many links are eliminated when considering actual examples since there are closer relationships with some partners, depending on the nature of the product, price, and capacity of the supply base.



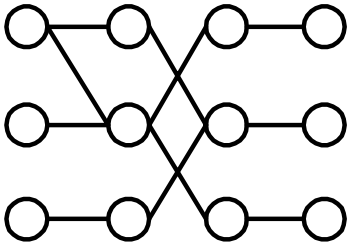
Note: M=3, N=4

Figure 4-1 Completely Disjoint Supply Networks



Note: M=3, N=4

Figure 4-2 Completely Overlapping Supply Networks



Note: M=3, N=4

Figure 4-3 Partially Overlapping Supply Networks

Examples of supply chains in each category are listed in Table 4-1. Note that examples that fall under 'true' are primarily vertically integrated, historically or geographically dispersed supply chains.

[70] This analysis uses concepts from a personal interview with Thomas Malone.

[71] Unless the company is completely vertically integrated, then the company is in fact the entire supply chain and it competes as such.

Table 4-1 Examples of Supply Network Based Competition

True	False	Limited Overlap
Vertically Integrated manufacturers like Perdue vs. Tyson Foods in the poultry production	Compaq vs. HP (modular product architecture and fragmented supplier base create significant overlap)	The Limited vs. branded apparel products from Levis sold through retailers
Automobile manufacturing supply chains of the US, Germany and Japan in 1970s	Airbus vs. Boeing (overlap in engines, electronics, avionics, tires, seats, and others)	PC vs. Mac supply chains in the 1980s (overlap limited mostly to memory and software)

Source: Author.

4.7.3 Research Findings

Candidates interviewed were asked whether they agree with the proposition that in the future competition will be among supply chains and, in the case of affirming the proposition, how this statement should be interpreted.[72] The distribution of responses categorized by respondent sector is illustrated in Figure 4-4.

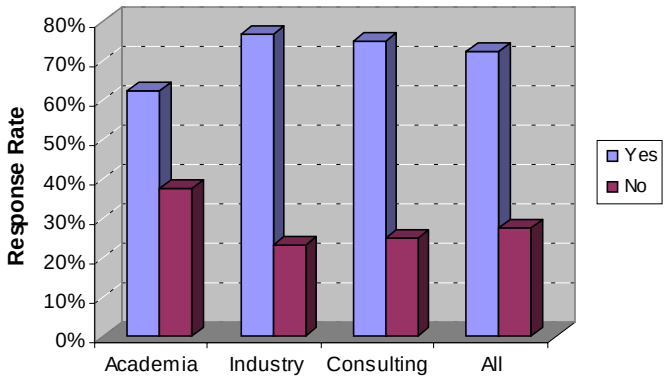


Figure 4-4 Respondents Affirming Supply Network Competition

As a group, respondents in academia and consulting were undecided whether supply network versus supply network is an evolving trend and responses were evenly distributed. Respondents in industry predominantly agreed with the proposition. Approximately 20% of all respondents affirming the proposition argued that supply chain based competition has occurred for several years already.

[72] The same candidates used for the Delphi study were asked to contribute to this research. The list of candidates can be found in Appendix C on page 135.

Respondents that affirmed the proposition had different interpretations of what this mode of competition means. The distribution of definitions used by respondents is illustrated in Figure 4-5. Supply Network competition was interpreted as one the following five interpretations by respondents:

- *Supply chain capability* referring to the responsiveness of the chain, having the right configuration of products available[73]
- *Supply chain design* based on the supply chain design used – built-to-stock, build-to-order – and choice of distribution channel – i.e. retailer, direct, distributor.
- *Channel master centric group* referring to a conglomeration of companies led by a channel master that determines the terms of trade among partners
- *Selected group of partners* consisting of companies that identify themselves to be strategic partners and compete against other groups of strategic partners
- *Informal group* refers to a set of partners that come together on a more informal basis to satisfy demand, includes horizontal – in some instances partial competitors – and vertical partners.

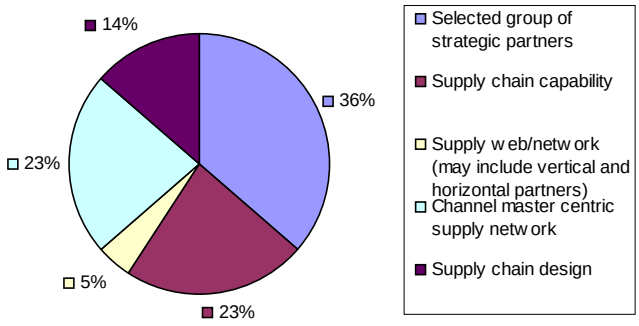


Figure 4-5 Interpretation of Supply Chain Competition

The wide distribution of responses shown in Figure 4-5 is surprising given the common use of the proposition in literature.

Finally, two respondents in academia suggest that supply chain versus supply chain competition occurs in two dimensions. One is 'inter' supply chain competition, which refers to two supply chains composed of different participants competing against each

[73] Supply chain responsiveness is sometimes measured by the total average length (measured in days) of the supply chain. This metric is derived from the average plan, source, build, and deliver cycle times.

other. The second dimension is 'intra' supply chain competition, where even though each participant in the network is interested in the collective survival of the network, it is also in individual survival and competitive advantage within the network. This intra- supply chain competition is also suggested by Fine [128] and Kumar and Christiaanse [129].

4.7.4 Evidence in Agri-Food Industry

Based on the literal definition, evidence of supply chain versus supply chain competition was found primarily in the agriculture industry. This industry has historically been very fragmented with low levels of coordination among members of the same supply chain.

This makes the industry a favorable environment to create supply chains that collaborate and synchronize operations with most parties having little to loose – as opposed to highly concentrated industries where the company with the largest control would see a lot of downside in giving away control. The limited supplier base and high volumes to downstream customers facilitate exclusive vertical arrangements. In addition, many suppliers are dedicated to one single customer, which enhances the value of sharing demand forecasts since the suppliers know that this volume is directly assigned to them.

This type structural realignment is documented by case studies in the "Chains of Success" initiative sponsored by the Agriculture, Fisheries, Forestry – Australia [130]. It includes examples of specialty food producers that use information technology and reciprocal visits with other partners in order to build aligned chains that are more responsive to customer requirements.

Further emphasis is on companies concentrating on building close relationships with all participants of their supply chain to gain a competitive advantage over fragmented competitors.[74] More recently, production is changing from an industry dominated by family based, small scale, relatively independent firms to larger alliances that are more tightly aligned across the production and distribution chain as concluded by Boehlje and Sonka [131].

4.7.5 Summary

The questionnaire based research presented in this section suggests that: (1) supply chain versus supply chain is not taken as a literal statement, it is a metaphor for the type of relationships in the channel, responsiveness of the supply chain and other factors that affect competition besides product characteristics, (2) the incongruence of responses makes it necessary to establish different categories of supply chain competition, and (3)

[74] Miandetta Pty Ltd (Australian specialty asparagus and pig meat producer), Wood Fisheries (fish trawling and export company), and Pacific Foods (supplier of primal and portion control meat cuts).

supply chain competition definition differs based on business models used in each industry.

4.8 Coordination in Supply Networks

4.8.1 The Layered Model Revisited

As illustrated in Chapter 2, the coordination framework to structure the discussion of this thesis was defined in three dimensions. These dimensions correspond to optimally coordinating information, materials and financial dependencies among supply network participants. They differ in time horizon, strategic level and risk/benefit extracted as presented in Table 4-1.

Table 4-2 Three Dimensions of Coordination

	Planning Level	Time Horizon	Risk/Reward
Information	Operational	Seconds-Hours	Low
Logistics	Tactical	Days-Months	Medium
Financial	Strategic	Months-Years	High

Source: Author.

Separating coordination of logistics activities into physical and information sub-structures makes it feasible to optimize each substructure independently as observed by Lewis and Talalayevsky [132]. Coordination entities in each separate dimension provide the benefit to respond and adopt new technologies and coordination approaches with a higher degree of independence if considered this way.

Decoupling information flows from the flow of physical goods allows better allocation and flexibility in deciding when and where information is most useful. In a JIT environment, this requires that information arrive before the physical goods, allowing inbound logistics managers to prepare for the next shipment as illustrated by Rayport and Sviokla [133].

One example of such separation is found in the airline industry, where information flows through electronic networks while passengers “flow” through a hub and spoke system. Another example is financial institutions that exchange credit card information via a centralized broker while the money – the material – is distributed through a different substructure.

4.8.2 Benefits from Coordination across Multiple-Tiers

The most important question is whether coordination across multiple tiers makes financial sense for the organizations involved. The following sections present the rationale and argument for such initiatives.

4.8.2.1 Identifying Opportunities

Increased information sharing and collaboration in the supply network facilitates identifying mutual opportunities by all participants involved. Through higher level of information sharing and closer day-to-day collaboration in logistics, participants obtain a better understanding of the supply chain partners' capabilities, limitations, and ability to work jointly to fulfill customer demand.

Cooper et al. [134] illustrate how changing traditional relationships where interaction between firms is limited to the buyer-seller to an approach where multiple functions in both organizations communicate yield new benefits to the organizations involved. The analogy presented is based on Sam Walton's bow-tie and diamond model used to change the historically adversarial relationship between P&G and Wal-Mart to one of a more cooperative nature. By allowing multiple business functions to interact across companies, several inefficiencies and new ways of operating were discovered in the process.

4.8.2.2 Reducing Short-Term Redundancies

Short-term redundancies in the supply network are primarily inventory used as safety stock, which is utilized to buffer against uncertainties in demand, supply, and lead times. This buffering is replicated at each tier in the supply chain, increasing in magnitude as one moves upstream.

With higher sharing of information and better visibility of point of sales data participants in the supply chain can reduce *demand* uncertainty. By tracking shipments en route, the uncertainty of *lead-time* is reduced. Finally, by having insight into the suppliers production schedule and inventory position, uncertainty in *supply* can be reduced. Examples presented such as VMI, and CPFR in Chapter 2 often successfully reduce these redundancies.

4.8.2.3 Reducing Long-Term Redundancies

Long-term redundancies include excess capacity in manufacturing, transportation and warehousing. Based on the bullwhip effect discussed in Section 2.5.3, upstream suppliers often carry excess capacity in manufacturing to be able to fulfill highly variable order patterns.

Such is the case of the Eastman Chemical Company's operations in South America, a manufacturer of polyethylene bottles used by beverage manufacturers. Despite a

moderate seasonal variation of 9% in the consumption of soft drinks, there is a 90% variation in polymer bottle orders. Eastman Chemical is required to carry excess manufacturing capacity in manufacturing to address order variability despite stable demand in soft drink sales.[75] A reduction of this variability by closer coordination of the forecasts and ordering procedures with the beverage manufacturer *and* distributors could result in a reduction of capacity requirements.

4.9 Summary

This chapter illustrated the supply network concept and evidence found in companies designated as being virtual organizations. Based on the supply network concept, research on the competition among supply networks by polling experts in the supply chain management field illustrates that it is inconclusive whether the focus of competition is shifting from company centric to supply network centric.

An overview of the three dimensions of coordination illustrates the usefulness of a layered approach to the supply network coordination problem. Benefits from identifying opportunities and the reduction of short and long-term redundancies in coordinating across multiple tiers are illustrated.

The next chapter, Chapter 5, presents the research methodology and the development of a meaningful questionnaire based on the premise of multi-tier coordination discussed up to this point in this thesis.

[75] Data from interview with James Hines, March 2001.

Chapter 5 Research Methodology

This chapter outlines the research methodology and process used to collect data. It is divided into five sections discussing: (1) research objective, (2) research methodology, (3) questionnaire design, (4) test subject selection criteria, and (5) data collection procedure.

5.1 Research Objective

The literature review in Chapter 2 presented selected coordination approaches and coordinating bodies relevant to this study. Chapter 3 illustrated how different forms of supply chain governance determine coordination in the supply chain. Chapter 4 presented the concept of supply networks and examples of how companies tightly integrate with supply chain partners.

The literature reviewed, however, did not specify what *specific* approaches, processes and entities are projected to coordinate across multiple tiers of a supply network. The majority of examples reviewed in Section 2.3, 2.5.4, and 2.5.5 illustrate narrowly focused and separate approaches to this problem, primarily dyadic in nature.

Such approaches do not readily facilitate identifying mutually advantageous opportunities or reduction of redundancies between multiple firms of the same supply network, due to the lack of facilitating mechanisms among the parties.

The objective of this research is to obtain a better vision of which coordinating approaches, processes, and entities are required for optimal coordination in supply networks in the near future.

5.2 Research Methodology

5.2.1 The Delphi Technique

This research was designed and conducted according to the Delphi technique – a method to combine the informed judgments from a panel of experts. It is relevant when no hard

data or well-established theory is available, but experts have relevant information about the research in focus. The Delphi method is a procedure for aggregating the information from a panel of experts, based on the premise that aggregation reduces the error of individual responses.

Since the Delphi technique is frequently used in forecasting number-based quantities that can be averaged, some additional validation of our non-quantitative responses is necessary.[76] In view of this, both the 'consensus' and 'breadth' of responses will be considered in order to maximize the likelihood of identifying likely approaches to the problem.

The Delphi technique is an old method, dating to the 1950s, developed by a team of researchers named Dalkey and Helmer. Dalkey [135] illustrates that in its simplest form, the method has three features summarized in Table 5-1.

Table 5-1 Characteristics of the Delphi Technique

Feature	Explanation	Rationale
Anonymity	Each respondent submits his own independent answer to the relevant questions in the interview	Anonymity restricts possible bias from group pressure or dominant individuals. Ensures every individual's answer in the group is taken into account in the final group judgment
Controlled feedback and iteration	The results of a given round of responses are summarized and reported to the group, who are then asked to reassess their replies in light of the feedback	Iteration with feedback allows interchange among the members of the group in a controlled manner
Formal group judgment	Given the final set of individual answers, the group answer is expressed as a formal aggregation; e.g., if the questions involve numerical answers, the group judgment may be formulated as the mean, median, or other measure of central tendency.	Formal aggregation gives a well-defined group response

Source: N.C.Dalkey, 1998.

5.2.2 Delphi Result Significance

Multiple experiments performed in the late 1960s and early 1970s demonstrated that the Delphi method has explicit advantages over traditional, interactive group processes when

[76] This entails testing the validity of answers based on current trends observed in industry as well as the logic and feasibility of such responses.

the best available information is the judgment of knowledgeable individuals in question as shown by Dalkey [136] and Ziglio and Adler [137].

In an extensive series of experiments at the RAND Corporation and the University of California at Los Angeles, the effectiveness of the procedure, as well as many variations, was tested, using graduate students as subjects and 'almanac-type' questions where the subjects did not know the answers, but had some relevant knowledge.

The experimenters could obtain the answers from reference sources. A typical question was 'How many telephones are there in Africa?'. A typical group size was 20 to 30 subjects, and typically, 20 questions would be involved in a given session. In general, the subjects were able to make reasonable 'estimates' of these uncertain questions to them.

The conclusions from the studies are summarized in Table 5-2. It is concluded that the property of aggregation tends to cancel out individual error of responses.

Table 5-2 Delphi Test Result Significance

Factor	Results
Size of group	Average error of the group responses substantially declines with the size of the group One half of the individual error was observed with groups of 7 members. An additional 20 members reduced the average group error by an additional 10%
Iteration with feedback	Substantial reduction in the dispersion of individual responses (convergence) with iteration.
Individual and group self-ratings	Some exercises required individuals to rate their confidence in their answer to each question on a scale of 1-5 where 5 meant 'I know the answer' and 1 meant ' I'm just guessing'. A group self-rating could then be computed for each question by taking the average of the individual ratings. Between a group self-rating of 1.2 and 4, average error dropped by a factor of 5.

Source: N.C. Dalkey, 1998.

.

5.3 Questionnaire Design

The first questionnaire in a Delphi study is usually composed of a few, open-ended questions related to the broad problem. The questionnaire in this study consists of seven non-predisposing, open-ended questions to stimulate forward thinking – refer to Appendix B for the questionnaire.[77]

[77] Questions 2,3,4 and 5 used for Delphi study.

In order for executives to obtain a better understanding of the data the research team was seeking, a preliminary PowerPoint presentation was sent to the respondents to allow a quick start in the interviews and to ensure the respondent was aware of the research objective. The need to get unbiased data cannot be understated. The research team aimed to minimize any predisposed answers based on the preliminary material sent out, however, some structure in the discussion was sought based on the three dimensions of coordination.

