Supply Chain Collaboration

By

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Massey University
2004

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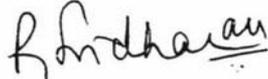**Candidate's Name: Togar Mangihut Simatupang**

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Te Kunenga ki Pūrehuroa

Inception to Infinity: Massey University's commitment to learning as a life-long journey

Supply Chain Collaboration

A thesis presented in
partial fulfilment of the requirements for
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Abstract

There is general acceptance within the literature that supply chain collaboration will become a focus area for research in supply chain management. Although collaboration has been examined widely in a variety of different contexts, relatively little attention has been given to systematically drawing them together. This study is thus conducted to offer an integrative framework in the context of an interorganisational supply chain to define collaboration by identifying its different elements and provides empirical evidence to support the theoretical framework. This framework would further allow the participating members to understand and examine the strategic importance of these elements of collaboration and what needs to be done to gain the benefits of collaboration.

The study includes a literature review, the discontent model, a theoretical framework for supply chain collaboration, measuring the level of supply chain collaboration, supporting the theory with empirical evidence, an innovative scheme for benchmarking, and an empirical study of benchmarking supply chain collaboration.

The theoretical framework offered in the study incorporates the five elements of collaboration, namely, a collaborative performance system, information sharing, decision synchronisation, incentive alignment, and streamlined intercompany business processes. To provide empirical evidence, supply chain collaboration between retailers and suppliers was chosen as a unit of analysis and data were collected from a survey of New Zealand companies.

Based on the survey results, the three empirical studies reported in this thesis provide the basis for testing a new measure for the extent of supply chain collaboration, testing the hypotheses on the relationship between supply chain collaboration and operational performance, and presenting the benchmarks for classifying high and low performing supply chains. Empirical evidence shows that collaboration between retailers and suppliers has a significant influence on operational performance.

Why Collaboration?

As iron sharpens iron, so one man sharpens another.
Proverbs

Two are better than one, because they have a good return for
their work.
Ecclesiastes

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In the effort of completing this thesis over the past four years, a great many people have provided me with invaluable help along the way. I must acknowledge those whose help made this work possible. I would like to thank my doctoral supervisor, Ramaswami Sridharan, for his guidance and constant encouragement throughout this research. Sri has been a thoughtful guru and a good friend of mine who spent a lot time with me in debating and discussing the subject matter and kept me on the right track. I am also grateful to my co-supervisor, Alan C. Wright, for his counsel and support. Alan has been instrumental in developing my critical thinking ability to analyse and synthesise the subject matter.

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Table of Contents

List of Tables

List of Figures

Chapter 1
Introduction

1.1. Background

The underlying trends in supply chain management have increasingly influenced independent companies or autonomous divisions along the supply chain to move away from adversarial towards cooperative arrangements (Bowersox, 1990; Sherman, 1998; Spekman *et al.*, 2000). These trends stem from several driving forces on both the demand and supply sides of the chain. There are two key driving forces on the demand side, namely globalisation and mass customisation. Globalisation provides plentiful opportunities to multinational firms to capitalise on economies of scale and scope in research, product development, and manufacturing. Further, they can expand their operations to capture increasingly similar demands of end users for global products. To tap these potential opportunities, they must deal with logistics problems such as long delivery lead times, outsourcing vendors who are located on a different side of the globe, complex transportation costs, high buffer stock, and complex transaction costs including tax and foreign exchange.

Mass customisation is characterised by more demanding customers who require expanding product varieties (Harrison and Van Hoek, 2002; Pine *et al.*, 1993). Nowadays customers have more options of products and purchasing power to decide which goods or services can satisfactorily fulfil their needs. To satisfy customer needs, companies compete by frequently introducing new products (Abernathy *et al.*, 2000). The escalating rates of product introductions cause shorter life cycles of various products and services. Fashion goods, toys, personal computers, and food are examples of innovative products that experience shorter life cycles (Fisher, 1997). Shorter life cycle products in turn provide more product varieties. A competitive environment with a mass of product varieties has a high degree of demand uncertainty. Only a quick response supply chain can survive in an environment with high demand uncertainties (Blackburn, 1991; Fisher, 1997). Otherwise, a supply chain

1

will suffer from a mismatch between demand and supply and will experience adverse outcomes such as price markdowns, stock outs, and excessive inventories.

On the supply side, there are three underlying trends that drive chain members to cooperate with each other. First, innovations arise from the application of information technology on supply chain processes (Harrison and Van Hoek, 2002; Simchi-Levi *et al.*, 2000). The use of information technology enables companies to link directly to their customers, suppliers, and partners around the world. This trend provides an opportunity to manage more complex logistic processes. Information technology and communications radically change how both individuals and firms work together along a supply chain (Kalakota, 2000). The predominant example of the use of information technology in a supply chain is quick response initiative (Blackburn, 1991). An effective information architecture that accommodates all suppliers in the channel enables them to shorten their replenishment cycle thereby providing customers with easy access to specific products and specific markets. Hammond (1993) found that the apparel industry could cut total channel time from 125 to 30 days and further perhaps to just 10 days. By implementing a quick response initiative, the U.S. apparel industry alone could save more than $12 million annually.

Second, retailing is a prevalent driver of supply chain management (Fisher, 1997; Poirier and Reiter, 1996). Nowadays retailers who operate in increasingly competitive markets and who suffer narrowing margins need to carry less inventory and require quicker response from their suppliers (Abernathy *et al.*, 2000; Burt, 1989). Logistics innovations such as vendor-managed inventory (VMI), efficient consumer response (ECR), and collaborative planning, forecasting, and replenishment (CPFR) are increasingly adopted by suppliers and retailers to improve their logistics performance (Barratt and Oliveira, 2001). Retailers then are able to introduce new incentives such as everyday low pricing and money back guarantees to attract end customers. Moreover, virtual retailing (armed with information technology) enables customers to access products and services more quickly than ever before. Customers can place orders at any time from any place such as from both home and office. For instance, internet retailing provides customers with abundant information, and retailers with unlimited shelf space, and reduced transaction costs. Internet retailing becomes a direct channel for customers who seek lower transaction costs. Consequently, all

players - including manufacturers, distributors, and retailers - should rethink their roles to serve customers better in this era of convenient retailing.

Third, innovations in manufacturing processes - such as just in time (JIT) oriented logistics - make the whole supply chain dependent on time-sensitive delivery of products and services. Time-based performance becomes a key driver to chain members to improve overall supply chain performance (Blackburn, 1991). By adopting JIT, the manufacturing companies meet the need to move goods and services quickly and match up with a huge increase in freight traffic along the supply chain (Bhatnagar and Viswanathan, 2000; Gill and Allerheiligen, 1996).

The above underlying trends imply a more competitive environment that forces firms to develop a win-win solution in creating value for end customers (Poirier, 1999). Creating a win-win solution is known as the "pie expansion initiative" (Jap, 2001). The pie expansion initiative refers to the collaborative process of creating mutually beneficial outcomes between participating members. This collaboration enables chain members to create strategic advantage and achieve a much better financial performance than they could expect working in isolation (Simatupang and Sridharan, 2002). Examples of pie expansion in a supply chain can be found in the marketplace. For instance, Xerox collaborates with Avery Dennison to develop new concepts to effectively deliver products to end customers (Seafort and Ercole, 1996). This collaboration was aimed at attaining shorter lead times, lowering overall inventory, and increasing profitability. Avery Dennison received sales and volume guarantees, an enhanced understanding of their customers' needs, and a strong position with Xerox for future sales. Similarly, Wal-Mart focused on the creation of optimal inventory levels and non-price benefits by delegating stocking authority decisions to its main suppliers (Hammond, 1993). Both parties received several valuable outcomes. Wal-Mart reduced lost sales and stocking costs, whereas its main suppliers received increased revenues, reduced ordering costs, and better brand loyalty.

1.2. Justification of the Study

As business increasingly relies on other companies in industrial and consumer products, the need to effectively manage external relationships is of considerable

importance. The ability to achieve effective collaboration becomes a strategic imperative in the era of information and globalisation. Collaboration with downstream and upstream members provides an opportunity to the company to ensure growth and reduce costs. A recent survey on e-business carried out by the Institute for Supply Management and Forrester Research revealed that more than half the responding companies (52%) reported collaborating with suppliers online (Carroll, 2002). This finding indicates that collaboration would be increasingly required in order to increase transparency, which enables chain members to reduce transaction costs, eliminate rework and error, and cut order cycle times. Based on a survey of 150 senior executives at Fortune 1000 companies across various industries, Accenture found that fifty-four percent of the respondents mentioned that developing collaboration in demand and supply planning with their suppliers and customers was very important (*Material Handling Management*, 2002). The survey confirmed the importance of sharing detailed information with suppliers and customers. Information sharing enables chain members to improve visibility in their supply chain operations and thereby helps them to increase efficiencies and ultimately reduce costs. Similarly, a recent survey of 2,000 US manufacturers, conducted by Gemini Ernst & Young and Industry Week, strongly verified that collaboration in information sharing resulted in positive benefits such as timelier delivery of goods, reduced inventory costs, and enhanced product quality (Dubin, 2001).