Question 1 tests the validity of the proposition of competing supply chains and was included as an 'add-on' to the Delphi study given the opportunity to interview candidates.

Questions 2,3,4 each ask for which entities could facilitate coordination in supply chain in each of the three dimensions developed in the thesis. Question 5 aims to explore how increased revenues, benefits, risks, and cost reductions from such coordination approaches could be distributed among supply chain members.

Additional questions, Questions 6,7, and 8, were used to test the perspective of companies in supply chains, control and compensation, and differences across industries when attempting to coordinate across multiple tiers.

The questionnaire was tested on three pilot individuals identified as having suitable experience. Improvements and feedback about the pilot questionnaire were incorporated into the instructions and final version of the questionnaire. After the pilot, there were fewer difficulties by members to clearly understand the questions and providing targeted answers.

5.4 Candidate Selection

The selection criteria and number of candidates to include in this Delphi study is important since it affects the accuracy of results.

Candidate Selection Criteria

The research team identified three fundamental characteristics and qualifications required for determining adequate test subjects: a history in supply chain management innovation, individuals who are viewed as "experts", and experts that are self-motivated – forward thinking. These factors are similar to candidate qualifications used in other studies like the Visionary Manufacturing Challenges for 2020 study by the Committee on Visionary Manufacturing Challenges and the National Research Council [138].

In order to reduce the bias from a group composed of candidates of similar backgrounds it was attempted to obtain equal numbers of candidates from consulting, academia and industry. This allows achieving a broad overview of current thinking without idiosyncratic bias inherent in each sector. The distinction also allows comparing and drawing conclusions form inherently different views amongst the sectors.

Number of Candidates

The majority of Delphi studies use a minimum of 15-20 respondents and run over periods of several weeks. The number of respondents is generally determined by (1) the number required to constitute a representative pooling of judgments and (2) the information summarizing capability of the research team. Consequently, very large numbers of respondents generate many items increasing the complexity of the summarizing process. This study involves 31 candidates, which allows enough breadth in responses but limits the number of respondents to a manageable number. Appendix C provides a list of the respondents in this study and their affiliation.

A research study by Debecq et al. [139] suggests using the minimally sufficient number of respondents – 7-10 – to minimize the dis-economies of achieving higher accuracies through a larger panel. However, research by Dalkey et al. [140] suggests that there is a definite increase in the reliability of group responses with increasing group size. As an example, reliability with a correlation coefficient approaching 0.9 was found with a group size of 13.

Distribution of Candidates

Figure 5-1 illustrates the distribution of respondents by segment, Figure 5-2 presents the distribution of respondents by geography, Figure 5-3 segments respondents by company size[78], and Figure 5-4 presents respondents by industry type.[79]

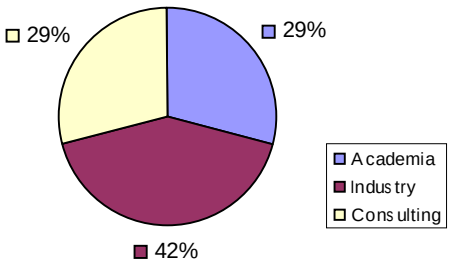


Figure 5-1 Respondents by Segment

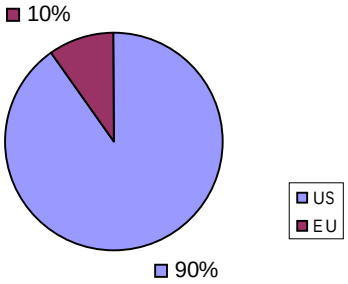


Figure 5-2 Respondents by Region

[78] For respondents in industry and consulting only.
[79] Excludes respondents from academia and consulting.

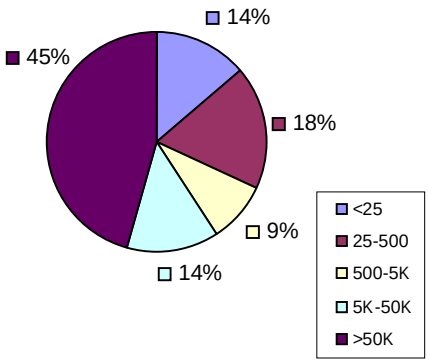


Figure 5-3 Respondents by Company Size[80]

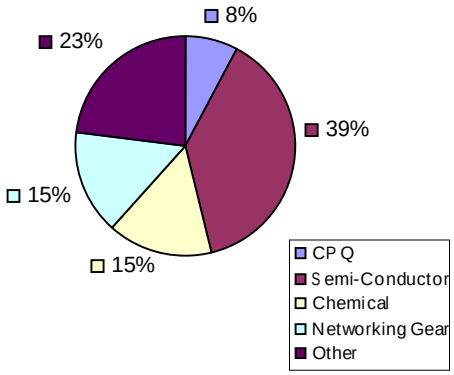


Figure 5-4 Respondents by Industry Type[81]

5.5 Data Collection

The interviews were scheduled and conducted over a period of three and a half months from January to April 2001. After distributing documents with the premise for the research study and the questionnaire, a 1-1½ hour interview was scheduled with each selected candidate. The response rate of interview requests was approximately 60% – an unusually high figure explained by the personalized method in to contact candidates.

When possible, interviews were conducted in person to get a better understanding of the issues involved. Approximately 30% of the interviews were conducted in person, while the other 70% was done through conference calls. When allowed, interviews were taped to transcribe the respondents' answers to obtain accurate quotes and interpretation of the answers and examples provided. Numbers were assigned to responses and input into a spreadsheet

Candidates were allowed to provide multiple answers – i.e. coordinating entities – for Questions 2,3 and 4. Question 5 is closely related to Question 4 and results were pooled. In order to obtain a broad range of responses in the coordination space, the *two* most elaborate answers for each candidate per question were considered in the data analysis.

Table 5-3 illustrates the percentage of candidates able to provide a second and third answer to Questions 2,3, and 4. Candidates were able to identify numerous examples and approaches for Question 2, but only a small fraction were able to provide a second and

[80] Company size based on the number of full-time employees. Reporting company size by revenue was not feasible due to the confidential nature of some figures.
[81] Excludes respondents from academia and consulting.

third answer for Question 3 and 4. Only one answer was allowed and evaluated for Questions 6,7, and 8 since these more targeted questions.

Table 5-3 Candidate Response Rate

	Candidates providing multiple examples		
	1st answer	2nd answer	3rd answer
Question 2	100%	77%	10%
Question 3	93%	33%	3%
Question 4	87%	40%	7%

Note: Two answers allowed for Questions 2,3,4. Only one answer allowed for Questions 1, 6,7,8 – therefore no analysis performed for these.

The distribution of answers was plotted and assessed as interviews were performed. It was observed that after approximately 18-20 interviews the relative distribution of responses to the questions did not vary significantly. This suggests diminishing impact of responses once this threshold is exceeded.

Delphi based rounds of interviews continue until a predetermined level of consensus is reached or no new information is gained. Altschuld [141] determines that in most instances, two iterations were enough to obtain a good estimate of the distribution and consensus view of candidates and often not enough new information was gained to warrant the cost of more rounds. Due to the time frame of this study, the scope of this thesis is limited to the initial, most elaborate, iteration.

Chapter 6 Data Analysis and Results

6.1 Introduction

This chapter intends to: (1) obtain a spectrum of coordination approaches and structures from the data, (2) categorize examples provided by respondents, (3) present illustrative examples based on the approaches identified, (4) determine trends based on the frequency respondents and consensus in the panel, and (5) assess the accuracy of responses obtained in the interview process.

Any quotes from respondents cited in this chapter are (1) representative of a larger sample, and (2) not attributed to specific candidates to maintain confidentiality of responses. [82] The term 'majority' is used to connote an answer rate of more than 66% to a given question.

6.2 Data Mapping and Categorization of Responses

In this Delphi round of interviews, candidates were asked on their vision on how to coordinate a supply network based on personal experience, knowledge of the subject in the field, and recent trends. The following section presents coordinating approaches identified in supply networks.

6.2.1 Coordinating Approaches

A *coordinating approach* is defined as an initiative or way to develop coordination in multiple tiers. It is based on the initiative of one or more members in a supply chain and describes the required relationships between organizations to engage in coordination.

A *coordinating structure* is an entity appointed to enable and facilitate coordination. There can be multiple structures – or entities – for a given approach to coordinate a supply network.

[82] A larger representative sample refers to at least three other respondents.

An illustrative list of the generic approaches to coordinate the supply network based on the respondents' answers to Questions 2, 3 and 4 is illustrated in Figure 6-1.[83] Seven different approaches were identified, with the structures that facilitate coordination shaded in black. The approaches are ordered based on governance structure – left to right – from pure open market coordination to governance by hierarchy, with intermediate hybrids in between.

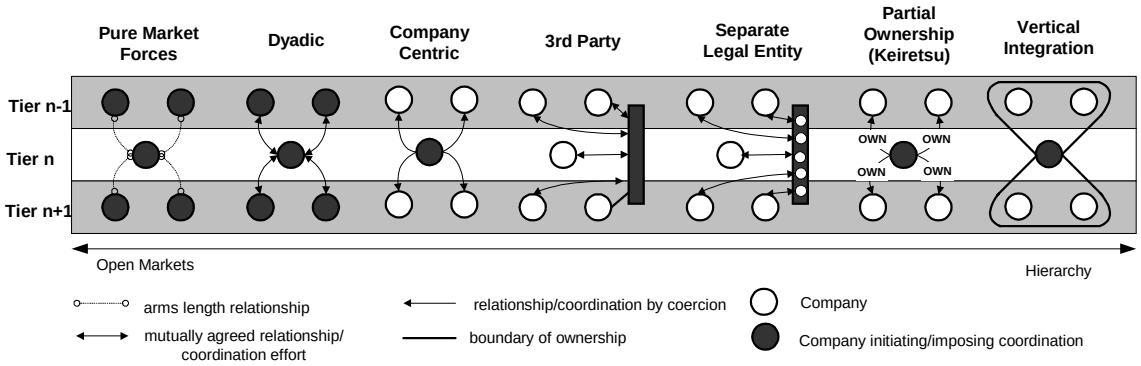


Figure 6-1 Approaches to Coordinate a Supply Network[84]

A description of each approach with corresponding examples is listed in Table 6-1.

Table 6-1 Description of Generic Coordinating Approaches

	Description	Example
Pure Market Force Driven	Participants in the same supply chain have arms length relationships based primarily on price. No significant information exchange or collaboration takes place other than buying and selling.	▪ International Paper ▪ US Steel
Dyadic	Focus on the immediate adjacent member of the supply network, i.e. dyadic approach. This approach does not require centralized coordination or ownership, which can be costly. Initiatives between two companies might spread through the rest of the network – P&G attempted to introduce ECR to its supply base after it had successfully implemented it with Wal-Mart.	▪ Xerox ▪ Wal-Mart
Single Company Centric	Channel master takes on the role of channel coordinator. It has direct contact to all supply network members to monitor operations and compliance. The channel master might run an optimization engine to determine the best configuration of the network, however, this	▪ Chrysler ▪ The Limited

[83] Figure 6-1 uses a generic supply network of two Tier 1 suppliers, one OEM, and two distributors/customers for illustrative purposes. The supply network could consist of more or less Tier 1 suppliers, Tier 2 suppliers or customers depending on the strategic importance of the relationship.
[84] From the OEM perspective in Tier n.

	results in channel master centric optimization. Some savings might be shared with supply network members.	
3rd Party Run	All supply network members interact with a neutral, non-biased third party, which potentially has a vested interest and compensation tied to the performance of the network as a whole.	▪ Tilion[85]
Separate Legal Entity	Supply network members form a separate legal entity with ownership distributed according to company size and value added in the channel. This legal entity facilitates shared investments and equitable distribution of benefits. Advantages come from centralization of control and the ability to jointly plan contingencies and long-term.	▪ Cooperatives[86] (horizontal) ▪ VISA (as an company analogy)
Partial Ownership	Channel master makes investments in supply network partners to increase competitiveness upstream and downstream in the supply network. A central manufacturer might control the channel through ownership interests.	▪ Toyota ▪ Mitsubishi ▪ IKEA[87]
Vertical Integration	When transaction costs for activities outside the firm are too high, the channel master might decide to backward or forward integrate to solve capacity, quality or market risk problems. By owning the entire channel, better coordination *might* be achieved.[88]	▪ Zara[89]

6.2.2 Spectrum of Coordinating Structures

This section presents the results from assigning respondents' answers to coordinating structures from Questions 2,3 and 4 to specific approaches in each of the three dimensions of coordination developed in the earlier part of the thesis. The categories are based on the six most frequent approaches mentioned by respondents.

Table 6-2 presents coordinating structures and selected representative examples for each dimension of coordination and coordination approach. Examples presented are based on the responses from candidates throughout the research interview process. The coordinating structures are sorted in ascending order of complexity and risk from top to bottom and left to right.

[85] Tilion is a privately held start-up company, refer to the Company Glossary on page 141 for more details.
[86] Cooperatives are found primarily in the agriculture sector.
[87] IKEA, the Swedish furniture retailer, acquires stock in its more than 2,300 suppliers in order to enforce quality standards.
[88] For very large organizations, even internal coordination can prove as difficult as external coordination.
[89] Zara is a Spanish clothing manufacturer with retail stores in the US. Refer to the Company Glossary on page 141 for more details.

Table 6-2 Spectrum of Responses – Coordinating Structures[90]

	Information Systems Coordination	Logistics and Operations Coordination	Governance/Financial Coordination
Single Company Centric	▪ Extranet based solution • Cisco e-Hub	▪ Company Assigned lead logistics provider (LLP) • Penske Worldwide Logistics (by Ford)	▪ Company driven incentive structures and risk allocation • Lucent Global Control Tower[91] • Monsanto (Risk Insurer)
Informal Arrangement	▪ Middleware connecting enterprise systems • Tier 1 and Tier 2 auto manufacturer suppliers	▪ Common strategy and goal at multiple tiers of supply network • Siemens Diesel Technology	▪ Collaboration initiatives between supply network members • Chrysler Supplier Program
Industry Consortium	▪ Industry standards consortium • RosettaNet • CPFR	n/a	n/a
3rd Party	▪ Public Exchange (independently owned) • Paper Exchange ▪ Private Exchange (SN owned or independent) or hosted applications provider • Baker Street Technologies • Tilion • Accenture • Company portals ▪ 3rd party logistics provider • UPS, FedEx	▪ 3rd party logistics provider • UPS, FedEX ▪ 4th party logistics provider[92] Schneider Logistics ▪ Hosted service • Nistevo • i2 freightmatrix • Tilion	▪ Consultant Facilitated • Accenture
Separate Legal Entity	▪ Public Exchange (owned by supply network partners) • Covisint • Exostar	▪ Third party logistics provider owned by supply network members ▪ Consultant Run • Accenture	▪ Inverted Holding Structure • Company analogy: VISA International ▪ Strategic Alliances ▪ Cooperatives
Vertical Integration	▪ Information systems are integrated and information flow coordinated by single owner	▪ Logistics operations are controlled and coordinated by the owner	▪ Financial distribution among business units is determined by the owner

Note: After categorizing respondents' answers, some spaces in the matrix do not have meaningful examples associated with them.

[90] No answers or examples were provided for sectors labeled with n/a.
[91] See Section 6.4.3.3 on page 112 for an illustrative example.
[92] Fourth Party Logistics (4PL) is a registered trademark of Accenture.

After categorizing respondents' answers, some missing elements in the above matrix remain; they are labeled with n/a. Respondents consistently exhibited highest interest in the third dimension of coordination – based on Question 4 and 5 –, but at the same time this was the most challenging question in the respondents' view. Only a limited number of examples were provided in this space.

Vertical integration is a feasible approach to coordinate supply chain operations, nevertheless, this option requires the consideration of various other factors and it is not obvious whether vertical integration allows better coordination. Vertical integration as a coordination approach is out of the scope of this thesis was not further explored.

The next section presents description, at a generic level of detail, of how these coordinating structures facilitate coordination among supply network participants.

6.2.3 Description of Coordinating Structures

6.2.3.1 Information Systems

Single Company Centric

In a company centric information systems solution, the most influential member of the supply network, often the channel master or company closest to the customer allows selected suppliers and customers to connect to the company's extranet or private exchange.[93] Participants have the advantage of using a pre-set application and standards but there is little or no input on the design of the system by these members of the supply network. This structure coordinates by suggesting or enforcing common systems use.

Informal Arrangement

In this arrangement, information technology managers from multiple companies of the supply network determine the technology platform and standards to be used based on a negotiation process. In order to achieve consensus, buy-in from a significant group of participants and consistent use of the technology proposed is required. Coordination occurs through adherence, data visibility, and structured data exchange among participants.

In many cases, information systems platforms are legacy systems that cannot be easily replaced. Disagreement and conflict of interests in technology often leads to separate middleware solutions to connect all supply network partners pertinent systems.

[93] A private exchange owned by a single company is interpreted to be the same as a company portal.

Industry Consortium

In this approach, companies decide to form an industry consortium to promote wide-ranging adoption of communication standards that benefit all participants in the industry. Getting industry consortia parties to agree can be a lengthy process in addition to long adoption times given limited first mover advantage.[94] An industry consortium coordinates by setting unambiguous communication standards, protocols, and processes that allow faster and more accurate processing of data.

Third Party

Third party coordinated information systems allow participating companies to use a neutral, independently developed and maintained solution to provide the standards and technology to store and process information among supply network members.

Such a third party approach can have multiple structures, one of them a hosted solution in which members of the supply network agree to use technology hosted on a third party's site. This allows minimal investment in infrastructure, outsourcing the operation and maintenance of the specific information system function. Other structures include electronic marketplaces and web-based collaboration spaces.

Separate Legal Entity

In this approach, supply network partners establish a separate legal entity, owned by the supply network partners, to provide the necessary standards, information technology infrastructure, and coordination of information flow. Such entity could be operated by a third party that represents the owner's interests and coordinates information flows and data formats among participants. This structure coordinates by facilitating the creation of consensus among owners, which is based on the equitable ownership of parties involved.

Vertical Integration

Vertical integration entails the ownership of information systems. In this manner, discrepancies of systems and standards among formerly separately owned businesses would be more readily eliminated. The new single owner is responsible and empowered to coordinate information flows across business units.

6.2.3.2 Logistics and Operations

Single Company Centric

In a single company centric coordination structure, the channel master or most influential organization appoints a lead logistics provider (LLP) that is empowered to manage the

[94] In a telephone network analogy, it is not useful to invest and own a telephone unless there is a large base of installed telephones.

logistics operations among supply network participants. The LLP is allowed to exercise control to operate at his optimal parameters, however, the control remains with the channel master that appoints him. The LLP potentially becomes the single party in charge of coordinating inbound and/or outbound materials flows among partners.

Informal Arrangement

This coordinating structure is comprised of logistics managers of various participating organizations in the supply network. It requires having round-table meetings on a frequent basis to determine how supply chain operation and design could be improved. Recommendations are taken back to their respective companies for approval by executives. This arrangement is relatively easy to install with limited resources, however, the implementation of suggestions is completely dependent on the interests of supply network participants and financial benefits created for the individual members.

Hosted Logistics Service

A hosted logistics service provider structure coordinates across multiple tiers by providing an information application solution that provides logistics managers with visibility of available capacity and binding constraints in the logistics network. The third party does not provide logistics execution capability such as a 3PL, but creates a structured process to coordinate logistics among participants. Such a service further facilitates the identification of potential conflicts, delays and other contingencies while allowing better use of transportation capacity and warehouse providers.

3rd Party Logistics Provider

In this approach, one or multiple third party logistics providers (3PL) take over all logistics operations including warehousing and transportation of the supply network members. The third party is able to coordinate all flows between members while consolidating volume. Logistics expertise and advanced logistics engines allow the third party to more efficiently manage the flows through the network on behalf of participants.

4th Party Logistics Provider

A fourth party logistics provider (4PL) has the expertise, data collection mechanisms and information systems to coordinate materials flows as well as long-term supply chain design. This structure is a supply chain integrator that manages the resources, capabilities, and technology of its own organization with those of complementary service providers such as 3PLs, IT service providers and client logistics capabilities.

Separate Legal Entity

A separate legal entity would be structured so that voting power is equitably shared among logistics departments in the network. Participation is by invitation and membership is based on performance and innovation of each partner. Membership can be

terminated voluntarily by a member or through expulsion by other members of the supply network.

Vertical Integration

Vertical integration would include the ownership of logistics systems and allow for eliminating inefficiencies in material flows among formerly separately owned businesses. The new single owner is empowered to coordinate material flows among business units.

6.2.3.3 Governance/Financial Allocation

Single Company Centric

In the case of organizations that command a large proportion of sales in a channel, there is implicit control and, to a large extent, allocation of benefits among members of the supply network. In this structure, coordination occurs primarily through market forces that require supply network members to accept or comply with the channel masters coordination initiatives.

Informal Arrangement

A common strategy and goal may be set for multiple members of the supply network. Financial incentives are granted to suppliers that are actively involved in the design process, and savings are equitably shared. These agreed mechanisms allow the efficient exchange of ideas and facilitate the introduction of coordinating efforts among supply members.

External Consultant Facilitated

In this approach, a jointly hired independent consulting firm would be appointed to identify deficiencies in the network and recommend improvement opportunities, along with equitable cost and benefit allocation to each party from the new operation method. The consulting firm would be compensated based on the performance and cost savings of the supply network.

Separate Legal Entity

A possible coordinating entity of a separate legal entity is an inverted holding structure – a member owned organization where power and benefits are equitably distributed.[95] The entity consists of multiple – tiered – councils or boards for which members vote for representatives based on each participants contribution. All decisions that can be made locally are done at the lowest board level possible, as long as those decisions don't affect

[95] Equitably refers to sharing in proportion to the value added or size of company. It does not mean that benefits will be split 50-50.

the higher board, in which case the decision is reverted to the higher council.[96] Other separate legal entities could are based on the formation of a strategic alliance or a cooperative structure.

6.3 Distribution of Responses

To examine the trends and consensus in the panel of experts, examples of coordinating structures were grouped into five categories for each question.[97] These five categories of coordinating structures are closely related to the classification in Section 6.2.2, and are intentionally broad since the range of responses exceeds five categories, but it is necessary to aggregate responses to obtain meaningful information. It also allows every response to be included in the evaluation as dictated by the methodology.

The term 'consensus' is used to connote the *majority* of responses, rather than 'agreement' among *all* respondents. A majority is defined to occur when the response rate in one category is higher than 66% or more than twice the second highest response rate.

A fraction of responses could not be categorized into one of the five categories for each dimension of coordination due to lack of clarity – these responses were dropped.[98] Representative quotes of respondents are used to illustrate statements that are representative of a larger group of respondents. No respondent is quoted more than once to avoid bias in the discussion.

6.3.1 Information Systems Coordination

All Respondents

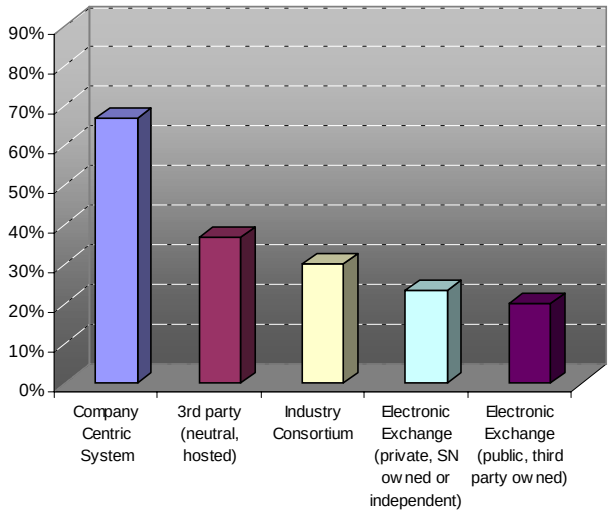
Figure 6-2 presents a frequency chart to determine the distribution of answers to Question 2, pertaining to which entities could coordinate information exchange and systems of a supply network. Answers from all three respondents groups are included.

The five coordinating structure categories are defined as follows:

(1) *Company Centric System* refers to a channel master centric extranet or electronic portal
(2) *3rd Party* refers to a third party that is neutral and independently owned, providing data communications standards and hosting of data and applications
(3) I*ndustry Consortium* refers to an industry communications standards setting body

[96] Refer to Section 6.4.3.2 on page 110 for an illustrative example of an inverted holding structure.
[97] Questions 2, 3 and 4. Question 5 is closely related to Question 4 and responses of candidates for Question 5 are included in Question 4.
[98] This applies to no more than 7 out of 64 possible responses for Question 2,3 and 4.

(4) *Electronic Exchange (public, third party owned)* refers to a electronic exchange that is independently owned and is open to firms outside the network
(5) *Electronic Exchange (private, SN owned or independently)* refers to an environment owned by several supply network partners or an independent party in which only supply network partners are eligible to participate



Note: Multiple responses allowed, totals do not add to 100%

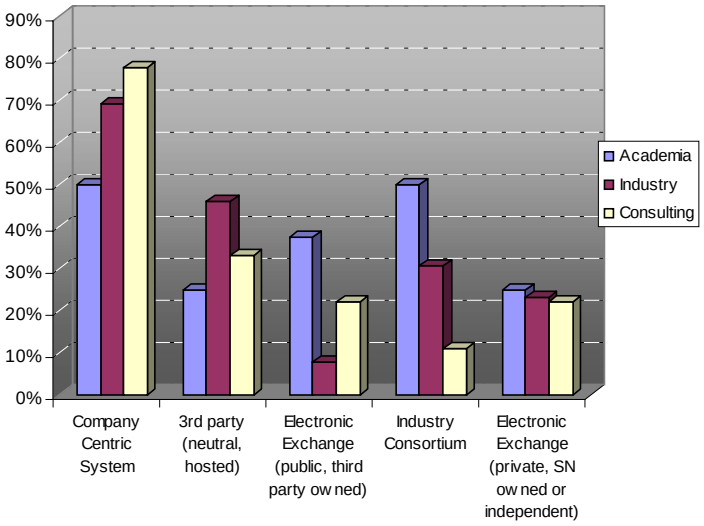
Figure 6-2 Information Coordination – All Respondents

The overall distribution of respondents' answers suggests that a company centric extranet or portal is the most likely coordinating structure for information systems and managing of information flow. Candidates suggest the use of an independent 3rd party to manage and coordinate information flows among participants as the second most likely structure.

The majority of respondents answered that coordination would most likely occur through a variety of simultaneous approaches given the complexity of product lines and operations of large organizations in addition to investments in information systems done in the past.

Respondents by Segment

Responses were further segmented based on the candidates' background to identify trends in academia, industry, and consulting. Figure 6-3 shows coordination structures among candidate segments.



Note: Multiple responses allowed, totals do not add to 100%

Figure 6-3 Information Coordination – By Segment

Responses from candidates in academia were evenly distributed compared to responses in industry and consulting. These responses are not as skewed towards a company centric structure as in the case of industry and consulting respondents. One academic explains the inherent difficulties from using the single company centric system, and therefore an increased likelihood of other structures:

> *"…if everybody [channel master] has their own system, the upstream suppliers can't manage this wide variety of technology."*

Industry experts foresee mainly a company centric or 3rd party approach to information systems coordination. One industry executive explains the inherent advantages of a third party structure:

> *"Most companies unfortunately don't have the core competence of a Cisco, so they will go to a third party for coordinating information flows and connectivity."*

The distribution of responses form consulting experts is similar to industry respondents, with higher emphasis on company centric extranet or portal structures. One well-respected consultant explains that based on 20 years of experience he has given up the hope that coordination can be initiated by multiple participants in the supply network. He explains:

> *"You simply can't get things done without the channel master. The nucleus firm [channel master] has to set this [the information system standards and information sharing procedure] because only brute force can help"*

The second most frequent answer by respondents in consulting was the use of a third party to manage information. However, one consultant points out the difficulties with such an arrangement:

> *"The problem [with a central repository of data] is that the data has to be transformed into something meaningful. In the case of suppliers in multiple tiers, one would need the bill of materials (BOM) at each tier to figure out demand information for different components. This is a very complicated process, it might work across your supplier and a 2nd tier supplier at most, after that is becomes prohibitively expensive. And nobody has the full BOM across multiple tiers"*

In conclusion, experts in all segments agreed that the creation and use of standards provides the basis for information coordination. Academics had different ideas on how to achieve this and, in overall, provided a broader range of alternatives. Among industry and consulting experts, it is projected that a single company centric structure would be most likely to provide coordination of the information systems in the supply network since it avoids delays inherent in industry consortia and creates a potential advantage for the companies involved.

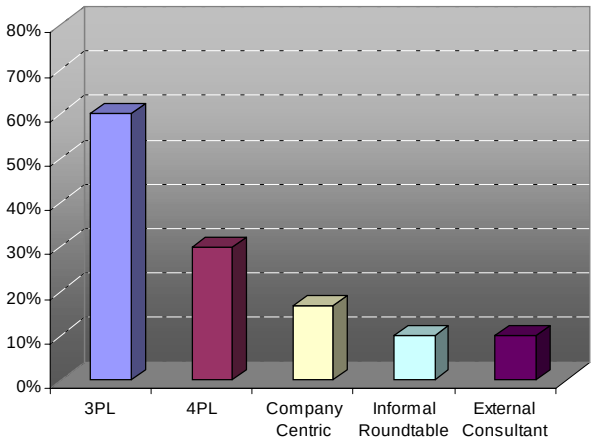
6.3.2 Logistics and Operations Coordination

All Respondents

Figure 6-4 illustrates the distribution of all respondents to Question 3, i.e. what entities could coordinate logistics and operations coordination in a supply network.

The five principal categories of logistics and operations coordination structures are defined as follows:

(1) *Third Party Logistics Provider* refers to an independently owned logistics operator that has the technology and capability to manage the transportation and warehousing operations for supply network participants
(2) *Fourth Party Logistics Provider* refers to an independently owned entity that provides technology and logistics expertise to manage a set of 3PLs and company logistics capabilities
(3) *Company Centric Appointed LLP* refers to the appointment of a lead logistics provider by a company in the supply network
(4) *Informal Arrangement* refers to agreements of supply network participants to operate based on mutually pre-determined principles and roundtable meetings to review network performance
(5) *External Consultant* refers to the empowerment of an independent expert to manage operations on behalf of the supply network partners



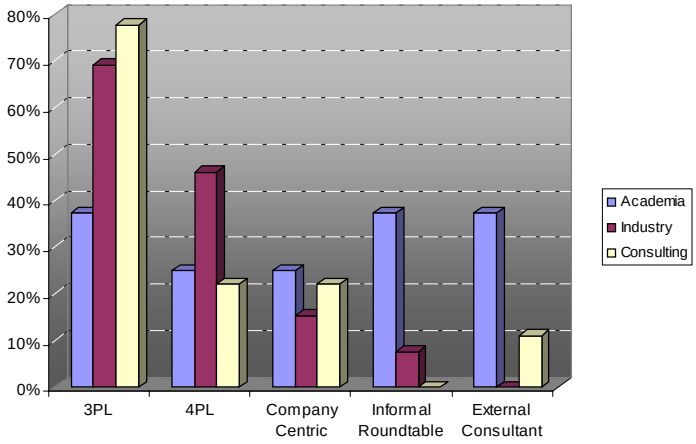
Note: Multiple responses allowed, totals do not add to 100%

Figure 6-4 Logistics and Operations Coordination – All Respondents

The distribution of responses strongly suggests the outsourcing of the logistics function to third parties whose core competence is the efficient management of material flows and leverages high volumes and economies of scale in logistics. The coordinating structures most often mentioned are 3PLs and 4PLs. Informal roundtables and external consultant based coordination structures were mentioned infrequently by experts in industry and consulting.

Respondents by Segment

Figure 6-5 shows respondents' answers segmented by candidate background.



Note: Multiple responses allowed, totals do not add to 100%

Figure 6-5 Logistics and Operations Coordination – By Segment

Responses from candidates in academia were equally distributed among the five categories while respondents form industry were highly skewed towards the use of a 3PL. Among respondents in consulting, the skew towards using a 3PL as the coordinating structure for logistics decisions is even more pronounced.