Besides the popularity of supply chain collaboration in mass media such as newspapers and business magazines, it has been recognised that the academic community should pay serious attention to the phenomenon of supply chain collaboration (Bowersox, 1990; Kopczak, 1997; Kumar, 1996). There are several reasons for conducting research on supply chain collaboration. The first reason for researching supply chain collaboration is that, although many companies realise the economic value of pipeline inventory, it remains relatively underexplored by chain members. The value of pipeline inventory that spans across companies along the supply chain is quite large. Fuller *et al.* (1993) estimated that the grocery pipeline inventory alone carried an inventory value of $75-100 billion, which comprised one-quarter to one third of annual sales (estimated at $300 billion). There is a certain irony that chain members have paid little attention to tapping the potential of supply chain collaboration to reduce the associated costs of pipeline inventory in spite of knowing

4

the enormous benefits such collaboration would bring. Kurt Salmon, for instance, found that the apparel pipeline - as a $125-billion per year industry - had a $25-billion efficiency loss (Blackburn, 1991). A large proportion of that efficiency loss (64%) happened in retailing, when events such as markdowns, out-of-stock items, and excess inventory costs occurred. Similarly, a recent study of the U.S. food industry estimated that poor coordination among chain members wasted around $30 billion annually (Fisher, 1997). Additionally, the KPMG Supply Chain Management Survey shows that the IT spend of New Zealand companies in supporting the supply chain is 1.5 percent of sales, whereas companies in U.S. and U.K. normally spend around 1.8-2 percent (Newman, 1998). The survey also showed that demand planning is rated as the most important supply chain process internationally, but that New Zealand companies had focused on inventory management that often undermined customer service.

Second, the productivity levels of collaborative firms are setting new standards of performance worldwide. For example, while most firms in the discount retail industry have struggled to survive because of fierce competition, high operating costs, and shrinking net profit margins, Wal-Mart has been singularly successful earning normal economic profits. One important reason for the competitiveness of Wal-Mart is its collaboration with its main suppliers, which emphasises synergistic problem solving to provide better value to customers (Kumar, 1996; Parks, 2001; Poirier, 1999). There is a considerable opportunity to increase profits through supply chain collaboration that coordinates decisions across purchasing, transportation, and inventory management. Bain & Company has identified this opportunity in an extensive survey (Cook and Tyndall, 2001).

The third reason is the basic fact that with the wide adoption of supply chain collaboration across all sectors, it has had a tangible impact upon the survival of companies in material and financial terms (Austin, 1998; Davidow and Malone, 1992; Dell and Fredman, 1999). Customers and shareholders no longer tolerate supply chain failures. Cook and Tyndall (2001) reported that the supply chain's deficiencies jeopardise the company's goodwill and stock prices. For example, Hershey lost a large proportion of its market share due to its inability to deliver high volumes of its Twizzler candies and Kisses chocolates in time for Halloween (Cook and Tyndall,

2001). The announcement of such supply chain's deficiencies was reported to affect stock prices decreasing them as much as 12 percent and shareholder wealth dropping by at least $120 million per company (Cook and Tyndall, 2001). Sodhi (2003) also noticed that failure to create supply chain integration was the main reason for inadequacy in enhancing shareholder value. In summary, the pervasiveness of the supply chain collaboration movement throughout North America, Asia-Pacific, Europe, and elsewhere is appreciated by mass media and managers and has had a significant impact upon the sustainability of many companies. Consequently, the costly failures of supply chains constitute a serious challenge for researchers. They must carefully examine the collaborative processes to understand how to develop better supply chain operations.

Fourth, supply chain collaboration is a paradigm shift from arm's-length relationships which focus on a "zero-sum" strategy to collaborative relationships which emphasise a "positive-sum" strategy (Johnson and Lawrence, 1988; McNary, 2003; Nalebuff and Brandenburger, 1996). Through collaboration, independent companies are able to create and capture a larger economic share, which benefits all participating members. Therefore, supply chain collaboration has been regarded as the frontier research topic in supply chain management (Frankel et al., 2002; Horvath, 2001; Lee et al., 1997; Sodhi, 2003; Spekman et al., 1998). The Supply Chain Council has also recently promoted collaborative planning, forecasting, and replenishment (CPFR) as a new strategy to build supply chain collaboration (Barrat and Oliveira, 2001; Sherman, 1998). Since the new trend of supply chain collaboration is still evolving, true success stories of its implementation are scarce (Bowersox et al., 2003; Moberg et al., 2003; Sabath and Fontanella, 2002). Furthermore, although diverse literature from operations management, information systems, and economics have recently appeared to explain the phenomenon of supply chain collaboration, relatively little attention has been given to bringing them into a more comprehensive approach toward improving supply chain collaboration (Trienekens and Beulens, 2001). There is a consequent need to further explore supply chain collaboration both in theory and in practice. The results of this study will add to the understanding of various elements of supply chain collaboration required to succeed in realising the value of collaboration. This study will also provide empirical evidence by examining the relationship between the practice of supply chain collaboration and supply chain performance.

6

The fifth reason for the importance of supply chain collaboration is that academics are beginning to take notice when consultants disseminate the wisdom of supply chain collaboration to the larger public (Fawcett and Magnan, 2002; Rigsbee, 2000). Consultants have launched a number of collaborative initiatives under different brands such as efficient consumer response (ECR), vendor-managed inventory (VMI), and collaborative planning, forecasting, and replenishment (CPFR) (Barratt and Oliveira, 2001; Sharpe and Hill, 1998). Although ECR and CPFR have been fully implemented in the grocery industry, this industry still carries more than an average of 14 weeks of inventory valued at about \$300 billion (Moberg *et al.*, 2003). There is a large gap between what has been achieved in practice and what consultants have promised. Consequently, academics need to provide an alternative source for the acquisition of supply chain knowledge that is examined and presented to ensure validity, generalisability and replicability of supply chain collaboration. Therefore, it is in the basic interests of academics to become actively involved in research on supply chain collaboration.

1.3. Problem Statement

Supply chain collaboration is not merely a new buzzword introduced to capture the imagination of current trends in supply chain management. It is a novel approach to a business relationship between independent companies; a shift from the antagonistic bargaining style that is dominantly oriented towards lowered prices, to a synergistic problem solving style that predominantly focused on "value creation" (Bowersox, 1990). The concept and its contribution for participating firms have been studied extensively in recent years to explore how to better utilise it in interorganisational settings. Attention has been diverted from an internal to an external perspective in explaining better performance (Spekman *et al.*, 1998). However, there are quite a few possible obstacles to the implementation of supply chain collaboration (Cook and Tyndall, 2001). The literature is beginning to reveal cases where applying supply chain collaboration failed to produce positive impacts on performance (Betts, 1994; Fisher *et al.*, 2000; Moberg *et al.*, 2003). Part of the reason includes misunderstanding about supply chain collaboration as an outsourcing means of volume guarantees and shifting responsibility to other members without appreciating the total picture of

collaboration (Bowersox *et al.*, 2003; Simatupang and Sridharan 2002). Consequently, this current research attempts to address the gap between theory and practice.

The subject of this research is the management of interorganisational boundaries of supply chain collaboration. The purpose of this research is to offer an integrative framework for supply chain collaboration. This framework would further allow the participating members to understand and examine the strategic importance of interorganisational designs and what is needed to be done to gain the potential benefits of collaboration. There are four research questions associated with the attainment of the main purpose.

An attempt at discussing and examining interorganisational boundaries of supply chain collaboration requires defining them and finding characterisations that prevent ambiguity amongst the participating members. The framework used should reflect design and implementation characteristics. The framework should also enable chain members to understand the links between important elements in supply chain collaboration (Bowersox, 1990). Simplicity and straightforwardness are considered prerequisites for the representation of the framework. This leads to the first research question: *How can interorganisational boundaries be characterised in such a way that chain members as well as researchers can understand and (re)structure their elements?*

An evaluation of the strategic importance of interorganisational boundary factors requires insight regarding the relationship between these factors and performance. There is a need for empirical investigation which tests the hypothesis that a greater level of collaboration is positively related to better performance. The second research question, therefore, is the following: *Is there a relationship between the practice of supply chain collaboration and operational performance?*

Given the importance of the interorganisational boundary concept to supply chain collaboration, relatively little research has been conducted on the widely accepted relationship between the level of collaboration and interorganisational performance (Ramdas and Spekman, 2000; Simatupang and Sridharan, 2004a). The paucity of such research could be the result of the difficulties in measuring the extent of collaboration.