In academia, respondents predominantly foresee logistics coordination through informal roundtables and external consultants. The rationale for the informal roundtable structure is illustrated by the following response:

> *"Within a supply chain most all activities revolve around price. If its [supply chain or channel master] price driven, all other logistics processes are subordinated. In order to better coordinate it is necessary to move away form a channel master centric system to a more collaborative focus [informal roundtable approach]"*

Another academic elaborates on the informal coordination structure:

> *"[The logistics processes] would be coordinated by a coordinating body like a committee or council that meets on predetermined [frequent] time intervals to review the performance of the network, and decide how much safety stock to hold..."*

Industry experts foresee a 3PL-based structure, where one single 3PL manages material flows among all supply network participants. The advantages of this structure are illustrated by an industry respondent:

> *"The days of doing this [logistics functions and planning] internally are long over. These processes will be managed in a collaborative way in a much larger scale [by the 3PL]. The issue is that everybody [supply chain participants] is doing their own optimization internally instead of putting up their needs, demand requirements on a larger host, and allow the host to do the matching of supply and demand. A comparison of benefits of doing it externally versus internally is a 20% pick up in cost efficiency"*

Answers from respondents in consulting are highly skewed towards the use of 3PLs, with little answers in any of the other categories. One consultant explains that the technology to use a 3PL is essentially mature, however, only few options exist when choosing full service 3PLs to operate the network:

> *"The basic ability to do this [use a third party] form a technology and warehousing perspective all exists, it's really whether someone is willing to give up substantial control over the planning, forecasting, and fulfillment operation. Companies will do this in manufacturing environment because there are lot of option like Solectron, Celestica, Flextronics, but there are really few in the fulfillment sector."*

Even though a set of supply network partners might limit themselves to use a single 3PL one consultant points out that such 3PLs would not be exclusive to one set of supply chain partners:

> *"They [UPS, FedEx] certainly have to be strategic partners, and should be involved in the data collection process. But for transportation and warehousing to be efficient,*

volumes of different supply chains have to be combined. This way, a UPS would always need to be part of several supply chains, it is not going to limit itself to participating in one single supply chain."

The second most frequent answer by respondents in consulting is a channel master approach of coordinating logistics, rather than a third party logistics provider based on the following rationale:

"It [logistics processes coordinator] can only be the person that knows the customer, and knows the intricacies of demand. The OEM could take on the lead on this, they understand the effects of different products on different players. By and large, it will be an OEM hosted system, and not the Schneider's and the UPS's. The manufacturing piece is at least as important as the logistics piece [in determining logistics coordination]."

In summary, respondents of all sectors foresee 3PLs and 4PLs as the significant coordinating entities in the logistics and operations. This stands in close agreement with general outsourcing trends of the logistics function observed in industries where logistics costs are a small fraction of total product cost.

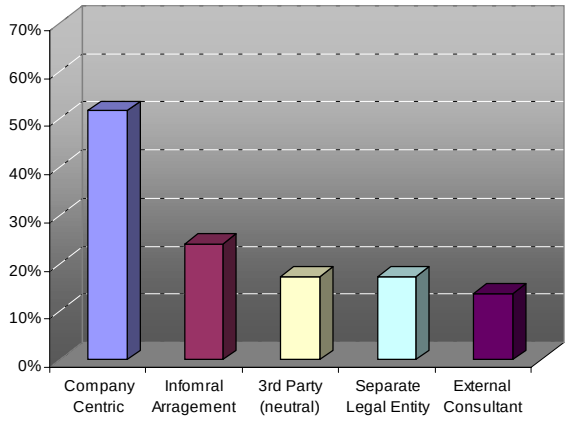
6.3.3 Governance/Financial Allocation Coordination

All Respondents

Figure 6-6 illustrates the distribution of all candidates' responses to Question 4 and 5, which explore the entities that could coordinate the allocation and distribution of costs, benefits, and risks in a supply network.

The five coordination structures to manage financial allocation categories are defined as follows:

(1) *Company Centric* refers to a channel master determining the terms of trade and benefit allocation
(2) *Informal Arrangement* in the case of periodic reviews of benefits allocation and negotiation by supply network members
(3) *3rd Party* refers to a neutral entity that assumes the role of collecting performance data of the participants and suggest or enforce trade-offs that benefit the network as a whole
(4) *Separate Legal Entity* refers to the formation of a separate coordinating body owned by supply network participants
(5) *External Consultant* refers to the appointment of an independent expert to suggest financial trade-offs to optimally coordinate across supply network partners



Note: Multiple responses allowed, totals do not add to 100%

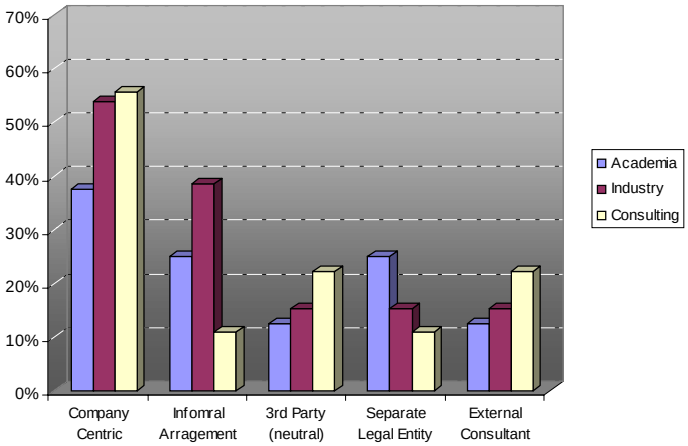
Figure 6-6 Governance/Financial Coordination – All Respondents

The overall distribution suggests that a company centric structure by an influential supply network participant would identify redundant processes and improvement opportunities and allocate resulting benefits based on each supply network participants costs incurred. This structure can attempt to maximize its own profits or share some savings form better coordination with partners. The second most frequent structure to coordinate is through an informal arrangement structure among organizations.

The majority of respondents suggested that this type of 'intricate' cooperation would make companies uneasy to a degree and the amount of information shared to make such improvements could potentially be restricted by government trade commissions.

Respondents by Segment

Figure 6-7 shows respondents answers segmented by candidate background.



Note: Multiple responses allowed, totals do not add to 100%

Figure 6-7 Governance/Financial Coordination – By Segment

Similar to the previous questions, Question 2 and 3, responses of candidates in academia were more evenly distributed among the five categories than the other two respondents' segments. Answers from industry participants were skewed towards company centric and informal arrangements to coordinate the distribution of financial benefits in the supply network. Responses from candidates in consulting were highly skewed towards a company centric approach.

In academia, one respondent points that the company centric structure is based on a simple principle of how business is done:

> *"In a private form the central entity selects whom it pays and how much, and suppliers would join depending if they want to compete in that channel."*

The rationale for using a separate entity is explained by the following respondent in academia:

> *"On the one hand market forces shape supply chains and optimal coordination is determined with the channel master in charge. On the other hand, supply chain partners could try to act as one and do better than the market forces. Acting as one company requires a new legal entity that would enable companies to give up some freedom for a better financial deal."*

Yet another respondent in academia points an observation made by a number of candidates, which is that highest benefit from coordinating with partners in multiple tiers would be achieved from reducing the magnitude of the bullwhip effect in the network:

> *"Getting the gross fluctuations out of the system [companies in the US] represents a payoff in the billions or trillions of dollars, due to overcapacity in factory and warehouses, cost of lay-offs and re-hiring, and other redundancies built into supply chains. The inventory part is only in the hundreds millions range."*

Industry executives foresee a company centric and informal arrangement structure to coordinate and distribute benefits. This is predominately what is observed in supply chains at present and in the literature reviewed. The second most frequent answer, an informal arrangement, would work as follows based on an industry executive's answer:

> *"Every member of the supply network would have a vote for a board of management that gets together on a regular basis for which they have to get approval at the board of their institution."*

The case against the informal approach is discussed by another industry respondent and others, arguing that informal arrangements often do not work as planned unless a third party can objectively manage the process:

> *"…don't think a group of CEO's [informal arrangement] could manage this, the chemistry is usually not right among them. But a consulting company can creates in the*

mind of each executive a non-zero sum game, that working together can benefit everybody."

Among respondents in consulting, responses were predominately skewed towards a company centric approach to allocate system wide financial distribution. One respondent in the consulting sector explains the simple fact that companies are reluctant to give up control for whatever reason:

"Everybody [companies in a supply network] rather have more control than less control in making decisions that affect their company"

One consultant points out the lack of business models or structures that would allow the trade-off benefits in the supply network based on the lack of incentive form an investor stand point:

"There isn't an appropriate economic model because investors values firms one off, and not as venture partners."

In conclusion, Question 4 and 5 exploring high-level and intimate coordination, was the most challenging in the view of respondents. Very limited current examples of structures that methodically and genuinely attempt to trade-off financial costs, rewards, and risks that benefit a set of supply chain partners were presented. From the examples offered, most examples were narrowly focused on one product or one business segment – sharing either costs, or benefits or risks at best.

6.3.4 Additional Findings

In addition to the general questions on coordination approaches & structures in each dimension, candidates were asked additional questions – Question 6,7, and 8 – to explore the requirements and impediments for achieving such a tightly coordinated network of supply chain partners.[99]

First, the respondents were asked to comment if organizations and managers thereof in a supply chain generally perceive themselves as being part of a broader supply chain. This question aimed to test to what degree participants in a supply network are aware of the consequences of their decisions on other participants in the network, and to what degree employees have a broader focus than the own company.

The results from Question 6 are illustrated in Appendix D, Figure D-1. Respondents were required to provide a binary yes/no answer to this question, however, some candidates insisted that organizations often view themselves as part of a broader supply chain only when convenient, noting the opportunistic behavior commonly observed in supply chains. Therefore, these answers were included in a category labeled 'depends'. The overall

[99] Refer to Appendix B on page 133 for the questionnaire.

distribution of answers suggests that executives in companies generally do not perceive themselves as being part of a broader chain.

Second, in order to explore how financial compensation and control is related, candidates were asked whether it is feasible for selected supply network participants to give up some operational control – like inventory or production planning – for higher or guaranteed returns, or both.[100] The results are presented in Appendix D, in Figure D-2, Figure D-3 and Figure D-4.

The results indicate that overall respondents agree – ranging form 78 to 88% among the three respondent's groups – that operational control can be given up for higher, guaranteed, or higher and guaranteed financial compensation. Approximately 20% of all respondents explain that this has already been happening among supply chain partners in the past. Respondents in industry differed in their response as they indicated that giving up operational control would not be based necessarily based on higher, but primarily on guaranteed returns.

Finally, candidates were asked to identify differences across industries that would either facilitate or require the formation of a coordinated supply networks. As seen in Appendix D, Figure D-5, the factors mentioned most frequently were: product lifecycle, industry concentration/fragmentation, and the requirement of focusing on core competencies.

Based on the respondents answers, the primary driver for coordinating operations in a supply network are short product lifecycles. One academic explains:

> *"Depending on what business partners are aligning about [e.g. in the automotive industry it is product development & design] in short product life-cycle you generally see partners staying together while in long product life-cycle you might more easily switch partners."*

One consultant points out that supply network coordination is only feasible when there is a high degree of industry concentration:

> *"A supply chain of 15 equal players will not work, they will not be able to agree on a governance structure. It is much more likely to happen if there is an anchor player who understands demand, that understands demand. The players that are not the power player will still play and get benefit, but at a disproportionate amount"*

6.4 Illustrative Examples

The illustrative examples presented in this section are based on the respondents' answers, and are presented as such without any elaborate analysis on the long-term viability of

[100] For example, when a supply network could operate more efficiently if one upstream supplier carried more raw material and an upstream OEM more converting capacity. Both investments would not be otherwise made unless there is a mechanism to coordinate the equitable sharing of benefits created.

such. When applicable, actual company names and initiatives are used.[101] Since respondents were asked about their vision of the future in each dimension, some structures are in development or do not exist in their current form. For these, non-company specific examples provided by respondents are presented.

6.4.1 Information Systems

6.4.1.1 Industry Consortium for Standardization

Approximately 25% of responses in the information coordination dimension mentioned RosettaNet. RosettaNet is a standardization consortium that attempts to promote the adoption of communications standards to facilitate coordination across multiple participants in a supply network. RosettaNet by itself is not a coordinating entity nor does it initiate systems integration among supply network participants, however, it facilitates the agreement of which electronic communication standards and business practices to use for inter-firm processes.[102]

The incentive to use RosettaNet as the coordination body to set standards is threefold: (1) Once standards are adopted by influential business, far reaching adoption of such standards in industry is likely[103], (2) standard processes developed through RosettaNet are less expensive than through a company centric structures to establish proprietary standards with supply network participants, and (3) the risk of failure is spread among a larger number of organizations.

Whether RosettaNet can become the established player providing the foundation of coordination of business processes between companies depends primarily on the speed to deploy such standards. One industry respondent points out that alternative means of coordinating information flows among business partners often occur due to delays from initiatives like RosettaNet and UCC Net:

> *"Standards like the ones created by RosettaNet are helpful, however, some of these organizations [RosettaNet, UCC Net] have been slow to deliver. This has made companies look for other, quicker solutions to bypass these institutions that coordination."*

From respondents, the fundamental reasons for circumventing industry consortia are twofold: (1) the skepticism that these can effectively build coordination tools in an acceptable time span and (2) the concern that such structures will create a 'level' playing field in the industry.

[101] When allowed by respondents.
[102] A detailed discussion of RosettaNet can be found in Section 2.5.5.2, page 43.
[103] Refer to Figure 2-10 on page 44 for an illustration of this concepts.

6.4.1.2 Third Party – Hosted

An illustrative example of an independent third party facilitating information coordination on behalf of supply chain partners is Baker Street Technologies. Compaq Computer Canada is currently in the process of integrating its web-based sales out reporting system with Baker Street Technologies hosted *streetworks* solution.[104] This creates a connected reporting structure between Compaq and its family of 150 resellers in Canada.

The third party solution improves the ability to coordinate the relationships by connecting multiple partners without regard to their specific sales and fulfillment model, complexity of relationship or installed technology.

Two mutual advantages are created between Compaq and its resellers enhance their relationship under this structure: (1) the platform generates accurate sales information, which helps Compaq to develop and target market programs for resellers. This potentially increases reseller revenue. (2) The automation of sales information reduces costs at Compaq Canada and its resellers through reduced errors and timely sales-out reporting.

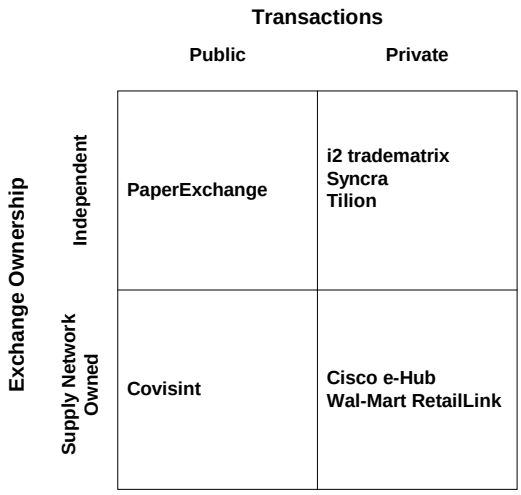
In this coordination structure, a third party, with no stake in one particular supply chain participant provides the information systems platform, data format, and facilitates the coordination of the exchange of business information that facilitates managing dependencies between multiple participants of the Compaq supply network in Canada.

In addition, even though only limited present examples exist, a number of respondents suggested the use of objective, third party run information exchanges or repositories maintained by information technology consultancies such as Accenture. This type of third party would be appointed to build the infrastructure to connect information systems of supply network participants, and determine optimal format and routing of information among participants without a vested interest in any single participants.

6.4.1.3 Third Party – Electronic Exchange

Approximately 30% of respondents foresee the use of electronic marketplaces – supply network owned or independent. Based on respondents' answers, Figure 6-8 illustrates classification of supply chain related electronic exchanges. A frequently mentioned third party information systems coordination structure, owned by supply chain participants, was the automotive industry electronic exchange Covisint.

[104] Baker Street Technologies is a provider of Internet-hosted sell side supply chain visibility tools. Refer to the Glossary of Companies on page 141 for more details.



Source: Author

Figure 6-8 Classification of Supply Chain Exchanges

Covisint is open to qualified members form the automotive supply base. It is owned by the channel masters of competing supply networks in the industry.[105] Covisint's mission is to promote coordination based on establishing the procurement information standards and automated exchange of data among OEMs and supplies in multiple tiers.[106] Covisint provides participants to share information on product demand, inventory levels, and capacity constraints at various nodes in the supply chain.

Covisint can only provide multi-tier coordination if Tier 1 suppliers join with their own suppliers, creating information exchange across three tiers of the supply chain. For this, Covisint has started helping smaller suppliers, which often use technologies limited to telephone and fax to bid on and process orders, by sending out technical staff to realign their processes before joining the market place.