If collaboration plays such an important role in supply chain management, there is a consequent need for finding a means of measuring it (Bowersox *et al.*, 2003). The third research question is thus: *How to measure the extent of supply chain collaboration?*

Finally, developing a means of measuring the concept of supply chain collaboration should enable chain members to assess their performance *vis-a-vis* their competitors. This calls for understanding benchmarking of the collaborative practices and operational performance. Consequently, the fourth research question is: *How to benchmark collaborative activities that lead to better performance?* More specifically, *If there are performance differences in the companies, what collaborative practices account for these differences?*

1.4. Research Method

Supply chain collaboration implies that chain members become involved in coordinating activities, that span the boundaries of their organisations, in order to fulfil end customer needs (Bowersox, 1990; Harrison and Van Hoek, 2002; Simatupang and Sridharan, 2002). This collaboration shifts the focus of supply chain management away from simply looking within the four walls of the individual member organisation, to how chain members interact with each other to create an agile supply chain which contributes to competitive advantage. There are three key assumptions underlying the study of supply chain collaboration. First, the supply chain performance is explained by how chain members manage across their boundaries. Previous studies provide empirical evidence that supports this first assumption (Bowersox, 1990; Lee *et al.*, 1997; Spekman *et al.*, 1998; Stank *et al.*, 1999). The first assumption is based on the premise that independent chain members choose to collaborate because they can presumably provide better services to customers collectively than individuals are capable of producing alone and thus generate a larger economic opportunity set. The complementarity of resources is a key reason that collaboration exists (Barney, 1999; Dyer *et al.*, 2001). Supply chain collaboration can be viewed as a focal point for a set of agreements among resource owners who voluntarily cooperate with each other to benefit each party.

Second, the key to effective supply chain collaboration is the careful selection of the levels of coordination structure that drive supply chain performance (Simatupang and Sridharan, 2004a). Chain members need to choose interorganisational design variables that contribute most directly to overall performance. Previous literature recommends that chain members need to design a supply chain strategy that fits various levels of demand uncertainties (Fisher, 1997; Lee *et al.*, 1997). This second assumption aims to address the general problem of controlling chain members' behaviour and describes how the interorganisational boundaries can influence behaviour. Individual chain members will maximise their own profitability, sometimes to the detriment of the other members' profitability, unless provided with proper interorganisational settings - such as incentives - to do otherwise.

Third, interorganisational settings across boundaries of chain members change over time because of competitive and environmental changes. This assumption implies that chain members need to regularly re-evaluate their interorganisational settings to determine the necessity for redesigns.

On the basis of the three assumptions above, this study employs multiple research methods including exploratory, conceptual, descriptive, and explanatory methods (Cavana *et al.*, 2001; Churchill and Iacobucci, 2002). The four research questions introduced in Section 1.3 are addressed in the following seven chapters of this thesis. Chapters 2, 3, and 4 relate to the conceptualisation of supply chain collaboration as stated in the first research question. The major emphasis of this stage is on the discovery of insights and research gaps in order to generate possible explanation for the concept of supply chain collaboration. A taxonomy is developed in Chapter 2 to elicit different research foci relevant to supply chain collaboration. This taxonomy provides a simple and straightforward lens with which to locate and identify the specific focus of supply chain collaboration. Identifying common objectives for the specific research area also enables one to seek the possibility of complementarity. The taxonomy presented here is thus able to unite relatively fragmented research on supply chain collaboration and to recognise directions for further research.

In Chapter 3, a study on supply chain discontent showed the paucity of previous work in examining completely the sources of discontent that contribute to lowered

performance. Multiple sources of supply chain discontent include incongruent strategic objectives, disintegrated performance systems, information asymmetry, unsynchronised decision making, misaligned incentives, and fragmented intercompany business processes. The discontent model assumes that chain members are responsible for identifying and mitigating sources of supply chain discontent. Findings from the discontent study are then adopted to develop a theoretical framework.

In Chapter 4, a conceptual model is offered to address the first research question in this thesis which is the characterisation of interorganisational boundaries between chain members. At the theoretical level, this research highlights incomplete characterisation of different aspects of supply chain collaboration found in previous studies. It is shown that interorganisational boundaries between chain members can be represented by five elements, namely appropriate performance metrics, information sharing, decision synchronisation, incentive alignment, and integrated intercompany business processes. Chain members can employ these five elements to (re)structure their interorganisational boundaries to motivate individual members to make choices that increase their collaborative value. What previous studies typically have not addressed is the complementarity of these five elements. The basic premise of the conceptual model is that performance is a result of the interactions and dynamics among the five elements of supply chain collaboration. This framework thus serves to clarify the theoretical basis for studying the practice of supply chain collaboration.

The model described in the theoretical framework was used to examine the practice of supply chain collaboration using a cross-sectional survey of 400 New Zealand companies. The unit of analysis is the collaborative contact between suppliers and retailers because the intention is to understand the behaviour of chain members in collaborative practices rather than that of an individual chain member. There are 76 firms participating in the study that represent a range of product categories, including clothing and footwear (22%); food and beverages (21%); home improvement, building supplies, tools and furniture (20%); electronics and appliances (18%); stationery and toys (11%); and health products (8%).

A questionnaire was sent to each respondent. The content of the survey is around the three dimensions of supply chain collaboration that act as enabling factors in the practice of supply chain collaboration, namely information sharing, decision synchronisation, and incentive alignment. Two classes of questions were employed in this research: those that asked about behaviour in the practice of supply chain collaboration and those that asked about attitudes about supply chain collaboration (Sudman and Bradburn, 1982). Behavioural questions are required to capture facts or things respondents have done relating to the practice of supply chain collaboration, whereas questions about psychological states are important to elicit respondents' opinions about supply chain collaboration. The questionnaire was developed based on these two classes of questions. The first part of the questionnaire sought general information about the respondent. The second part consisted of items representing the behavioural practices of supply chain collaboration. The third part contained items about specific perceptual opinions on the practice of supply chain collaboration. Items about performance measures were outlined in the last part of the questionnaire. Data from answers to questions about attitudes towards the practice of supply chain collaboration are used to test the hypotheses (see Chapter 5). The answers to behavioural questions are used in the studies of measuring supply chain collaboration (see Chapter 6) and benchmarking supply chain collaboration (see Chapter 8).

During the development of questions, a panel of experts was asked to verify and modify questions in the questionnaire. Furthermore, information from interviews of key informants in a retailing company which took part in this research was also used to refine questions in the questionnaire. Using key informant techniques for content validity has been found to be effective for survey research (Cavana *et al.*, 2001).

Chapters 5 to 8 of the thesis involve the following content: (i) an explanatory study for testing hypotheses to explain the relationship between the practice of supply chain collaboration and operational performance, (ii) a descriptive study for developing and testing a measure for the extent of supply chain collaboration, (iii) a conceptual model for benchmarking supply chain collaboration, and (iv) an empirical study to examine the benchmarking of collaborative practices in New Zealand companies. The four chapters are thus organised as follows. An empirical study was conducted focusing on hypothesis testing, which attempted to explain the relationship between supply chain

collaboration and operational performance. At this empirical level, it examines the evidence regarding effects of supply chain collaboration on performance. This evidence serves to clarify the importance of supply chain collaboration in improving performance. Data analysis was carried out to investigate the effects of the three dimensions of supply chain collaboration, namely information sharing, decision synchronisation, and incentive alignment, on operational performance.

A collaboration index is developed to answer the third research question about measuring the extent of supply chain collaboration. Newly created indicators were used to measure the extent of collaboration contained in the research model. The survey results showed that the scales for measuring the extent of supply chain collaboration were reliable and valid.

A conceptual study of benchmarking provides the theoretical framework for supply chain collaboration that incorporates a collaborative performance system and the three dimensions of collaboration. The three dimensions of collaboration, namely decision synchronisation, information sharing, and incentive alignment, provide the basis for chain members to examine the current enabling practices that drive performance metrics.

An empirical study on benchmarking supply chain collaboration is presented in Chapter 8. The scales tested previously in the study of measuring supply chain collaboration were employed in this study. The benchmarking study provides insights that will help in understanding the ongoing practices of supply chain collaboration that contribute to operational performance.

1.5. Contributions of the Study

The scientific contribution of this research is fourfold. First, a new conceptualisation of supply chain collaboration is proposed based on the strategic boundary dimensions which are important to practitioners but which have not been used in previous studies. In particular, a framework is developed as an integrative representation for supply chain collaboration. The integrative framework developed in this research consists of five elements, namely collaborative performance system, information sharing,

decision synchronisation, incentive alignment, and streamlined intercompany business processes. This proposed framework provides both a descriptive and an explanatory framework for critically examining the key elements of supply chain collaboration. There is no published research prior to this study that explores the complementarity of key elements of collaboration at the interorganisational level (Simatupang and Sridharan, 2004b). The framework proposed in this research enables the extension of the concept of supply chain collaboration from an intraorganisational focus to an interorganisational focus.

The second contribution is the provision of empirical evidence that justifies the conceptual model. More specifically, using the conceptual model, this research investigated the effects of supply chain collaboration on performance empirically. The results of regression analyses showed that collaborative practices positively contribute to operational performance. The findings of this study suggest that operational performance is dependent upon the current status of information sharing, decision synchronisation, and incentive alignment. This, in turn, provides guidance on how to identify necessary changes to improve performance.

The third contribution is the development of new instruments to operationalise the concept of collaboration. The extent of collaboration is represented by three dimensions, namely information sharing, decision synchronisation, and incentive alignment. The items for each dimension were developed based on the literature and verified using a panel of experts including both researchers and practitioners. Data analysis from the survey showed adequate levels of reliability and validity of the scale. A collaboration index was also developed as a new composite to measure the extent of supply chain collaboration. The survey results showed a strong correlation between the collaboration index and operational performance, which confirmed the concurrent validity of the proposed instrument.

The fourth contribution of this research is the development and testing of a benchmarking scheme for supply chain collaboration (Simatupang and Sridharan, 2004a; 2004b). Little attention has been given in previous work to explicitly showing the relationship between the practice of supply chain collaboration and operational performance. In addition, the previous work in benchmarking often operates at the

intracompany level (Basnet *et al.*, 2003; Knuckey *et al.*, 2002). This study contributes to the literature by initiating benchmarking study at the intercompany level. Empirical evidence on the benchmarking study allows practitioners to know not only the collaborative practices that drive performance but also why they do so, and therefore it improves understanding of how to manage supply chain collaboration.

The results of this study will be valuable to academics, consultants and practitioners involved in the study of supply chain collaboration. Academics receive insights into new concepts and empirical evidence of supply chain collaboration. They also receive better understanding of the interplay between different aspects of collaboration. Managers and consultants who are responsible for collaboration should be able to use the results to explain the value of examining their ongoing collaborative practices. They would be able to use a common view based on an integrative framework proposed in this study, namely performance metrics, information sharing, decision synchronisation, incentive alignment, and streamlined intercompany business processes. Through intimate dialogue they will be able to identify design variables that need to be redesigned or restructured in order to improve overall performance. It is expected that the integrative framework developed here will help mitigate the conceptual challenge and generate more insights in research on supply chain collaboration.

The basic concepts, theoretical framework, and empirical evidence of this research have been published in proceedings and refereed journals. The intent of this dissemination is to obtain comments and critiques from peer reviewers to enhance the model and process of the research. Simatupang *et al.* (2000) highlighted the basic idea of this research, which addressed the problem of asymmetric information and misaligned incentives in a supply chain. Simatupang and Sridharan (2001) explored and characterised information sharing in supply chains. Simatupang *et al.* (2002) and Simatupang and Sridharan (2002) identified elementary enablers of managing supply chain collaboration. Simatupang and Sridharan (2004a) provided a conceptual model for benchmarking supply chain collaboration and Simatupang and Sridharan (2004b) presented its empirical evidence. Finally, Simatupang and Sridharan (2005) discussed the discontent model that attempts to identify and mitigate its sources.

1.6. Outline of the Study

The thesis comprises nine chapters. The first and last chapters serve to link the relationship between chapters in between. Chapters 2 to 8 are structured in a way that allows the thesis to be presented as independent but related studies of the supply chain collaboration phenomenon.

Chapter 1 clears the foundation for the rest of the thesis. The justification for and purpose of the study have been set out in this chapter along with an introduction to the research method used to investigate the phenomenon of supply chain collaboration.

In Chapter Two, the literature on supply chain collaboration is reviewed. The first part of the review examines the recent emergence of supply chain collaboration as a critical concept in supply chain management. This is followed by development of a research taxonomy in supply chain collaboration. Interorganisational norms and the nature of linkages across the boundaries of chain members are two factors used to develop the taxonomy. The taxonomy was used to identify different foci of previous work that can be divided into four research streams: interorganisational information systems, interorganisational business processes, interorganisational incentive schemes, and interorganisational performance systems.

In Chapter Three, a discontent model is presented. This model argues that the main responsibility of chain members is to identify and mitigate discontent that prevents them from achieving better performance. Multiple sources of discontent identified in this chapter include incongruent strategic objectives, disintegrated performance systems, information asymmetry, unsynchronised decision making, misaligned incentives, and fragmented intercompany business processes. The antidotes for discontent are also presented in this chapter.

An integrative framework for supply chain collaboration is described in Chapter Four. This integrative framework consists of five elements, namely collaborative performance system, information sharing, decision synchronisation, incentive alignment, and streamlined intercompany business processes. This framework is also

16

shown to be useful to augment the collaborative planning, forecasting, and replenishment (CPFR) model.

Chapter Five provides an empirical study of supply chain collaboration. The effects of information sharing, decision synchronisation, and incentive alignment on operational performance are investigated in this chapter. Data analysis shows a positive link between supply chain collaboration and operational performance.

The collaboration index used to measure the extent of supply chain collaboration is presented in Chapter Six. The scales developed in this chapter include items for information sharing, decision synchronisation, and incentive alignment as well as operational performance. Data analyses show that the scales achieve adequate levels of reliability and validity.

A theoretical framework for benchmarking supply chain collaboration is described in Chapter Seven. This framework attempts to link the three dimensions of supply chain collaboration as enablers and supply chain performance. The three dimensions are information sharing, decision synchronisation, and incentive alignment. This framework is also shown to be useful for developing collaborative performance systems that span the interorganisational boundaries of chain members.

The results of the empirical study on benchmarking are given in Chapter Eight. This empirical study showed which practices of supply chain collaboration differentiate between high and low performers.

In Chapter Nine, the conclusions drawn from the study, implications of the findings, and areas for future research are presented.

Chapter 2
A Taxonomy of Supply Chain Collaboration

2.1. Introduction

The productivity levels of collaborative firms are setting new standards of performance worldwide (Cook and Tyndall, 2001; Dyer and Ouchi, 1993; Spekman *et al.*, 2000). Collaboration with downstream and upstream members that coordinates decisions across purchasing, transportation, and inventory management provides a considerable opportunity to a company to increase profits and reduce costs (Harrison and Van Hoek, 2002; Stewart, 1995). For example, while most firms in the discount retail industry have struggled to survive because of fierce competition, high operating costs, and shrinking net profit margins, Wal-Mart has been massively successful by earning normal economic profits. One important reason for its competitiveness is collaboration with its main suppliers, which emphasises synergistic problem solving to provide better value to customers (Kumar, 1996; Parks, 2001).

Previous surveys also reveal the increasing importance of supply chain collaboration for sustaining better performance. A recent survey on e-business carried out by the Institute for Supply Management and Forrester Research revealed that more than half of responding companies (52%) reported collaborating with suppliers online (Carroll, 2002). This finding indicated that collaboration would be increasingly required in order to increase transparency, which enables the chain members to reduce transaction costs, eliminate rework and error, and cut order cycle times. Based on a survey of 150 senior executives at Fortune 1000 companies across various industries, Accenture found fifty-four percent of the respondents mentioned that developing collaboration in demand and supply planning with their suppliers and customers was very important (*Material Handling Management*, 2002). The survey confirmed the importance of sharing detailed information with suppliers and customers. Information sharing enables the chain members to improve visibility in their supply chain operations and thereby helps them to increase efficiencies and ultimately reduce costs. Similarly, a

recent survey of 2,000 US manufacturers, conducted by Gemini Ernst & Young and Industry Week, strongly verified that collaboration in information sharing resulted in positive benefits such as timelier delivery of goods, reduced inventory costs, and enhanced product quality (Dubin, 2001).

A common reaction to the competitive challenges of rapidly changing global markets is that the chain members collaborate across the boundaries of their organisations to create responsiveness and flexibility (Bhatnagar and Viswanathan, 2000). Supply chain collaboration shifts the focus of understanding supply chain management away from simply looking at internal processes within the four walls of the individual company to how the chain members coordinate their efforts across several segments of the supply chain (Harland, 1996; Simatupang and Sridharan, 2002; Spekman *et al.*, 1998). Although the term supply chain collaboration appeared with the instigation of time-based competition in the mid-1980s (Blackburn, 1991), there has been relatively little research that investigates the state of the art. Observations are drawn primarily from previous research on supply chain collaboration that mostly focuses its attention on one specific area of collaboration such as information sharing or operational improvements (Blackburn, 1991; Fisher, 1997; Lee *et al.*, 1997). Little attention has been given to explaining the progress of supply chain collaboration and to providing the answer to the question of how to integrate different types of collaborative foci. For example, Hammer and Champy (1993) highlighted the importance of business reengineering across boundaries such as between Wal-Mart and Procter & Gamble. The emphasis is on restructuring the entire process of order fulfilment by taking advantage of information technology to enhance decision-making capabilities throughout the supply chain. However, this research stream has paid little attention to the question of how to restructure rewards and punishments.

There is also a large gap in perspective between academics and practitioners about the term "collaboration". This is evidenced by the number of synonyms used to describe collaboration such as "partnership", "alliance", "cooperation", "interenterprise relationships", and "extended enterprise" (Lemke *et al.*, 2003; Thoben and Jagdev, 2001; Trienekens and Beulens, 2001). A literature review will, therefore, benefit both parties. Academics will receive recent feedback about the state of the art in research methods and design variables in studying supply chain collaboration, whereas

practitioners will obtain helpful explanations about the current progress of supply chain collaboration.

The purpose of this chapter is to provide a framework within which to understand the recent literature on supply chain collaboration. Since the critical phase in scientific progress is the examination of the state of the art, it is argued that the progress of supply chain collaboration needs to be reviewed to account for different foci that shape the practice of supply chain collaboration. The analysis proceeds based on a taxonomy that aims to identify and highlight four research streams of supply chain collaboration that have recently emerged in the literature (Hart, 1998). The four research streams are interorganisational information systems, interorganisational business processes, interorganisational incentive schemes, and interorganisational performance systems. Each stream focuses on specific enablers such as instruments or devices that can be used to influence the participating members to exert the productive behaviour of attaining overall performance. Results of the review show a great variability of key concepts across the four streams of the taxonomy and increased attention is given to achieving complementarities amongst research streams. Directions for future research are also identified both at the levels of conceptualisation and empirical work on supply chain collaboration.