Finally, private collaboration spaces on Covisint allow select groups of supply chain participants to collaborate in an exclusive and secure environment. This applies primarily to collaborative design for which Covisint is establishing a virtual workspace to provide an information management and communications site for multi-enterprise product development teams. One of the biggest potentials for multiple tier coordination in the automotive industry is the collaborative design of automotive parts, more so than logistics coordination across multiple tiers.

6.4.1.4 Company Centric Extranet

Cisco Systems was predominately offered as the most progressive example of a single company centric information/systems coordination structure. With its electronic hub (e-

[105] General Motors, Ford, DaimlerChrysler, Nissan, and Renault.

[106] Tier 1 suppliers are encouraged to join with their suppliers, propagating standards upstream in the supply network.

Hub), the company integrates its customers and suppliers through two separate web-based portals – the Cisco Connection Online (CCO) for suppliers and the manufacturing connection online (MCO) for customers. In addition, the company manages all financial transactions for these exchanges through its enterprise system. Through e-Hub, Cisco also handles information management, sets the data standards for exchanging forecasting information and orders, provides security of data, and network support for the supply network of suppliers and customers.

Cisco's strategy, characterized by deep information sharing and core competence in networking, has allowed the company to develop its own information coordination system, without looking outside to third parties for this. Its suppliers, even though imposed to use Cisco's system, benefit from not having to develop a proprietary system and by higher exchange of information, visibility, and shared forecasts. According to respondents, in most cases using the Cisco e-hub leads to a cost reduction of doing business with Cisco for the suppliers.

Despite these lower transaction costs, a key issue with the company centric hub approach is the dominance of the information systems owner. One respondent in consulting points out that selling through channels with company centric information systems yields lower margins:

> *"In a hub system that is private like Wal-Mart [RetailLink] or Cisco [e-Hub] … the central entity selects whom it pays how much, and suppliers would join depending if they want to compete in that channel … you get less benefit [margin] since you sell lower to Wal-Mart in the hopes for higher volumes and less variability."*

6.4.1.5 Informal Arrangement

Respondents from industry pointed out that at present the vast majority of initiatives aim to coordinate information distribution and connectivity among members in a supply network through middleware solutions among the departments participants.

Approximately 85% of industry respondents indicated that their company and business partners had separate information systems that were not directly compatible with each other. In one instance, an OEM and three suppliers were using the same SAP ERP system, but even this arrangement, such systems were currently isolated from each other, with some limited use of middleware solutions for the electronic transmittal of orders.

6.4.2 Logistics and Operations

6.4.2.1 Third Party Logistics Providers

The absolute majority of respondents mentioned that it is more likely for qualified logistics providers to take on the role of coordinating material flows and storage among

supply network partners as opposed to being exclusively managed by the logistics departments of each institution.[107] Logistics services providers (LSP) such as JB Hunt and Schneider National provide complex logistics engines, technology – in some instances with built in artificial intelligence –, and have already invested heavily in the infrastructure for this.[108]

The argument for using LSPs for the entire network of suppliers is based on the 3PLs core competence in managing logistics operations. In several instances, these parties are able to operate sophisticated cross-docking, merge in transit, and vendor managed inventories.

Two aspects were suggested as being problematic under this approach: (1) the consequence of using only one or a limited number of providers creates a lack of competition and possibly artificially high prices and (2) in actual logistics networks of multiple companies it is nearly impossible to have one single logistics provider have capabilities and capacity for all lanes in the network.

6.4.2.2 Fourth Party Logistics Providers

A fourth party logistics provider (4PL) could take on the role of logistics operations and design – e.g. planner and network loader – buy overseeing multiple third party logistics providers. This 4PL, likely a consulting company or technologically innovative 3PL such as Schneider National, would perform forecasting and planning of the material flows through the network on behalf of the customer and supply network participants.

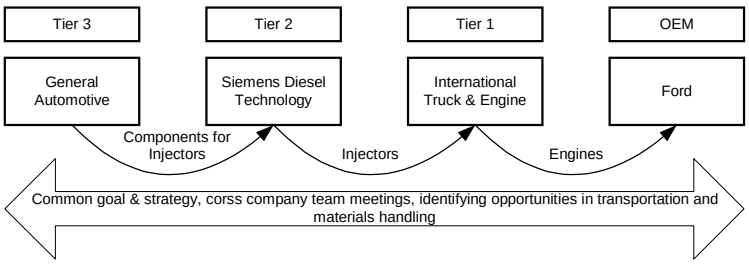
From the respondents' answers, 4PLs were described as having four main capabilities: (1) *provide multiple logistics services* offering customers combinations of warehousing, transportation, and a variety of other logistics services, (2) c*hange management skills* by advising partners on logistics issues and providing recommendations on supply network design, (3) *decision skills* based on analytical skills that allow optimal operation of material flows, and (4) *information systems* to provide IS capabilities in the logistics space for the supply network members.

6.4.2.3 Informal Arrangement

Siemens Diesel Technology (SDT) is a manufacturer of diesel engine components. SDT manufactures fuel injectors, a critical component in engines manufactured by International Truck & Engine, which are installed in Ford pick-up trucks and vans.[109]

[107] Nevertheless, logistics departments would be required for network design decisions and overseeing proper execution.
[108] Even some electronic transportation exchanges use logistics engines developed by 3PLs. For example, www.transplace.com uses JBHunt's logistics engine.
[109] Navistar is now part of International Truck & Engine.

SDT buys three critical fuel injector components form General Automotive. This linear supply network is depicted in Figure 6-9.



Source: Author

Figure 6-9 Siemens Diesel Technology Supply Chain

In order to coordinate logistics operations among these four supply network partners, all three suppliers have agreed to set a common goal and strategy for each tier in the supply network: "delivering perfect engines to Ford". This common strategy creates better alignment of incentives and goals, making coordination easier than otherwise. In this coordination structure, the company employs a so called 'launch-team', comprised of representatives from General Automotive, SDT, International Truck & Engine and Ford, that meets once a month to determine adequate logistics operation parameters of the companies involved.

Examples of coordination include the introduction and use of the same bins throughout the supply chain, from General Automotive to Ford. In addition, "milk-runs" among the supply network participants are mutually identified to more efficiently use transportation providers. SDT structures its contracts with suppliers so that suppliers are encouraged to come forward with cost reducing suggestions and are guaranteed that resulting benefits are equitably shared.

6.4.2.4 Company Centric Appointed LLP

A company centric example of how logistics operations among supply chain partners can be coordinated is Ford's appointment of Penske Logistics as the lead logistics provider (LLP) for its inbound materials network in America.

For this, Penske maintains a dedicated facility staffed by 200 members, to manage order-to-delivery on an inbound basis for Ford's Tier 1 suppliers. In-plant managers coordinate the movement of inbound materials as well as the return of reusable containers to suppliers. In addition, Penske is implementing Ford's inbound planning engine (IPE), the decision support tool that emerged from a Ford-SynQuest effort.[110]

[110] Source: Kurt Hoffman, "Ford Develops Different Kind of Engine – One that Powers the Supply Chain", *Global Logistics & Supply Chain Strategies*, 2000.

Through a joint modeling laboratory, Ford shifts the more standardized modeling logistics plans to Penske. At various stages, Penske provides expertise in operations, network management, and network design. Preliminary results show a dramatic increase in delivery frequency to, on average, at least once a day without higher transportation costs.

6.4.3 Governance/Financial Allocation

6.4.3.1 Informal Arrangement

A possible informal structure to allocate benefits among partners is for strategic partners to jointly establish a common *value* sharing mechanism in the supply network. Such a mechanism would be structured according to two factors at its highest level: (1) the value of the product sold, i.e. the amount that the customer is willing to pay for a product at the point of sale, and (2) compensation of participants of that product's supply network based on the value each participant contributes to the final product – subject to periodic revisions.

The advantages from using this approach is that upside and downside risks are directly shared, which is more difficult to achieve through short term contracting. In this model, only a final sale counts, creating the need for supply network participants to strongly focus on delivering the right product and configuration at the right time and place to the customer.

The primary problem with such an approach in practice is that it might be impossible for all supply network partners to agree on which percentage of the value each contributes to each final product – if it's measurable at all. Furthermore, damaged goods, lost sales, and actions that are not in the best interest of the network by downstream participants can substantially decrease end-consumer sales, which would negatively affect the compensation of upstream suppliers. These would have little means to monitor, enforce compliance or avoid such a situation.

6.4.3.2 Separate Legal Entity

Several difficulties of sharing information, costs, and benefits among supply network participants stem from the separate ownership structure of companies. In addition, investors through financial markets value companies as separate entities, and seldom consider the value of venture partnerships. One form of separate legal entity that mitigates the incongruence from separate ownership is based on a company analogy: VISA International – refer to Hock [142] and Breuner [143] for details on VISA's structure.

VISA International is structured as an inverted holding structure, which allows supply chain partners to mutually own and equitably distribute profits. In this structure, each

member, based on his contribution, has voting rights to elect a council of representation. That council of representation, with other participants, come together to elect the next higher-level council – or board. Eventually the participants have a governance structure at the top that can make decisions that could not otherwise have been made for the entire network. The arrangement is structured so that no board can make a decision if this decision could have been made at the lower level board. In this manner, decisions are made as close to the source as possible.

In the supply chain scenario, a supply network participant could elect a member to the lowest information, logistics or financial council. Each council is empowered to make decisions that do not necessarily require approval from the next higher council. When decisions produce an impact on another participants councils, their boards would then proceed to the next higher level to resolve the dispute.

Influential participants in this arrangement might be guaranteed a seat at the highest level of the board, but they would have only one vote at that highest level. If the separate legal entity goes public, there needs to be a mechanism that avoids the acquisition of the majority of the stock, which would facilitate getting a majority controlling stake again.

If these were boards of competing supply chains, a supplier might be more willing to join a board where there is equitable distribution of power.

Other examples of governance approaches in a committee or board based separate legal entity are presented in Table 6-3.

Table 6-3 Possibel Governance Structures of Separate Legal Entities

Type of Governance	Meritocracy	Democracy	Federated	Anarchy	Chaordic[111]
Composition of Governance Committee	Number of members appointed based on the individual achievements of companies	Members appointed matches the number of companies one to one	Members appointed according to revenue, value added, and customer knowledge	No committee, channel master imposes terms of trade	No formal governance, organic adaptive system
Invitation	Yes, need to earn the privilege	Yes, granted	Yes	No, appointed by channel master	Yes, by vote of members
Degree of centralized control	Medium	Low	Medium	High	Low
Level of trust	High	Medium	Medium	Low	High
Level of commitment by members	High	High	High	Low	High
Coordinates the entire supply network globally	Possibly	Possibly	Possibly	Unlikely	Possibly

Source: Author.

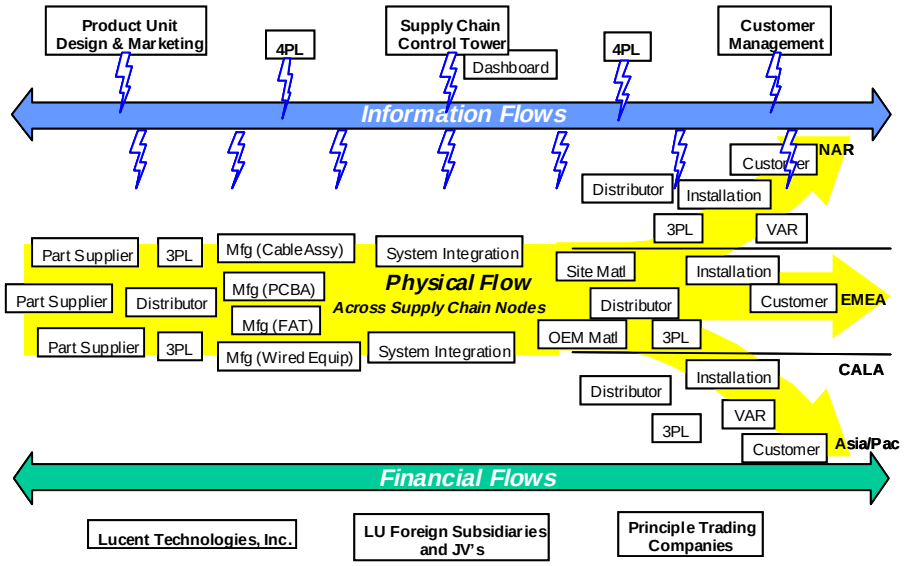
[111] Hock [142] defines a chaordic organization as any self-organizing, self-regulating, adaptive, non-linear, complex organization whose behaviour harmoniously exhibits characteristics of both chaos and order.

6.4.3.3 Single Company Centric

Lucent Technologies – High Level Coordination Attempt

The 'Supply Chain Networks' group at Lucent Technologies is an example of a company centric attempt to simultaneously coordinate information, materials, and financial flows across Lucent and its suppliers and customers.

Lucent Technologies is in the process of a substantial organizational restructuring with considerable manufacturing outsourcing plans throughout 2001 and 2002. In order to effectively manage its suppliers, logistics providers, contract manufacturers, and value added resellers, Lucent is forming a 'Supply Chain Networks' group, a 200-person structure in charge of managing information, materials, and financial flows among these entities. Figure 6-10 illustrates the activities encompassed by the Supply Chain Networks Group.



Source: Lucent Technologies, 2001 [144]

Figure 6-10 Lucent Supply Networks Group Structure[112]

The single overlooking supply chain organization lead by the control tower benefits Lucent from improvements in (1) *internal* efficiencies like reduction in operational redundancies, standardization of processes, and disaggregated demand and (2) *external* efficiencies in the supply network by closer integration with customers, leveraging the supply base and having one central entity interacting with customers and suppliers.

The Global Control tower manages the end-to-end flows, determining which supply nodes are best suited based on capability, capacity, distribution expenses, and material availability.

[112] Legend: NAR = North American Region, EMEA = European Market and East Asia, CALA = Central and Latin America.

Monsanto – Risk Distribution Example

Monsanto Company, the provider of biotechnology solutions to improve farm productivity and food quality, actively analyzes the distribution of risk in the supply network to determine the optimal risk allocation. In agricultural supply chains, the highest risk is usually located at the growers end.[113]

Farmers are required to pay all production costs for every season up front – including the seeds they purchase from Monsanto. Uncertainties like weather and varying seasonal earth quality make it difficult for growers to accurately estimate yields. In addition, spot market prices for most products vary considerably over the season. At the same time, the farmers are often the smallest financial entities in agricultural chains, being the least able to carry the risk of large sunk costs and highly variable selling price.

Monsanto actively recognizes that this risk distribution is not according to who is best suited to bear risk in the network.[114] Therefore, the company offers farmers insurance against variations in yields and effectively shifts the risk burden onto itself – however, it is compensated for doing so. Since Monsanto sells products to farmers in various geographical regions, on average the risks for Monsanto cancel each other out. The outcome is that risk is distributed to the entity that is best able to bear it while farmers have a more stable financial structure if they choose to participate. It is observed that everybody is better off than before: the farmer has the option to reduce his risk exposure while Monsanto profits from reduction of lost sales due to uncertainty and the additional insurance business.

The company also advises its regional retailers on the amount of herbicide stock to carry for a given season. Monsanto's sophisticated forecasting tools and higher-level outlook allows the company to produce better estimates than regional retailers.[115] The initiative to suggest optimal inventory levels at each stocking point has faced two obstacles in the past: (1) there is considerable mistrust and (2) fear of being left with excess inventory on the retailers behalf. To create a win/win situation Monsanto has started to implement vendor-managed inventories based on its competence in forecasting.

6.4.3.4 Vertical Integration

In rare instances, vertical integration is desirable to ensure adequate supply chain coordination. Tyson Foods and Perdue Farms are two fully integrated poultry producers

[113] Risk defined as the probability of financial loss. It is considered relative to the size of each entity in the chain, not in absolute terms.
[114] In this case, the supply network chosen by Monsanto is very large, and includes hundreds of farmers.
[115] Usually this is exactly the opposite, local retailers being able to obtain better forecasts due to closeness to the demand region. However, in the Monsanto case, the high cost of sophisticated forecasting models does not allow most regional retailers own these systems and achieve better estimates than Monsanto.

with ownership of the supply chain all the way from the packaging processing, and growing down to the genetics. Some production is outsourced in some instances.

The primary requirement to vertically integrate identified is the necessity to trace inputs free of genetically modified organisms (GMO) in this food chain. In addition, high variability of market prices in non-vertical chains and the perishable nature of the product make it desirable to own the entire chain. The key driver is tracking, creating the need for these food producers to take ownership and coordinate operations of upstream supply to ensure GMO free products. It ensures that product origin is accepted by the end-consumer, and avoids costly recalls.