2.2. Prior Research Reviews

This section discusses prior reviews of supply chain collaboration, and aims to provide evidence as to the paucity of prior study on supply chain collaboration. The presentation starts with definitions of collaboration and closes with emergent research on supply chain collaboration.

Collaboration has been defined in many different ways. Gray (1989) provides a generic definition of collaboration as "a process through which parties who see different aspects of a problem can constructively explore their differences and search for solutions that go beyond their own limited vision of what is possible" (p. 5). According to Jap (2001), collaboration refers to the extent to which independent firms combine their resources and skills to create joint benefits that cannot be produced in isolation. Furthermore, Mintzberg *et al.* (1996) contend that collaboration enables the

participating members to devise win-win solutions that benefit all members. From this discussion, it can be deduced that collaboration can be defined as a means to obtain a comprehensive appreciation of interorganisational problems and the possibility of devising innovative solutions that benefit all parties involved. This implies that the participants are willing to constructively handle any differences, accept joint ownership of decisions, and have collective responsibility for collaborative outcomes.

Within the discipline of supply chain management, diverse literature has appeared to examine supply chain collaboration. According to Bowersox (1990), supply chain management can be seen as a collaborative-based strategy to link cross-enterprise business operations in order to achieve a shared vision of market opportunity. Simatupang and Sridharan (2002) contend that supply chain collaboration is often defined as two or more companies working together to create higher profits through defining and delivering products to end customers than can be achieved by acting alone. Similarly, Blackburn (1991) argues that supply chain collaboration makes it easy for different companies along the supply chain to effectively meet end customer needs with minimum costs. Fisher (1997) supports the idea of matching supply and demand at the right time and in the right place as the main role of collaboration between interdependent companies along the supply chain. Based on this discussion, supply chain collaboration can be defined as a means for two or more companies to establish joint efforts in defining and delivering products to end customers that lead to better revenues and lower costs. This implies that the chain members are willing to devise mutual goals and engage in joint efforts that result in better performance for all parties.

Diverse literature on supply chain collaboration has developed into several separate bodies of knowledge. However, relatively little attention has been given to interschool reference. After reviewing previous studies in collaboration, Trienekens and Beulens (2001) found three research streams concerned with collaboration i.e.: business process integration (supply chain management, costing approaches), organisational collaboration (transaction cost economics and agency theory), and the business environment (strategic management, network theory, resource dependence theory). They identified the fact that minimum communication has been engaged in between these research streams. Other review papers also put less emphasis on how the chain

members distinguish different types of research areas. The search for a more comprehensive approach to supply chain collaboration has taken place on both sides - supplier and retailer relations. On supplier relations, Lamming (1993) reviewed literature about technological innovation and strategic collaboration in an attempt to analyse supplier relationships in the automotive industry. He suggests a four-phased model of customer-supplier relations as they advance over time, ranging from traditional, stressed, resolved, to partnership. The main argument of Lamming's study is that buyer-supplier relations under lean supply go beyond Japanese-style partnerships because they are based on collaboration between truly equal partners. However, this study exclusively suggests the importance of cost transparency and the sharing of costs-related information between customer and supplier which allows them to work together to reduce costs and make continuous process improvements (Berry *et al.*, 1997). On the retailing side, Lowson (2001) proposes an empirical taxonomy of the operational strategies based on the pattern of organisation and structure. The taxonomy is solely concerned with how both retailers and their suppliers can create flexible and responsive solutions to the requirement of mass customisation in fast-moving consumer goods sectors.

Thomas and Griffin (1996) review models in the literature associated with coordinated planning between two or more stages of the supply chain and seek to provide models for a total supply chain solution. While such models proved invaluable in improving the understanding of supply chain collaboration, they have not enabled the chain members to identify other streams – such as information systems and the costing methods – involved in collaboration. To fill this gap, Sahin and Robinson (2002) review literature on supply chain collaboration by combining the two dimensions of information sharing and flow coordination, but they put less emphasis on incentive and performance concerns. Similarly, Min and Zhou (2002) emphasise a review on modelling efforts in supply chain collaboration including an aspect of information technology. On the other hand, Tsay *et al.* (1999) exclusively deal with incentive issues such as supply chain contracts. Other reviews are more concerned with performance issues in supply chains (Caplice and Sheffi, 1995; Kleijnen and Smits, 2003).

Previous literature reviews on supply chain collaboration are concerned with one or two types of research areas and rarely refer to each other. Scant attention has been given to identifying and integrating the various research streams of the supply chain collaboration topic. Consequently, a new taxonomy is proposed to acknowledge different types of research areas addressed in previous studies. The next section thus attempts to develop a taxonomy that integrates these different research streams.

2.3. Building A New Taxonomy

This section provides the approach taken to review previous literatures. It begins with the development of a research taxonomy in supply chain collaboration and then closes with data collection and analysis. The main problem of previously reported research is the relatively scant attention given to providing linkages between the different supply chain collaboration research areas published in the literature. To address this problem, a taxonomy needs to be built to identify and link these research areas.

The taxonomy proposed in this research provides a framework for locating a particular research focus on supply chain collaboration and thereby enhances the understanding of the use of specific instruments that affect the behaviour of the chain members. In finding the basis for classification (Hart, 1998), a major assumption is that the chain members cannot be instructed to make decisions and take actions that lead to better overall performance. Chain members can only be influenced to behave toward the attainment of better overall chain performance. Therefore, the chain members are concerned with how to design and implement instruments to motivate productive behaviour that leverages overall performance. According to economic theories, the chain members are most likely to respond to instruments such as incentives in particular in their decision-making processes (Jensen and Meckling, 1992). The desired behaviour can be encouraged in economic ways, by lowering costs borne- or increasing benefits accrued by- the decision makers when they carry out desired actions. Once such instruments are implemented, they will become accepted norms that govern the chain members' relationships. Accepted norms can be outdated as competition changes over time and thereby outdated instruments need to be identified and redesigned. New instruments in turn shape new norms for influencing

the chain members to attain common objectives (Goldratt, 1990; Simatupang and Sridharan, 2002).

On the basis of the key assumption mentioned above, there are two factors that must be considered in developing the taxonomy: interorganisational norms and the nature of the linkage across boundaries (see Figure 2.1). First, interorganisational norms refer to the extent to which the chain members share acceptable standards or expectations, needed for effective functioning, whilst working with one another. This factor can be sub-categorised into action-oriented and directive-oriented norms. Action-oriented norms indicate how the chain members coordinate their tasks and information exchange. Directive-oriented norms specify how the chain members share acceptable standards for inducing their behaviour to align with the common goal. Second, the nature of the linkage across boundaries has the potential to affect how chain members relate with each other. This factor can also be sub-categorised into interchange-oriented and responsibility-oriented linkages. Interchange-oriented linkages contend with how the chain members define their cross-boundaries' contact points either as exchange information or exchange incentives. Responsibility-oriented linkages focus on sharing accountability in attaining the goal of collaboration. Combined, these two factors and their four-sub-categories project four key attention areas for the creation of devices for influencing the behaviour of supply chain members. These key subjects areas are shown in Figure 2.1.

		Interorganisational Norms	
		Action Oriented	Directive Oriented
Nature of Linkage	Interchange Oriented	1 *Interorganisational Information Systems*	3 *Interorganisational Incentive Schemes*
	Responsibility Oriented	2 *Interorganisational Business Processes*	4 *Interorganisational Performance Systems*

Figure 2.1. The taxonomy of research on supply chain collaboration

The four cells can be labelled respectively as: "interorganisational information systems" (cell 1), "interorganisational business processes" (cell 2),

"interorganisational incentive schemes" (cell 3), and "interorganisational performance systems" (cell 4). Table 2.1 shows their differences in terms of key research question, inherent objective, premise, primary task, and examples of main variants.

Table 2.1. Distinguishing the four research streams of supply chain collaboration

Distinctive Issues	Research streams			
	Interorganisational Information Systems	Interorganisational Business Processes	Interorganisational Incentive Schemes	Interorganisational Performance Systems
Key research question	What information drives the optimisation of total profits?	What processes drive the capture of total profits?	What incentive mechanisms drive productive behaviour?	What performance measurement drives total improvements?
Inherent objective	Information visibility and intelligence.	Matching supply and demand through sales.	Incentive compatibility.	Mutual success.
Premise	Information is the enabling factor for optimising the supply chain.	Process is the driving factor for matching supply with demand.	Incentive is the inducing factor for aligning behaviour with performance.	Performance is the motivating factor for attaining mutual success.
Primary task	Provision of accurate, reliable, timely, and relevant information to decision makers.	Development and implementation of efficient operating and management processes.	Establishment of mechanisms for sharing costs, risks, and benefits.	Establishment of performance metrics, measurement, and evaluation.
Examples of main variants	The role of IT and its impact (Byrd and Davidson, 2003; Barut et al., 2002; Hill and Scudder, 2002; Subramaniam and Shaw, 2002), IT solutions (EIS, WMS, ERP, GIS, TIS), information sharing modelling (Keskinocak and Tayur, 200; Lee et al., 1997; Lee and Whang, 2000).	Process redesign (Hammer and Champy, 1993; Venkatraman, 1994), supply chain design (Fisher, 1997; Van Hoek, 2001), management process (CPFR, QR) (Blackburn, 1991; Barrat and Oliveira, 2001), constraints management (Goldratt et al., 2000).	Performance-based incentives (Corbett et al., 1999; Grout, 1996; Tsay et al., 1999), risk sharing (Billington et al., 2003; Raman, 1998), cost sharing (Kaplan and Narayanan, 2001).	Performance system redesign (Holmberg, 2000; Lambert and Pohlen, 2001), cost management (Cooper and Slagmulder, 1999a), balanced scorecard (Kaplan and Norton, 2002), benchmarking (Polese, 2002; Simatupang and Sridharan, 2004a).

Each research stream represents a different combination of a type of norm and a type of linkage. Interorganisational information systems (cell 1) are required while the chain members exercise action-oriented norms and an interchange-oriented linkage. The chain members interact frequently to exchange information that allows them to consider the total picture of the supply chain in making decisions. The focus would be

26

to capture, store, and transmit relevant, timely, and accurate information to decision makers.

When the chain members face action-oriented norms and the responsibility of a shared offering, they need interorganisational business processes (cell 2) which represent enabling instruments to effectively match supply and demand at minimal costs. The main task is to minimise supply and demand variations, eliminate wastes, and increase responsiveness along the supply chain. When norms are directive-oriented and the linkage is interchange-oriented, the chain members can use interorganisational incentive schemes (cell 3) to encourage each member to share costs, risks, and benefits which result from collaborative efforts. The focus is on finding appropriate mechanisms that tie to overall performance. Finally, when norms are directive-oriented and the linkage is responsibility-oriented, the chain members need to design appropriate performance measurements that motivate them to carry out total improvements.

Paralleling the growing amount of research papers on supply chain collaboration, there has been a strong surge of interest in each of the research streams in Figure 2.1. Researchers have begun to look at each research stream as an important area of inquiry and this deserves serious and sustained attention. However, the research effort in each particular stream is fragmented in its development. Therefore, a number of published works was selected and reviewed to show that - based on the taxonomy - they contribute to advance a specific focus of explaining the supply chain collaboration phenomenon. Suggestions from peer researchers and databases such as Business Source Premier and Emerald were used to trace and find published work on supply chain collaboration. More than eighty published works - relevant to mirroring the content of supply chain collaboration - were selected. Each work was then analysed to locate its appropriate class in the taxonomy. Several iterative discussions with other researchers were carried out to verify the consistency of analysis. This review is not intended to be exhaustive but to map out the diverse body of literature on supply chain collaboration into a workable taxonomy. The next section provides results of the review.

2.4. Review of Supply Chain Collaboration

This section locates and reviews emergent literature according to the taxonomy proposed in Section 2.3. The results are divided into four subsections. Each subsection discusses selected published works that focus on a particular research stream of collaboration.

2.4.1. Interorganisational Information Systems

Information systems make it easy for the chain members to collect, process, store, and disseminate information to support decision-making activities including planning, control, analysis, visualisation, and coordination. Kumar and Van Dissel (1996) argue that an interorganisational information system has two different roles: a support role in reducing transaction costs and risks and an enabling role in making the collaboration feasible. Advances in information technology (IT) are causing integrated information systems to become the main enablers of supply chain collaboration by providing the necessary tools that make collaboration feasible. IT can be used to improve market knowledge, response capabilities, and strategy selection (Simchi-Levi *et al.*, 2000). Research on this subject attempts to define and design an effective information system that provides the required visibility and intelligence for the chain members to create flexible and responsive supply chain processes. Research variants of this category include the role of IT and its impact, IT solutions, and information sharing modelling.

Empirical studies on the role of IT attempt to examine the extent to which IT enables the participating members to reduce costs, improve productivity, and increase revenues (Barrett and Konsynski, 1982). Today's information and communication technology (ICT) allows the chain members to collaborate in an innovative way. According to Davidson and Malone (1992), ICT has transformed boundaries between company, supplier, and customer and allowed this network of companies, called "virtual corporations" to be market responsive and cost effective at the same time. Collaboration through the virtual corporation maintains integrated and ever changing data files on customers, products, and production and design methodologies. A retailer in the quick response movement, for instance, tapped IT to capture market information and pass the information from the points-of-sale all the way back along

the supply chain to its main suppliers. This enabled them to slash the response time between the appearance of new fashion in the market and product availability at the selling points. Blackburn (1991) provided cases in the U.S. textiles industry where IT-enabled quick response programmes allowed the participating members to reduce markdowns, potential sales lost by out-of-stock, and excess inventory. Hill and Scudder (2002) found that electronic data interchange was used to improve efficiencies rather than to facilitate supply chain integration. Based on a survey, Byrd and Davidson (2003) found a positive relationship between the impact of IT and firm performance.

Companies become more interested in evaluating their investments in supply chain IT because of the considerable money spent in the investment and the rapid changes of IT. They also need to know the impact of IT on competitive advantage. Consequently, studies on IT investments have emerged to provide various analysis tools for evaluating and quantifying the feasibility of IT investments. Talluri (2000) suggested a goal programming model for the effective acquisition and justification of supply chain IT. In selecting the right ERP (enterprise resource planning) system, the model considers various factors such as system acquisition and maintenance costs, flexibility, execution accuracy, and compatibility. Barut et al. (2002) proposed the "degree of supply chain coupling" as a measure of the intensity of information sharing about demand, capacity, inventory, and scheduling. Subramaniam and Shaw (2002) proposed a framework for quantifying and measuring the value of B2B e-commerce systems. The model specifies the relationship between four forms of web-based procurement, factors that create value, and factors that affect realised value. The potential of four forms of web-based procurement – buy-side procurement system, private B2B e-market, industry B2B exchange, and third-party B2B market – were identified and analysed in a major heavy-equipment manufacturer. The methodology proposed in this research is originally rooted in the value business model developed by Barua et al. (1995), which attempts to link IT drivers, intermediate measures, and financial measures. Various studies in the field of economics also intend to show that IT may reduce the coordination costs of outsourcing activities and therefore stimulate cooperation between firms (Barua et al., 1995; Clemons and Kleindorfer, 1992). Jayaram et al. (2000) carried out an empirical study of 57 top-tier suppliers to the North American automotive industry to examine the direct and complementary effects

of information system infrastructure and process improvements on time performance. The results showed that there is strong support for joint deployment of information system infrastructure and process improvements to improve cycle time performance in a supply chain.

IT solutions enable the participating members to integrate and coordinate various phases of supply chain planning and execution using application software. The aim of this research variant is not only to enhance knowledge about visibility throughout the supply chain but also to optimise decisions that increase the overall performance. The scope of the research covers various areas of applications such as executive information systems (EIS), warehouse management systems (WMS), enterprise resource planning (ERP), geographic information systems (GIS), and transportation information systems (TIS). EIS - that help the chain members to outsource components of the supply chain – provide tools for optimising the sourcing alternatives and contain software for analysing promotional forecasting and implications (Nickles *et al.*, 1998). EIS also provides visibility that reduces the complexity of decision making. For example, the availability of demand data - such as points-of-sale, inventory levels, and customer behaviour - enables a retailing manager to determine ordering schedules that reduce lost sales due to stock-outs.

WMS refers to a software application and hardware that integrate bar coding, radio frequency communication, cycle counting, and other warehouse-related operations to accelerate the flow of material and utilise space throughout the warehouse (Min and Zhou, 2002). A software application such as load planning and optimisation serves to support and improve stock locating, inventory control, material handling, and productivity measurement. Accurate "visibility" of the quantity, location, and age of inventory enables users to track and control the movement of inventory through the warehouse from receiving to shipping. According to Richmond and Peters (1998), a WMS has two functions: planning and execution. Planning includes order management, transportation planning, order wave management, labour planning, and dock area management. The execution function covers receiving, put-away, picking and shipping. Richmond and Peters (1998) also suggested a three-phase approach for WMS adoption including operations strategy and software selection, detailed design, and implementation and start-up.

30

ERP is a multi-module software package for managing and controlling a broad set of supply chain activities including product planning, part purchasing, inventory control, order tracking, and human resource planning. ERP serves as a basis for collaboration to accelerate the velocity of inventory throughout the supply chain. Al-Mashari and Zairi (2000) developed ERP architecture for this purpose based on SAP R/3 comprising of three components: graphical user interface (GUI), application, and database. A conceptual diagram is also proposed to create value-oriented supply chains that enable a high level of integration and communication across supply chain processes.