Similar driving factors are found in the pork industry. As an example, Smithfield is a vertically integrated pork producer, in charge of processing, packing, genetics, and most recently, production. Some growing business is outsourced. In some production, Smithfield has a completely vertically aligned system, and the company argues it has improved its competitive position by doing so. The general trend in the pork industry indicates that 83% of pork produced today is under some sort of vertically aligned system, up from 30% in 1995.[116]

These food production chains illustrate clear trends towards vertical integration as the preferred and most effective approach to coordinate supply chain dependencies.

6.5 Assessment of Respondent Answers

6.5.1 Key Points of Consensus

Current State of Multi-Tier Coordination

- *Information Sharing.* The current state of coordination in traditional supply chains is based primarily on information sharing initiatives that provide the foundation for efficient communications and data sharing. Such efforts are mostly software based, with little emphasis on decision-making and coordinating mechanisms that determine how information is distributed in the chain. More elaborate coordination structures in logistics and explicit approaches to invest and distribute benefits in multiple tiers in the supply network are observed only in very narrowly focused initiatives

- *Collaboration Efforts*. Based on the majority of responses, it is observed that collaboration to coordinate information and material flows are primarily dyadic, and currently are the exception rather than the norm among organizations

- *Optimization in Supply Networks.* The next higher attempt to improve operations in the supply network would be based on optimization. No examples of

[116] Data from respondent.

optimization across three or more tiers of a supply chain were identified. It was further found that even between companies in adjacent tiers there are no clear examples of full-scale optimization, at most optimization in the transportation or warehousing space but not on a system wide basis

- *Operating more Efficiently by forming a Supply Network.* The majority of respondents agree that often situations in which a group of supply network members could operate more efficiently if one member changed its operations are identified. Having a participant take on additional cost to operate in better alignment with other network participants should be compensated accordingly, but there are limited formal mechanisms to do so at present

- *The Role of Standards.* Respondents highly agree that standards are desirable and would facilitate coordination, yet they are very slow in coming, reason for which many respondents interviewed answered that they are seeking alternative ways of coordinating information at present

Information Systems

- *Information Systems Coordination.* The consensus of responses in this dimension is the lead role by a channel master extranet or portal to coordinate information systems, with limited propensity to use third parties to assume this role[117]

Logistics and Operations

- *Logistics and Operations Coordination.* The consensus of answers points to the use of 3PLs to assume the lead role to coordinate logistics operations and designing the logistics network. This observation stands in direct context of the general outsourcing trend of logistics observed as providers expand their offerings, grow capabilities and choices increase to a level similar to contract manufacturing in the manufacturing space

Governance and Financial Allocation

- *Governance/Financial Allocation Coordination*. The consensus observed in the respondents' answers is a channel master centric or informal coordination structure to determine optimal allocation of investments and distribution of benefits in the supply network. These approaches are similar to the way in which distribution of benefits occurs in supply chains at present

- *Companies as Part of a Broader Supply Chain*. A trend in the respondents' answers indicates that organizations generally do not perceive themselves as being part of broader supply chain. This suggests that the notion of operating in the

[117] Consensus is used to connote the *majority* of responses. Refer to Section 6.3 on page 93 for the definition of how consensus in this study.

context of a broader supply chain is not readily acknowledged and a myopic view of the supply chain persists

- *Control and Compensation.* The majority of respondents offer a compelling argument for shifting operational control in the network to the most informed party based on appropriate compensation to the participants giving up control[118]

Additional Observations

- *Differences in Industries.* From the data collected it is observed that the primary drivers of supply network coordination are shortening product lifecycles and the degree of industry concentration – i.e. how concentrated is control at the channel master end. Both of these factors were determined as being critical in making a supply network arrangement desirable and necessary

- *Using Multiple Coordinating Structures in each Dimension.* It was observed that it might be necessary – depending on the size, product lines, prior investments in technology, and complexity of the organizations part of the supply network – to use several coordinating structures in each dimension

- *Cross Training and Education.* Cross training – i.e. rotating managers through the supply network participants – and education were two factors repeatedly mentioned that would facilitate initiating and maintaining external coordination activities in the supply network

6.5.2 Key Points of Divergence

The following issues consistently varied among respondents from all segments, with no clear trends or consensus observed.

- *Role of Internet based Exchanges and Capabilities.* Despite three years of Internet based commerce, there remains general uncertainty over the role of electronic based exchanges and the capabilities promised by these. The majority of respondents noted that many of these efforts take a large amounts of value from the savings or efficiencies created

- *Selection of Supply Network Partners.* Candidates had consistently different perceptions of the supply network concept and provided different approaches and criteria on which companies should be selected to be part of this network. Specifically, the absolute number of companies seemed to vary significantly, from

[118] Control in this case refers to the degree of empowerment to determine inventory levels, transportation, and manufacturing schedules.

a couple to several hundreds, however, respondents asserted that the number of supply network partners should be kept to a manageable number[119]

- *Which Coordination Approaches to use in Specific Situations.* Amongst the responses, a general uncertainty about which coordinating structures are adequate for which specific instances, products and partners persists

- *Benefits from Supply Network Coordination*. The financial benefits of creating a tightly aligned supply network were estimated differently by most candidates. While the majority of respondents agreed that closer coordination with adjacent supply chain partners is desirable, a general disagreement of the usefulness of sharing information across more than three tiers was expressed. The primary reason for this being the difficulty of exploding multiple bills of materials, reconciling demand and translating end-demand into meaningful information to upstream suppliers

- *Governance Structure and Financial Allocation.* A general uncertainty of how financial investments and benefits distribution among partners in the network can be achieved and which entity – other than the most influential player in the supply network – would be responsible for doing so. Answers to this segment were scarce and concepts not fully developed

- *Participants Belonging to Multiple Supply Networks.* The idea of belonging to multiple supply networks complicates and duplicates the targeted efforts by each participant. A shared supplier competing as part of two separate supply networks creates potential conflict of interest among the participants

6.5.3 Validation of Layered Model

The use of the three coordination dimensions deductive model is based on the difficulty to appoint a single party to facilitate *all* coordination activities, this task is extremely complex, and no single structure or organization has the core competency in all areas required.

The separation into three dimensions of coordination was enforced by respondents' answers explaining the reasons and usefulness of the separation.[120] One expert from the consulting sector explains the separation of the information and governance layers:

> *"There is a big difference between the entities that will host the information and the entities that have responsibility for the decision making. There is a big difference from one neutral party that hosts the integrated software and makes sure that the information*

[119] A manageable number was generally defined as 10 or less partners by respondents, depending on the company size.

[120] Respondents were not aware of the three-layered model, except through implicit structure of Questions 2,3, 4, and 5.

is distributed fairly.[…] Nobody sees that entity having the authority to make these decisions [financial benefits distribution].”

Another respondent in academia points out the distinction of the logistics coordination structure and the entity ultimately determining financial benefits allocation in the supply network:

“In many supply chains the controller is going to be different than the owner. […] This is what McDonalds does in the French fry business, they set the rules and leaves execution [and implementation] to J.R. Simplot. But Simplot has no control [to determine financial allocation], they just organize.”

The separation into layers allows a structured approach to the problem and reduces the scope of the problem to segments that can be more easily analyzed. By using multiple structures, the risk is spread more widely, and each segment can be independently optimized.

The next section provides a critical view of the validity of results obtained based on the research in this thesis.

6.5.4 Significance of Results

6.5.4.1 Sources of Error

Based on the Delphi methodology and the interview based data collection procedure, there are several potential sources of error in every step of the research process that need to be addressed. The four phases of error introduction are illustrated in Figure 6-11.

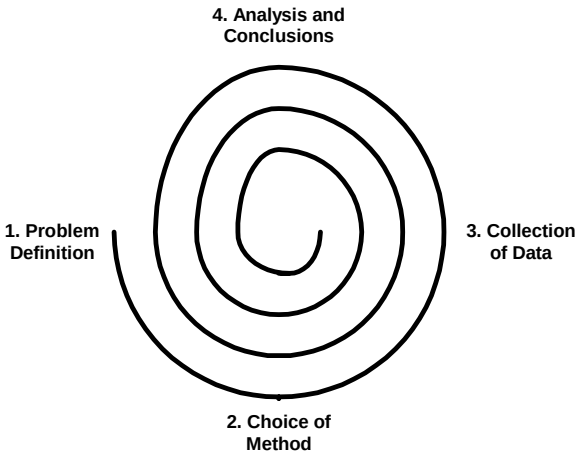


Figure 6-11 Sources of Error in Delphi Study

6.5.4.2 Problem Definition

The potential of choosing the wrong problem to analyze occurs from using the wrong sources of information. This error was reduced by reviewing previous literature on coordination efforts in various forms and industries, and attempting to gather all relevant prior work on the topic.[121]

In addition, the use of badly defined questions to answer the problem is a significant source of error. This error was reduced by interviewing three test subjects and adjusting the questions based on the interpretation of the questions.

6.5.4.3 Choice of Method

Based on the Delphi methodology presented in Section 5.2, each respondents answer is equally weighted in the evaluation process. This implies that no one answer is considered more valid than another. The data collected was treated accordingly, even though some responses varied significantly in terms of structure and coherency. Even though the results of each *individual* respondent are not reliable, the statistics generated form *all* 31 respondents give a reasonably good picture of the relevant issues.

The choice of method for the study appears to be adequate given limited evidence and the desire to explore future developments in supply chain coordination. The principal disadvantage from using this self-generated method is that certain aspects identified by a more formal method might be missed. The author acknowledges this study by itself does not allow transferring results to a larger population by establishing the statistical significance of the results. Depending on results of a similar study with different candidates, geographic region, and point of time, such inference could be made.

6.5.4.4 Collection of Data

Table 6-4 presents the various effects that introduce error during the process of collecting data and the approaches used to mitigate these sources of error.

[121] This excludes business logistics mathematical models out of the scope of this study.

Table 6-4 Sources of Error in Data Collection

Type	Description	Approach Used to Reduce Error
Instrumental Effect	Refers to the error from incorrect formulation of questions and the medium used to ask questions (e.g. oral, written, in person)	▪ Conducting interviews in person or by telephone reduces the risk of unclear questions or formulations
Interviewer Effect	Refers to the risk of interpreting answers incorrectly	▪ Repeatedly drilling down on specific examples provided to get comprehensive and detailed answers ▪ Record interviews to transcribe and retain all data
Interviewee Effect	Refers to the error introduced through interviewees when providing different answers to the same question throughout different points in the interview or untruthfulness in the answers	▪ Open ended questionnaire design provided little incentives/reasons for candidates to take a specific stance on an issue ▪ Question 5 was designed to revisit Question 4 and further validate answers to test congruence

To identify the relationship of number of respondents and reliability of results, answers of respondents were plotted as interviews were completed. It was observed that the relative distribution of responses did not change significantly after the 18th to 20th interview. This suggests that last third of responses did not substantially affect the results form the first set of 20, and that there were decreasing marginal returns from interviewing more than 18-20 candidates in this study.

6.5.4.5 Analysis and Conclusions

Several analyses could have been performed on the data. The use of frequency charts to determine trends in the data and representative quotes to explore the breadth of responses seemed to be the most objective approach to convey a clear picture of the information collected. Candidate answers were treated as such, without elaborate validation of the feasibility of the examples provided.

6.6 Summary

This chapter presented a structured analysis of the results from the Delphi interview process.

First, generic coordinating approaches were determined based on the breadth of candidate responses. These seven distinct approaches to coordinate across the supply network were

illustrated in a spectrum and discussed. Second, coordinating structures in each generic approach and dimension were identified and current examples from the data presented. Third, the distribution of responses of coordinating structures in each of the three coordinating dimensions was analyzed and representative quotes from candidates used to illustrate key issues of how to achieve coordination across multiple tiers of a supply network. Fourth, illustrative examples describing such coordination mechanisms were presented. Finally, an assessment of the data was done to determine the consensus, divergence and sources of error in the data.

Chapter 7 Summary and Conclusions

The purpose of this thesis was to explore how information, material, and financial flows of mutually dependent and strategic business partners in supply chains can be coordinated across multiple tiers of the supply chain. For this, coordinating approaches and structures were researched that allow (1) the reduction of redundancies in the supply network and (2) identifying new opportunities that would have otherwise not been identified.

This chapter summarizes the findings and major conclusions of the preceding chapters. Section 7.1 provides an overview of the research findings. Section 7.2 summarizes the conclusions drawn from the analysis of results. Finally, Section 7.3 recommends directions for further research.

7.1 Summary of Findings

Literature Reviewed

First, the literature on coordination models and collaborative efforts among companies was reviewed to illustrate the benefits and obstacles from such. Dyadic efforts identified were primarily based on information sharing and collaborative initiatives. It was determined that the most representative examples of initiatives such as VMI, ECR, and CPFR have clear financial benefits for both parties involved, but these efforts are often focused on coordination between two participants in adjacent tiers of the supply chain only.

Examples of multi-tier collaboration were limited, with most initiatives such as collaborative logistics, industry standards groups, business-to-business exchanges and multi-tier spanning software are in the development phase. The examples identified were primary narrowly focused initiatives on specific functional areas such as transportation or warehousing and limited to sharing either costs, or risks.

Second, a review of transactions costs analysis illustrated that coordination in the supply network occurs through three primary governance structures: open markets, hybrids, and hierarchies. Economic theory states that supply chains are, by definition, coordinated through open market or hybrid governance structures since coordination by hierarchy in the supply chain context would mean ownership of the entire chain.

Third, the concept of the supply chain as a supply network was developed by illustrating an increasing number of non-linear information and material flows in supply chains. Further evidence of supply networks was presented through virtual organization models, based on companies that rely heavily on outsourcing, but appear as a single company to the consumer, even though separate legal entities are responsible for demand fulfillment.

Supply networks are coordinated primarily through hybrid governance structures, which allow deeper and longer-term relationships that can be used to increase the efficiency of the supply network as a whole. Hybrids provide the benefit of increased control without the need to own the production assets, but also limit the flexibility that is inherent in open market mechanisms.

Delphi Round Findings

Seven generic approaches, ranging from pure market forces based to hierarchy, to coordinate a supply network were identified from the data.[122] These approaches differ in the choice of governance structure, organization initiating the coordination effort and, type of relationships used to achieve coordination across multiple supply network participants.

For each dependency in the network – information, materials, and financial – and generic approach, several coordination structures, entities that facilitate or perform coordination activities, and corresponding examples were identified. At least five different coordination structures were identified for each dimension through the interview based process.[123]

The respondents' data was analyzed by using frequency charts and representative statements from candidates. It was observed that academics provided a more evenly distributed range of responses for each coordination question, while the distribution of answers in industry and consulting was highly skewed towards one or two coordination structures per dimension.[124]

Illustrative examples provided by candidates were presented to illustrate the mechanisms of these coordinating structures in more detail. The examples provide a better understanding of the coordination activities, issues, and obstacles that need to be overcome in each structure.

Finally, the breadth of responses and prevailing trends in each dimension were identified and discussed.

[122] Refer to Table 6-1 on page 86.
[123] Refer to Table 6-2 on page 88.
[124] Refer to Figure 6-3 on page 95, Figure 6-5 on page 97, and Figure 6-7 on page 100 for response distribution by segment for information, logistics and financial coordination structures, respectively.

Significance of Results

The validity of this qualitative research approach lies in the choice of representative examples to illustrate concepts, the logic in the research methodology, and the structure used to assess answers. Even though the results of each *individual* respondent are not reliable, the statistics generated form *all* 31 respondents give a good picture of the relevant issues and examples.

It was noted that error was introduced at all four stages of the research process: problem definition stage, choice of research method, collection of data, and analysis and conclusions stage. The error introduction was actively mitigated at all four stages by taking into account and using methods to reduce the amount of error in the study as illustrated in Section 6.5.4.

7.2 Conclusions

Validation of Layered Approach

The three-layered deductive coordination model used to assess requirements was compellingly validated based on the following key findings:[125]

1. Several candidate responses asserted that a segmentation of coordinating responsibilities – and degree of influence of each – is needed given the difference in strategic decisions, time horizon, and actions that take place in each dimension. It also avoids the risk of using one large, unmanageable and complex structure.

2. For each coordination dimension, different coordination structures were identified. The data suggests that each single dimension might require several coordination structures based on the size, complexity and invested technology of a participant in the supply network.