GIS provides a geographic view of the database information that enables the chain members to visualise geographical aspects of the supply chain using different colours. These systems allow users to analyse sales figures, market activity, customer stores, population density, topography, and climate by zip code, country, and city on a map. By superimposing geographic information, one can differentiate one geographic site from others. GIS also enables the chain members with better information to enhance communication, finding the best locations and the proper number of facilities for a given area, and establishing the most efficient delivery routes and truck schedules (Gates, 1997). Camm *et al.* (1997) developed a flexible decision support system (DSS) by combining an integer-programming model involving different locations of distribution centres and sourcing of multiple products with GIS. Johnston *et al.* (1999) developed a GIS model for searching near-optimal storage locations for stock items in a multi-facility warehousing environment. Furthermore, Min and Melachrinoudis (2001) combined GIS and a mixed integer programming model to redesign the warehousing structure in a supply chain network to minimise total logistics costs while satisfying capacity, demand, and delivery requirements.

TIS are software solutions that facilitate the sourcing of transportation services, the short-term planning and optimisation of transport activities such as fleet management and pricing, and the execution of transportation plans. Bergmann and Rawlings (1998) proposed four primary categories of the functionality of TIS: transport planning, vehicle routing and scheduling, delivery execution and shipment tracking, and performance management. An effective TIS enables the chain members to coordinate

transport shipments in the supply chain network through load consolidation or truck space sharing to increase the utilisation of transport assets, improved delivery routing and scheduling to reduce variable costs, optimisation to generate cost savings, process automation to improve operational efficiency, and visibility to provide insight into critical transportation data (Moozakis, 2001). For example, advance-shipping notices sent via EDI from suppliers to retailers confirming shipment details and delivery times can be used to achieve accurate and consistent delivery performance. This is also in line with a study by Esper and Williams (2003) who found that collaborative transportation management provides benefits for buyers and shippers in terms of reduced transportation and administrative costs, on-time performance improvements, and better asset utilisation.

Information sharing modelling has appeared as a distinct research variant that employs analytical models and standards of information exchange between two or more parties to improve and evaluate mechanisms and benefits of enhanced visibility. Hardwick *et al.* (1996) developed technological standards for exchanging information. To overcome costly traditional EDI, Fürst and Schmidt (2001) proposed a prototype realisation for Internet EDI using XML (eXtensible Markup Language). In their seminal work, Lee *et al.* (1997) characterised information sharing as one of the most critical drivers of supply chain performance. Similarly, Yu *et al.* (2002) developed a model for quantifying the benefits of information sharing in a two-level supply chain. Lee and Whang (2000) reviewed the latest development of information sharing amongst the chain members and identified three alternative models of information sharing including the information transfer model, the third party model, and the information hub model. Mason-Jones and Towill (1999) suggested the information decoupling point to move the marketplace upstream in order to give more players with undistorted data as a key to gaining strategic advantage. Keskinocak and Tayur (2001) conceptually proposed the emergence of quantitative modelling for internet-enabled information sharing.

2.4.2. Interorganisational Business Processes

Interorganisational business processes refer to a set of workflows and decision rights that enable the participating members to deliver joint offerings to end customers. These processes include operating processes (i.e., production, transportation,

warehouse, cross-docking, transhipment, distribution, etc.) and management processes (planning and execution). Operating processes describe the sequence in which resources are used and the activities which should be performed in order to deliver products to end customers. Management processes refer to the extent to which the chain members are involved in joint decision rules for planning and execution of operating processes. Research in this area attempts to design and implement streamlined processes that provides values to end customers in an efficient manner. Research variants of this category include: process redesign, supply chain design, management processes, and constraints management.

Research based on supply chain processes views collaboration as a joint effort to redesign supply chain operations that result in better customer service and lower costs (Evans *et al.*, 1995; Hammer, 2001). This literature suggests that integrated supply chain processes are necessary preconditions for collaborative outcomes and, thus, a valued focus of research (Dershin, 2000). The chain members need to engage in reengineering shared processes to facilitate the swift and effective flow of information and collaborative problem solving, so they can expand mutual gains to become greater than the gain that could be generated in isolation. Hammer (2001) argued that streamlining cross-company processes is the next frontier for reducing costs, enhancing quality, and speeding up operations.

There are two strands of process redesign research in terms of the cycle of the process design. First, Hammer and Champy (1993) argue that IT solutions should be taken as the starting point of the design process to achieve dramatic improvements in cost, quality, service, and speed. Since IT provides powerful potential solutions, it replaces existing business processes with new ones that are fundamentally different. IT solutions can be viewed in terms of the opportunities they present and the problems they might solve, while business processes are redesigned to maximise the use of offered opportunities. In line with this argument, Short and Venkatraman (1992) argue that the interrelationships between IT and work processes offer the new capability to redefine business networks. Business network redesign enables the company to create value-added partnerships with larger business scope for improving product distribution and delivery performance to end customers (Venkatraman, 1994). The second strand asserts that the design process begins with redesigning the existing

business processes as solutions to problems (Davenport, 1993). According to this view, the process structure – consisting of a set of resources and workflows between the resources – should be redesigned first and followed by a decision structure and information structure. A decision structure can be deduced from the characteristics of processes to specify goals, measures, and decision rights. The information system reflects the decision structure and should be determined after the decision structure is in place. In this way, the information system is viewed as a function of the process structure and the decision structure. For example, Croxton *et al.* (2001) propose key supply chain processes which include customer relationship management, demand management, order fulfilment, and returns. Based on surveys, Bhatnagar and Viswanathan (2000) and Kopczak (1997) confirmed that increasing need for collaboration in supply chains led to significant changes in streamlined supply chain processes across interorganisational boundaries.

Trienekens and Hvolby (2001) attempt to bridge the dichotomy of the two strands above by arguing that different problems in supply chains require different modelling approaches. They suggest three domains of supply chain reengineering including functions (process), organisation (decision/task), and information and resources. Similarly, in finding common grounds which underlie business process reengineering (BPR) and supply chain management (SCM), Evans *et al.* (1995) contend that companies that have implemented the philosophy of SCM are consistent with the application of BPR in redesigning their supply chain processes. In addition, Berry *et al.* (1999) propose different scopes of business process engineering to improve supply chain performance.

Supply chain design encompasses the configuration of the physical supply chain including the location of the decoupling point that defines where and who designs, produces, and delivers the products across the supply chain in order to minimise total costs (Kopczak and Johnson, 2003). This variant stresses the importance of product design in defining the supply chain and its associated performance. The chain members need to collaborate to design a family of products starting from its preliminary stage, production, and distribution. They may also need to design a suitable configuration that effectively delivers products to end customers. Fisher (1997) argues that the optimal configuration of the supply chain for innovative

34

products is different from that of functional products because of differences in production costs and the costs of a mismatch between supply and demand. Womack and Jones (1994) propose a lean enterprise – consisting of a set of groups of companies that creates, sells, and services a family of products – to speed up product development in order to expand product offerings. Lean thinking is employed in this approach by cutting out various sources of waste in business processes (Harrison and Van Hoek, 2002). Bowersox *et al.* (1999) proposed lean launch to reduce risk associated with new product launch. This strategy involves a limited commitment of inventory during introductory rollout and a flexible logistics system that rapidly responds to early sales success. An agile supply chain is another initiative of supply chain design that attempts to create a flexible and responsive supply chain that exploits profitable opportunities in a volatile marketplace (Fine *et al.*, 2002; Naylor *et al.*, 1999). Other strategies of supply chain design include accurate response (Fisher *et al.*, 2000), build-to-order (Holweg and Pil, 2001), modularity (Baldwin and Clark, 1997), and postponement (Van Hoek, 2001). Product design can be used to effectively match market demand by postponing the point of differentiation in the order-fulfilment process (Lee, 1996; Pagh and Cooper, 1998).

Management processes cover joint planning and execution activities. Supply chain planning aims to generate demand forecast of a product and to develop production and distribution plans for that product. Supply chain execution aims to manage the flow of products through manufacturers, distribution centres, and warehouses to ensure that products are delivered to the right selling points with minimal costs. Interorganisational management processes explain the growing interest in concepts that use collaborative planning to improve forecasting demand accuracy amongst the business partners. The chain members often customise the reference model of collaboration to facilitate their collaborative efforts. A typical example of the reference model for the automotive industry is the CIMSO (computer integrated manufacturing for multi-supplier operations) programme (Schneider *et al.*, 1994). The model distinguishes three business processes (buy, produce/store, and sell) within each participant. Process chains linked through buying and selling enable the chain members to identify all actors subsequently adding value to the product flows. The result of the process mapping is reference models that can be used to identify the information to be exchanged throughout the supply chain. Another reference model

relies on the use of a collaborative management process to facilitate supply chain collaboration (Ireland and Bruce, 2000). Quick response (QR) has been known as an earlier version of collaborative management process (Fiorito *et al.*, 1995; Perry and Sohal, 2000). Kurt Salmon Associates promoted Efficient Consumer Response (ECR) that facilitates planning and execution for efficient promotions, efficient replenishment, efficient store assortment, and efficient product introductions (Blackburn, 1991).