3. By separating activities into information, material, and financial substructures, it becomes feasible to optimize each substructure and respond to new technologies in each environment independently.

4. Segmenting the problem in layers allows simplifying an otherwise unmanageable problem into smaller and more focused parts that can be meaningfully analyzed.

[125] Refer to Section 2.3 on page 25 for a description of the coordination model used in this thesis. Layer = Dimension of Coordination.

Multi-Tier Coordination at Present

Throughout the interview process, candidates were asked about the current state of coordination in the supply network to provide future requirements. It is concluded that:

1. Limited examples of active coordination across three or more tiers of the supply network currently exist, based on a very limited number of examples provided by respondents and the literature. These examples include initiatives where materials or information flow are managed across three tiers, and informal approaches of coordinating in the network.

2. No optimization based on mathematical models across more than two tiers was identified; in many instances, respondents pointed out that even optimization within the company is usually not achieved.

3. The majority of external coordination efforts are based on information sharing, and are primarily software focused. These initiatives are based on collaborative efforts between two organizations in adjacent tiers in the supply network, but currently increasing in both quantity and scope.

4. No formal allocation of financial resources and benefits in the network was observed. The distribution of benefits occurs primarily through open market forces and influential companies in the supply network.

These findings suggest that the organizations researched have achieved some success in achieving internal supply chain management efficiency improvements, and are beginning to achieve the same with efforts to coordinate dependencies between adjacent downstream and upstream organizations.

Consensus of Coordinating Structures

From the research, it was attempted to present the full breadth of responses as well as the consensus.[126] By considering both, there is a higher probability that the most accurate and reliable approaches are identified. The conclusions are drawn form the groups consensus answer in each coordination dimension:

1. Information Systems and Sharing Coordination

    - The consensus in information systems coordination is the use of a company centric extranet or portal. This structure is most likely a channel master centric system, in which suppliers are encouraged or required to join. It allows a faster way of establishing communication standards and processes to share information than through industry standardization consortia. The use of such

[126] Consensus defined as the majority of responses, *not* unanimous agreement among respondents. Refer to Section 6.3 on page 93 for details.

system potentially provides the supply network with a competitive advantage over other supply chains that do not extensively coordinate information flows

- Respondents in academia foresee a larger role of third parties such as industry consortia and electronic exchanges to facilitate coordination, while respondents in industry and consulting primarily project the single company centric approach to managing information systems

2. Logistics and Operations Coordination

   - Consensus of responses points to 3PLs as taking the role of logistics and operations coordinator in the supply network. This is not only consistent with the current trend to outsource operations to 3rd party value added logistics providers but also foresees the role of these to provide coordination activities. The core competency in the field makes specialized third parties an attractive option for organizations whose logistics costs are a small part of the product value. 3PLs further achieve efficiencies in logistics through the consolidation of volume from multiple supply networks

   - Respondents in academia project the possibility of informal roundtables of logistics managers or external consultant assisted structures to coordinate material flows through the network. Industry and consulting executives responses are almost exclusively based on 3PLs

3. Governance Structures and Financial Allocation Coordination

   - The consensus of responses suggests a company centric mechanism to determine financial investments, distribution of benefits in the network, usually performed by the channel master in the chain due to its influential financial position. This conclusion corresponds to the findings of benefit distribution in traditional supply chains from the literature

   - The use of third parties is limited in the view of respondents from all three segments. Separate legal entities to collect and suggest optimal operations in addition to equitably sharing benefits, costs, and risks are (1) desirable and would increase efficiency of a supply network but (2) too complex to implement with current business law and practices

This research identifies consensus on coordinating structures but it should be noted that the choice of any given approach and structure is specific to each supply network and participants thereof. The selection of a structure depends in part on the historical relationship, the invested technology, strategic importance of supply network partners, trust in the relationship, and capabilities of supply network participants

Obstacles and Issues

- Industry leaders are uncertain whether information technology based systems are the coordination structures that manage dependencies among supply network partners. It was observed that these entities provide an environment to collaborate, but do not take an active role in coordinating across multiple participants of the supply network. They provide a basis from which to coordinate, but inter-organizational relationships and trust are still the most frequent factors mentioned. It was noted that trust takes a long time to develop, and is based primarily on long-term proven business performance and relationship

- Even though exploding bill of materials through multiple tiers of the supply network provides demand figures that are helpful for second, third and fourth Tier suppliers, they are not necessarily meaningful figures. Since there are multiple suppliers in each tier, there needs to be accompanying reconciliation of demand to each in each tier, which becomes a very complex problem to solve. It might be possible to break out and assign demands of each product to particular suppliers but it is not evident if the cost of doing so is lower than the benefits achieved.

- The respondents predominately state that companies view themselves primarily as separate entities in a supply chain, with only modest consideration of the consequences of their internal decisions on supply network partners. This suggests a myopic view of the supply network and limited systems thinking. In addition, market valuation of companies is based primarily on company profits, and not on the portfolio of alliances and partners, therefore not directly valuing a company as part of its broader supply chain

- Separate information systems and standards are an obstacle to achieve coordination in the supply network, but achieving wide-ranging consensus in this segment is difficult since many organizations have already invested in different technologies

- Participants belonging to multiple supply chains complicate the formation of disjoint supply networks. A shared supplier competing as part of two separate supply networks creates potential conflict of interest among the participants

7.3 Suggestions for Further Research

The primary recommendation of this study is to perform a second Delphi based interview round. This would include the development of a second questionnaire with multiple choice questions based on the coordination approaches and structures identified to obtain a quantitative distribution of responses. Controlled feedback and a second round iteration would also allow creating higher level consensus among respondents and refining requirements and obstacles necessary to achieve external coordination.

Second, a similar study with an entirely different set of experts and at a different point in time would provide useful insights into the congruence of results.[127] If similarity can be established, this would allow further validation of the results.

Third, a more in depth study exploring the criteria and framework to determine which supply chain partners should be part of a company's supply network. Research in this area would include identifying a set of requirements, issues, and obstacles for building the supply network. A detailed framework from these findings would help the supply chain manager determine for which products and situations the supply network arrangement would make strategic and financial sense.

Fourth, from the respondents' geographic distribution it is observed that the study is US centric. A more comprehensive overview of non-US companies might be interesting. Especially to explore the contrast between Japanese, West European and North American approaches to the problem.

Fifth, it might be necessary to take each of the forms identified and analyze legal implications associated with each. A number of coordination structures required for such close coordination, specifically in the separate legal approach, are not rigorously analyzed in their viability under the current legal system and business law at present.

Finally, the development of a mathematical optimization or a system dynamics model of a supply network, and a quantitative measure of the value created, would be beneficial. This research area is necessary to assign hard numbers to the potential benefits from multi-tier coordination. From industry respondents, it was evident that if mathematical models with positive data and measurable benefits would exist, it would substantially accelerate the adoption rate of the coordination structures.

7.4 A Final Comment

Organizations have been seeking effective and efficient approaches to integrate with outside supply chain partners for the last decade. As the opportunity of external supply integration has been discovered, there still remains great uncertainty of what role technology, the value of information, and new business models will play in inter-company coordination. The research presented in this thesis intended to clarify some of the current and future approaches to this problem and is intended to be a useful tool for the supply chain designer in the organization.

Applying the most appropriate coordination approaches in supply chains is potentially a very effective strategy to improve logistics operations and overall performance of the

[127] Conducting the same study at a different point in time can reduce the effect that economic conditions, time related factors, and other developments have on the respondents' answers.

value chain. It is hoped, that this thesis illustrated the benefits from focusing on external coordination with supply chain partners.

Appendix A – Propositions of SC vs. SC Competition

Statement	Source
"Increasingly, two key trends, value and cost conscious customers and globalization of markets and supply-sources, are shifting the competitive focus from the competitive advantage of firms to competitive advantage of entire supply chains."	Kuldeep Kumar, Ellen Chriatiaanse, University of Amsterdam
"Competition or rivalry occurs not in the form of individual firms competing with one another for market share within a stage, but in the form of supply chains competing for their share of the consumer's expenditures."	Michael Boehlje and Steve Sonka, Purdue and University of Illinois,
"As a result of this process of vertical linking, we can see the appearance of supply chains as a concept in the last decade. It is not only the competition between companies that is of importance, the aspect of chain competitiveness is important too."	Mark Overboom, Department of Managerial Studies, Wageningen Universtiy
"International Competition is increasingly moving from being traditionally 'company vs. company' to becoming 'chain vs. chain'. To be successful companies need to join others to build competitive agri-chains."	Chains of Success, Agriculture, Fisheries and Forestry – Australia
"As the 1990s fade into the 21st century, entire supply chains are competing. To be successful, distributors and non-distributors that are SCM-savvy need entire supply chains that are equally willing to embrace SCM and are just as capable of following through."	Ted Stank, Professor of Marketing and SCM at Michigan State.
"In more and more industries, it is becoming apparent that the competitive field is no longer limited to company A versus company B. The game is now supply chain network versus supply chain network, with an increasing reliance on collaborative relationships to create links of value."	Timothy L. Mould, C. Edwin Starr, Andersen Consulting
"It's a supply chain vs. supply chain world today. Companies don't only compete with each other but with an extended web of suppliers."	Rob Rodin, CEO of electronics distributor Marshall Industries
"Rather than companies competing against one another and then worrying about managing their supply chain, now it's supply chains competing against supply chains."	Hollis Bischoff, Vice President of Electronic Business Strategies at the META Group
"By working together in a collaborative way, the trading partners will behave as an extended enterprise. They must perform together was if they are one company."	Gary Cokins, ABS Technologies, Inc.
"Business Competition is moving away from the traditional company vs. company model in favor of a system that pits supply chain against supply chain."	Academic Alliance Forum, Sponsored by Andersen Consulting

Appendix B – Supply Network Coordination Questionnaire

Introductory Question – Add on to Delphi Study

1. As companies have shifted from competing on products to competing based on service, supply chain performance has become increasingly important. Some have suggested that the basis of competition in the future will shift from company-vs-company to supply chain-vs-supply chain – do you agree?
   - What does this supply chain-vs-supply chain based competition mean to you?

Delphi Study – General Questions

The following questions intend to expose a general picture of what efforts are required to achieve state-of-the-art, multi-tier collaboration and subsequent optimization of the supply network.

2. How should information systems be coordinated?
   - What other entities could facilitate this? Any examples?

3. How should logistics processes be coordinated?
   - What other entities could facilitate this? Any examples?

4. What new entities and/or governance structures are needed to enable an optimally coordinated supply network?
   - What other entities could facilitate this? Any examples?

5. Within the noted entities/governance structures, how would costs, risks and benefits be equitably shared among the supply network partners?

Delphi Study – Additional Questions

6. Do business partners generally perceive themselves as being part of a broader supply chain?

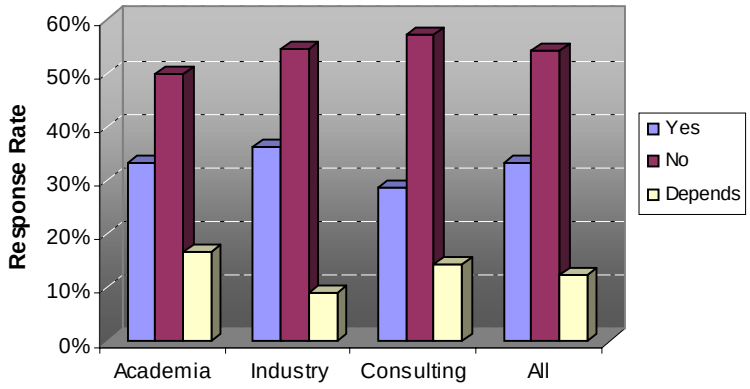
7. Do you think it would be realistic and feasible to have certain supply chain partners give up some operational control in exchange for higher/guaranteed returns?

8. What differences may exist across industries when optimizing across the supply network? Are there unique characteristics of firms in a specific industry that makes multi-tier coordination more likely in some industries than others?

Appendix C – Delphi Study Interview Candidates

Name	Affiliation
Academia	
Ellen Christiaanse	University of Amsterdam
Edmund Schuster	Center for Transportation Studies, MIT
Charles Fine	Sloan School of Management, MIT
Fred Hewitt	Aston Business School
James Hines	Sloan School of Management, MIT
James Masters	Center for Transportation Studies, MIT
Kuldeep Kumar	Erasmus University, Rotterdam
Michael Boehlje	Department of Agriculture & Economics, Purdue University
Thomas Malone	Sloan School of Management, MIT
Industry	
Bill Shepard	Transentric
Brain Cassim	Siemens Energy & Automation
Donna Edwards	Intel Corporation
Dorothea Kuettner	Hewlett-Packard
Garth Blanchard	Monsanto Company
Jake Barr	Procter & Gamble Company
Janet Rosa	Helix Technology
Jim Shoefield	Lucent Technologies
Joseph Bellefeuille	Lucent Technologies
Larry Buchanam	Monsanto Company
Lynn Mercer	Lucent Technologies
Mary Kotler	Siemens Diesel Technology
Tom Shields	Texas Instruments
Consulting	
Charles Poirier	CSC Consulting
David Anderson	Global Supply Chain Practice, Accenture
Jonathan Byrnes	Swift Rivers & Jonathan Byrnes & Co.
Jonathan Fleck	Zefer
Larry Lapide	AMR Research
Lou Peluso	Surgency
Ram Reddy	Tactica Strategy
Stanley Elbaum	Surgency
William Ulrich	Tactical Strategy Group

Appendix D – Additional Delphi Results



Note: Answers labeled as 'depends' to be interpreted as 'when convenient'.

Figure D-1 Part of Broader Supply Chain – Respondents by Segment

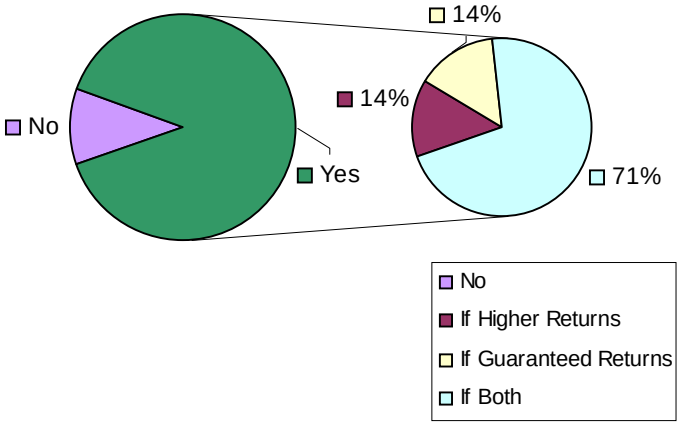


Figure D-2 Exchanging Operational Control for Compensation – Academia

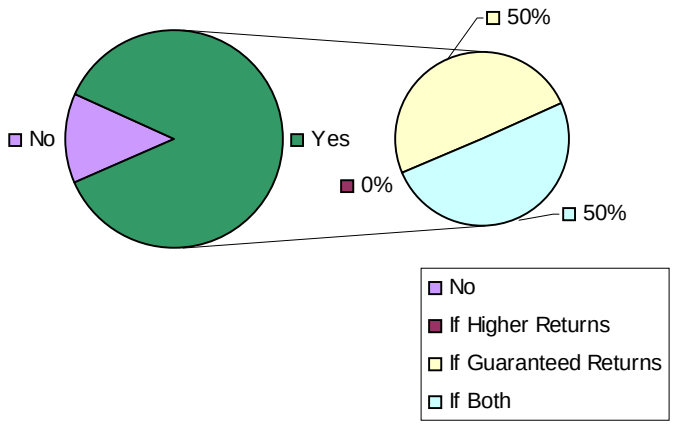


Figure D-3 Exchanging Operational Control for Compensation – Industry

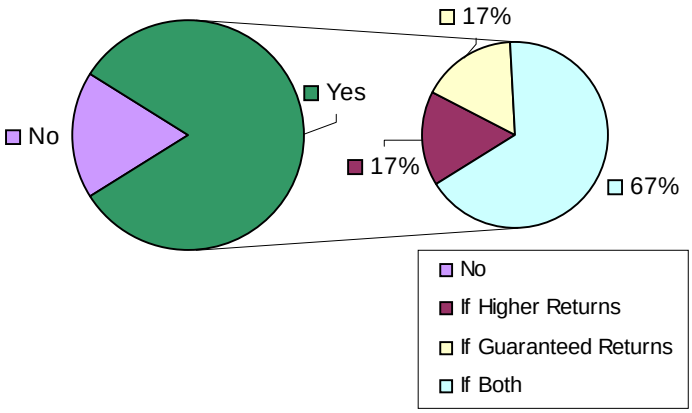
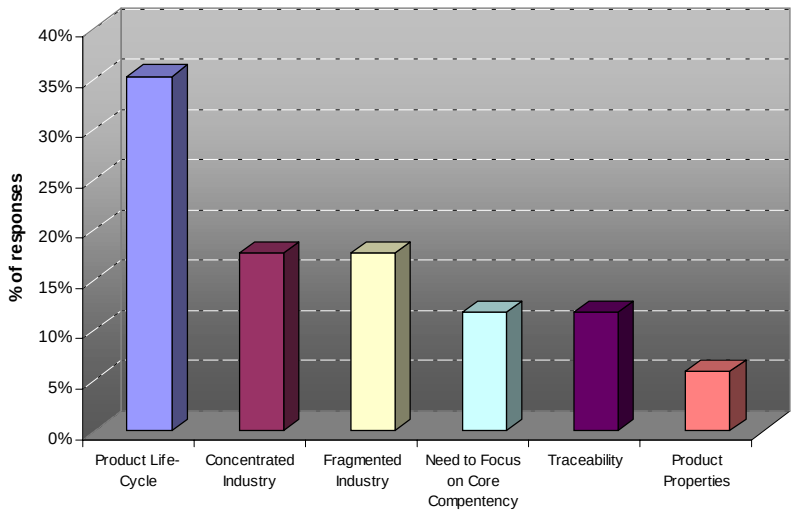


Figure D-4 Exchanging Operational Control for Compensation – Consulting



Note: A concentrated industry is the exact opposite of a fragmented industry, but each factor was listed individually because it conveys a different idea.

Figure D-5 Factors Driving Coordinated Networks

Glossary of Companies

3M- Minnesota Mining & Manufacturing manufactures and markets pressure-sensitive adhesive tapes, abrasives, and specialty chemicals. 3M also markets electrical & telecommunication products, medical devices, office supplies and major automotive parts.

Advanced Micro-Devices- The principal activity of AMD is the manufacturing of semiconductors with facilities in the US, Europe and Asia. The companies' products include semiconductors used in product applications such as telecommunications equipment, data and network communications equipment, consumer electronics, personal computers and workstations.

Ahold N.V.- Ahold, a Netherlands based company, is principally engaged in the operation of food retail supermarkets.

AMR Research- AMR is a Boston-based research firm, focused on providing information for the selection of manufacturing software applications such as ERP, MES, Supply Chain, and Logistics.

Accenture (formerly Andersen Consulting)- Accenture is a global provider of a wide range of information technology related consulting and management strategy services.

Applied Micro Circuits- Applied Micro Circuits develops, manufactures and markets high performance silicon solutions for the communications markets.

Atlas Commerce- Atlas Commerce builds contract and order management, logistics, and settlement software for supply chain hubs, communities, and marketplaces.

Ariba- Ariba provides comprehensive intranet- and Internet-based business-to-business electronic commerce solutions for operating resources. Ariba ORMS is a network application that operates primarily within a buying organization's internal network and Ariba Network is a global business-to business electronic commerce network that enables organizations, suppliers and distributors to automate procurement transactions on the Internet.

BAE Systems- BAE is UK based systems, defense and aerospace company and a contractor and systems integrator in the air, land, sea and space defense market sectors.

Baker Street Technology- Baker Street Technologies provides Internet hosted sell-side supply chain visibility and automation. Baker Streets creates collaborative fulfillment networks which synchronize the movement of products and cash across multiple trading partners and provides supplier measurement and analysis.

Benchmarking Partners (now Surgency)- Surgency is a global e-business solutions firm. In 1994 the firm received a multimillion dollar award from the U.S. National Institute of Standards and Technology to develop Internet-based trading partner networks. Surgency implemented the first B2B Internet commerce standard and was among the industry leaders to establish CPFR.

Best Practices Benchmarking- Best Practices, LLC is a consulting company providing services in the field of business operations benchmarking and process improvement.

Bose Corporation- The Bose corporation manufacturers high-end speaker and audio systems for market segments including entertainment, automotive industry, home audio, aviation, stadiums, arenas and auditoriums, computers, department stores, restaurants and retail businesses.

Canhers In-Stat Group- provides research in digital communications covering data, voice, video communications, wireless, and Internet technologies. The group also provides analysis to allow technology vendors and service providers to make more informed business decisions.

Celestica- Celestica, based in Canada, provides electronics manufacturing services including design, prototyping, assembly, testing, product assurance, supply chain management, distribution and after-sales services.

Cisco Systems- Cisco Systems is a supplier of networking equipment and network management for the Internet. Products include routers, hubs, Ethernet, LAN/ATM switches, dial-up access servers and software.

Comergent- Comergent is a vendor of sell-side e-commerce software solutions which delivers collaborative commerce applications to companies and their selling partners, covering the three different categories: interactive sales and marketing, collaborative commerce, and management and analysis.

Compaq Canada Corp.- Compaq Canada, with 3,500 employees and 41 offices, is a wholly owned subsidiary of Compaq Computer Corporation, marketing offerings comprised of hardware, software and services.

Covisint- Covisint is an electronic based exchange to provide procurement, supply-chain management, and collaborative product development services in the automotive industry.

CSC Consulting- CSC is one of the world largest information technology services providers. The company specializes in the application of advanced and complex I/T to achieve its customers' strategic objectives.

DAMA (Demand Activated Manufacturing Architecture Project)- The DAMA project is a collaborative research consortium working to shrink the supply chain which links the U.S. fiber, textile, sewn products, and retail industries.

Dell Computer- Dell designs, develops, manufactures, markets, services, and supports a range of computer systems, including desktop, notebooks, & enterprise systems. Dell also markets software, peripherals, service & support programs.

Eastman Chemical Company- The Eastman Chemical Company is a leading international chemical company that produces 400 chemicals, fibers and plastics. Eastman is the world's largest supplier of polyester plastics for packaging and a supplier of coatings raw materials, specialty chemicals and plastics

Ericsson- Ericsson, a Sweden based international manufacturer, specializes in advanced systems and products for wired and mobile communications in public and private networks. The Company also produces electronic defense systems.

European Aeronautic Defense and Space Company- EADS is a transnational manufacturer of space systems, military and commercial aircraft, aeronautics, and defense systems. The founding companies of EADS include Aerospatiale Matra (France), DaimlerChrysler Aerospace (Germany) and Construcciones Aeronauticas (Spain).

Federal Express- FeDex is a global provider of transportation, e-commerce and supply chain management services. Services offered by FedEx companies include worldwide express delivery, ground small-parcel delivery, less-than-truckload freight delivery, global logistics, supply chain management and customs brokerage, as well as trade facilitation and electronic commerce solutions.

Flextronics International- Flextronics provides electronics manufacturing services to OEMs in the networking, computer, medical, consumer, and telecommunications industries

Forrester Research- Forrester is an independent Internet research firm that conducts research and analysis on the impact of the Internet and emerging technologies on business strategy, consumer behavior and society.

Frito Lay- Frito Lay, a subsidiary of Pepsi Co., is a producer of chips and other snack foods.

Gartner Group- Gartner provides research and analysis of the computer hardware, software, communications and information technology related industries.

Glaxo Wellcome (now GlaxoSmithKline)- A subsidiary of London-based Glaxo Wellcome plc, the company is committed to fighting disease by bringing innovative medicines and services to patients and to the healthcare providers who serve them. The company's prescription medication line in the United States includes approximately 60 products.

Helix Technology- Helix provides critical enabling vacuum system technology to a broad range of electronic component manufacturers for the production of semiconductors, data storage & flat panel displays.

Hewlett-Packard- Hewlett-Packard is a global provider of computing and imaging solutions for business and individual consumers.

i2- i2 is a provider of planning and scheduling software for supply chain management.

InfoNow- InfoNow provides integrated Enterprise Channel Management (ECM) solutions. Software and services include licensed and/or hosted business services for e-commerce, lead generation and management, loyalty programs, customer profiling and traditional Partner Relationship Management (PRM).

Ingram Micro, Inc- Ingram Micro is a wholesale distributor of computer based technology products and services worldwide. IM markets microcomputer hardware, networking equipment, and software products to more than 175,000 resellers.

Intel Corporation- Intel is the maker of semiconductor chips, supplies the computing and communications industries with chips, boards, systems and software that are integral in computers, servers, and networking and communications products.

JB Hunt- J.B. Hunt Transport Services is US based transportation services and logistics company. J.B Hunt primarily transports full-load containerizable freight throughout the U.S. and portions of Canada and Mexico.

Kimberly Clark- Kimberly-Clark Corp. is principally engaged in the manufacturing and marketing throughout the world of a range of products for personal, business and industrial uses, mostly made from natural and synthetic fibers.

K-mart- Kmart Corp. is a mass merchandise retailer, operating discount department stores in all 50 states in the United States as well as Puerto Rico, Guam and the U.S. Virgin Islands.

Lucent Technologies- Lucent designs, develops and manufactures telecommunications systems, software and products.

Miandetta Farms Pty Ltd- Miandetta Farms is a specialist asparagus and pig meat producer. It has been supplying the Japanese market with asparagus since the mid-1980s.

Manugistics- Manugistics is a provider of intelligent supply chain optimization solutions for enterprises and evolving electronic business trading networks. Its solutions, which include client assessment, software products, consulting services for implementation and solution support, can be optimized to the supply chain requirements of companies.

Microsoft- Microsoft Corporation develops, manufactures, licenses and supports a range of software products, including scalable operating systems, server applications, worker productivity applications and software development tools.

Miller Electric- Miller is a contracting company that provides electrical services to commercial, healthcare, industrial, pulp & paper, communications, repair & maintenance, safety, and specialty services.

Miller SQA- Miller SQA is a unit of Herman Miller, engaged primarily in the design, manufacture, and sale of office systems, products, and services principally for offices.

Monsanto Company- Monsanto business units focus on discovering, manufacturing and marketing agricultural and biotechnology products, prescription pharmaceuticals, food ingredients and performance chemicals used in consumer products.

Nabisco (now part of Kraft Foods)- Nabisco is a $8.27 billion international manufacturer of biscuits, snacks and other premium food products. Nabisco markets products in the United States, Canada and more than 85 other countries.

Nistevo- Nistevo is a provider of web-based, collaborative logistics networks. The Nistevo.com network allows buyers, shippers and carriers to collaboratively manage the procurement and execution of logistics services throughout the supply chain via private and semi-private networks. Through this trusted partner network, organizations can share capacity, automate interaction with carriers and streamline their supply chain processes while carriers on the network optimize their capacity.

Pacific Foods- Pacific Foods, an Australian based company, is a supplier of primal and portion control meat cuts to the restaurant and hotel markets in Japan.

Penske Logistics- Penske Logistics, a subsidiary of Penske Corporation, provides complete logistics services in North America, Europe and South America.

Perdue Farms- Purdue is a producer, processor and marketer of chicken and poultry based food products.

PMC Sierra- PMC-Sierra designs, develops, markets and supports high-performance semiconductor networking solutions for use in the high speed transmission and networking systems of the global telecommunications and data communications infrastructure.

Procter & Gamble Company- The Procter & Gamble Co. markets a broad range of consumer products worldwide in five business segments: Laundry and Cleaning, Paper, Beauty Care, Food and Beverage, and Health Care.

RAND Corporation- The RAND Corporation is a nonprofit Institution, which performs research and analysis on policy improvement and decision-making.

SAP- SAP AG is an international developer and supplier of integrated business application software designed to provide cost-effective comprehensive solutions for businesses.

Sara Lee- Sara Lee is a global manufacturer and marketer of brand-name products in the foods, coffee & tea, household & body care, foodservice, and branded apparel industries.

Schneider National- Schneider National is a privately held, privately owned company that provides transportation logistics solutions focused on providing full truckload shipments. The company also provides information technology solutions to facilitate order entry, tracing and tracking and electronic proof of delivery.

Seagate Corporation- Seagate designs, manufactures and markets products for storage, retrieval and management of data on computer and data communications systems.

Siemens Diesel Technology- SDT is a subsidiary of Siemens Corp, focused in developing next-generation diesel fuel injectors.

Solectron- Solectron provides electronics manufacturing services to OEMs who design and sell networking equipment, workstations, personal and notebook computer peripherals, and telecommunications equipment.

Spartan Stores- Spartan Stores is a grocery wholesaler distributing to independently owned grocery stores in Michigan, Indiana and Ohio.

Swift Rivers- Swift Rivers provides solutions in the reverse logistics space to traditional and Internet based companies. Swift Rivers multi-channel solution links customers with resellers through the web, stores or call center operations.

Syncra Systems- Syncra Systems enables supply-chain collaboration via its industry-leading next-generation collaborative commerce technology. Through company extranets and industry trading exchanges, Syncra solutions help manufacturers, distributors, logistics providers and retailers to create collaborative networks.

Tactical Strategy Group- Tactical Strategy Group is a management-consulting firm that specializes in information and business planning strategies.

Target- Target Corporation is a general retailer focused on providing low price merchandise. Target operates 900 stores in 44 states.

Texas Instruments- Texas Instruments is a semiconductor company and a designer and supplier of digital signal processors and analog integrated circuits. In addition to semiconductors, TI has two other principal segments. Sensors & Controls sells electrical and electronic controls, sensors and radio-frequency identification systems to commercial and industrial markets. Educational & Productivity Solutions (E&PS) is a supplier of graphing and educational calculators.

The Limited- The Limited is engaged in the purchase, distribution and sale of women's and men's apparel, women's intimate apparel and personal care products.

Tilion Inc.- Tilion gives companies visibility into the status of their supply chain operations, particularly those components outside of a company's four walls. It provides a neutral, third-party service that collects relevant transaction data from supply chain processes across multiple systems and serves it to Tilion subscribers in the form of a consolidated, web-based analysis.

Transentric- Transentric provides software and e-commerce message exchange services to improve visibility all along the supply chain - from shippers and carriers to 3rd party logistic providers, consignees and e-commerce enterprises. This technology makes it possible to provide aggregated, complete, real-time inventory visibility along with connectivity, data control and technical services.

Transora- Transora is an online marketplace linking suppliers, distributors, and retailers in the consumer products industries.

Tyson Foods- Tyson Foods is a fully integrated producer, processor and marketer of chicken and poultry-based food products. The company also produces corn and flour tortillas and supplies chicken breeding stock.

United Parcel Service- UPS is primarily engaged in the delivery of packages and documents throughout the United States and in over 200 other countries and territories. UPS also provides logistics services, including supply chain management.

Voluntary Interindustry Commerce Standards (VICS)- Since 1986, VICS, the Voluntary Interindustry Commerce Standards Association, has worked to improve the efficiency of the entire supply chain. VICS establishes cross-industry standards that simplify the flow of product and information in the general merchandise retail industry for retailers and suppliers alike.

Wal*Mart- Wal-Mart operates discount department stores (Wal*Mart), warehouse membership clubs (Sam's Clubs) and a combination full-line supermarket & discount department store (Wal-Mart Supercenters) in the U.S., Puerto Rico, Mexico, Indonesia, Canada, Argentina, China and Brazil. Revenue for fiscal 2000 was roughly $200bn.

Warner Lambert (now part of Pfizer)- Warner Lambert is a global pharmaceutical and consumer products company, which discovers, develops, manufactures and markets innovative medicines for humans and animals.

Wegmans- Wegmans is an east Coast supermarket retailer Wegmans offers in-store eateries as well as selections of private-label products and natural and health foods. With 57 markets located primarily in upstate New York, Wegmans has about $2 billion in annual sales.

Wood Fisheries- Wood Fisheries is a fish trawling and export company, specializing in the sale of Stout Whiting (Sillago robusta) to Japanese and other Asian markets.

World Wide Retail Exchange- The World Wide Retail Exchange (WWRE) is a retail-focused electronic business-to-business marketplace.

Xerox Corporation- Xerox Corp. is engaged in the global document market, providing document solutions that enhance business productivity, including digital publishing, printing and copying equipment, and light-lens copiers and duplicators.

Zara- Zara, based in Spain, is a global specialty retailer that operates stores selling casual apparel for men and women. The chain owns most of the apparel channel, outsourcing some sewing, but keeping most activities in house to ensure fast responsiveness to fashion trends. The supply chain responsiveness time is approximately 2-3 weeks for most products allowing the company to quickly react to 'hot' selling items.

Zefer- Zefer is a strategy-led Internet consulting and services firm.

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