Another initiative, called vendor-managed inventory (VMI), relinquishes stocking decision rights to main suppliers so that the supplier is responsible for monitoring stock levels and for replenishing products sold at the retailer stores (Holmström, 1998). Sherman (1998) reported a recent movement of Collaborative Planning, Forecasting, and Replenishment (CPFR). CPFR enables the participating members across the supply chain to remain competitive by taking a holistic approach to deliver products to ultimate customers (Barratt and Oliveira, 2001). CPFR is designed to link consumer demand with supply chain planning and execution by promoting a single, jointly owned demand plan and forecast throughout the entire supply chain (Ireland and Bruce, 2000). Fliedner (2003) reported the latest development of CPFR as a basis for the chain members to share relevant information for improving overall performance. This approach has the potential to deliver increased sales, interorganisational streamlining and alignment, administrative and operational efficiency, improved cash flows, and improved return on assets. A recent development called Supply Chain Event Management (SCEM) is a reference model that aims to produce the kind of control for a supply chain such that products will arrive in the right locations at the right time (Alvarenga and Schoenthaler, 2003; Strozniak, 2002). The chain members collaborate to monitor moving products, activities, events, and disruptions that take place across the supply chain and to quickly respond to fix bottlenecks and delays that could jeopardise future sales.

Constraints management is a management philosophy, coined by Goldratt (1990), that aims to initiate and implement breakthrough improvement through focusing on constraint(s) that prevents a supply chain from achieving its goal. Goldratt and Cox (1992) define a constraint as any element or factor that limits the system from doing more of what it was designed to accomplish (i.e., achieving its goal). The fundamental

goal of most supply chains is to make more money now and in the future through selling products to end customers. The end consumer is thus the actor who justifies all the chain's activities. The theory of constraints (TOC) paradigm essentially states that every supply chain must have at least one constraint. Constraints management encourages the participating managers of the supply chain to collaboratively identify what is preventing them from moving towards their goals - as well as necessary conditions for achieving their goals - and find solutions to overcome this limitation. According to Kendall (1998), there are three potential weakest links in every chain that block the chain members from moving closer to making more sales: supply constraint – someone in the supply chain is choking the supply, market constraint – enough capacity to produce products but cannot sell them, and distribution constraint – the chain has too much supply in some locations and not enough in others. He also proposes a step-by-step process to manage around the constraint(s): diagram the chain, identify the constraint of the chain, develop a plan to remove or work to exploit the maximum from the constraint, identify the next constraint and determine if it must be addressed now, and go back to identify new constraint.

Covington (1996) started to apply the TOC thinking process to identify problems in the apparel supply chain and describes the bringing together of managers from different firms to cooperate in improving the overall supply chain profit. Goldratt *et al.* (2000) argued that IT solutions are necessary - but not sufficient - conditions to supply chain success. The chain members should redefine their business rules such as policies and measures in order to tap the benefits of IT solutions. Watson and Polito (2003) compared financial performance between Distribution Resource Planning-based order planning and a TOC-based heuristic for buffering and inventory replenishment. They found that the TOC-based system resulted in better financial performance in terms of inventory costs, retail-level transhipment, and obsolescence expenses. Recently, Simatupang *et al.* (2004) have contended that managing physical constraints should be combined with redesigning performance metrics that encourage total improvements.

2.4.3. Interorganisational Incentive Schemes

Besides improving performance through better process coordination and information exchange, the chain members are concerned with capturing mutual benefits. As the

chain members have different cost and revenue structures, they also have different individual gains in capturing benefits from collaboration. One of the most difficult problems in supply chains is that the economic interests of the chain members are not always incentive compatible. To address this problem, research on incentive schemes has emerged to place wealth distribution as the main lever of collaboration. Research on incentive schemes suggests that the chain members need to agree about the types of such mechanisms to be used for rewarding collaborative performance (Simatupang and Sridharan, 2002). This research attempts to verify the purposes of incentives, targeted behaviour caused by incentives, and types of appropriate incentives. Research variants in this category include: performance-based incentives, cost sharing, and risk sharing.

Performance-based incentives deal with how the chain members specify payments that tie to the overall performance which results from collaboration. The chain members realise that compensation is a function of the incremental value that they add to end customers. The compensation system should consider the degree of difficulty of fulfilling services to end customers, the changing roles of the chain members, and differences in value added or contributions given by the chain members. Supply chain contracts generally fall into this category (Grout, 1996; Tsay *et al.*, 1999). Corbett *et al.* (1999) empirically showed that successful process improvement, such as inventory management and order fulfilment, has higher probability for success when the chain members become involved in aligning joint optimisation rules with logistics and commercial benefits. Logistics benefits include improvements in operational performance. Commercial benefits depend on how the chain members obtain better profitability from the improvement efforts. Kaplan and Norton (1996) suggest the balanced scorecard to assess and reward the chain members according to their roles and contributions in the supply chain.

Cost sharing refers to how the chain members compensate each other for the costs related to joint offerings. Kaplan and Cooper (1998) suggest activity-based costing to estimate investments of collaboration. Kaplan and Narayanan (2001) argued that customer profitability is the key to aligning incentives between companies and their customers. Valid pricing based on the cost to serve provides an appropriate parameter

to determine three actions to improve performance: process improvement, pricing decisions, and relationship management.

Risk sharing refers to how the chain members compensate for risks related to supply and demand uncertainties. Raman (1998) suggested that the chain members need to share risks associated with demand uncertainties such as sharing a portion of markdown costs and rewarding responsiveness needed to eliminate lost sales. Billington *et al.* (2003) argued that risk could be mitigated and distributed across a portfolio of possible participants through the use of a real-options approach. Bichler *et al.* (2002) proposed flexible pricing as a means of managing the risks of supply and demand uncertainties in business-to-business electronic commerce.

2.4.4. Interorganisational Performance Systems

Key performance metrics are required to stimulate the chain members to exert the correct behaviours for optimising overall performance such as better asset management and customer value. The wrong metrics will discourage the chain members from attaining overall performance. For example, if the logistics providers define "full-truck load" as a primary metric, they will tend to maximise this metric at the expense of on-time delivery. Performance systems also provide directions and magnitudes for total improvements and thereby determine the ultimate success of collaboration. These systems include metrics, measurement, and evaluation. Metrics are vital indicators that inform people within the supply chain how well activities within a process and outputs of a process are attaining specified targets. Performance measurement is the process of measuring activities or outputs within a specified time frame using their associated metrics. Evaluation provides feed-forward and feedback information that enable the chain members to understand the factors that contribute to high supply chain performance, to control or improve those factors, and to set new priorities.

Research on performance systems attempts to design and implement performance metrics in order to affect and change the chain members' behaviours toward overall performance (Goldratt *et al.*, 2000; Simatupang and Sridharan, 2002). Appropriate performance metrics enable the chain members to focus on those of their activities and decisions which improve both individual and overall performance. The chain

members also have to ensure the usefulness of the selected portfolio of performance metrics and the performance statistics that are derived from the raw performance data. This means that the portfolio should be readily understandable by decision makers to motivate them to support improvement initiatives that contribute to better customer services and lowered logistics costs as well as providing a guide for action to be taken (Simatupang and Sridharan, 2002; Van Hoek, 1998). There are three variants in this research stream: performance system redesign, cost management, and benchmarking.

The performance system redesign approach strives to design and implement performance metrics, performance models, and measurement methods as the main concern of collaboration (Chow *et al.*, 1994; Holmberg, 2000). Since performance metrics drive behaviour, this approach advocates that designing and measuring appropriate performance metrics can lead the chain members to chase the correct direction and thereby contribute to better performance. Callioni and Billington (2001) find that chain members need to focus on shared metrics rather than shared benefits so that they can measure their own gains using common metrics as the collaboration carries on over time. They propose three key metrics to evaluate the success of collaboration: product availability at the stores, inventory turns in the supply chain, and product sales. Lambert and Pohlen (2001) argue that supply chain metrics are very different from traditional metrics in the way they measure intercompany performance rather than just internal performance. They propose a combined customer-supplier profit and loss statements to capture how collaborative initiatives affect profitability for both firms. Lapide (2000) asserts that supply chain metrics must be common across the chain members to be meaningful. He proposes two related types of metrics: process metrics which span the supply chain such as perfect order, cash-to-cash cycle, and new product development and functional metrics that measure the efficiency of work within a department of an individual member. The Supply Chain Operations Reference (SCOR) model also developed a set of performance metrics for collaboration including reliability, flexibility and responsiveness, expenses, and assets/utilization (Stewart, 1997). The participating members collect best-practice information using the SCOR metrics that they can employ to assess and improve their supply chain performance.

40

In an attempt to find a balance between cost (efficiency) and service (effectiveness), Thomson *et al.* (1999) suggested a new metric referred to as make-to-cash (MTC). MTC is a connected set of processes that start with the completed product and end with the actual receipt of the payment. Farris and Hutchison (2002) introduced cash-to-cash analogues to MTC as a new supply chain metric. In determining the distribution of profits among the value chain activities, Gadiesh and Gilbert (1998) proposed a profit-pool map as a tool to isolate and measure variations in profitability. While facing the need for assessing supply chain investments, Grey *et al.* (2003) suggested return on investment (ROI) analysis to quantify the impact of supply chain initiatives on business value. Balanced scorecard is another model used to redesign performance systems that span boundaries of the participating members (Kaplan and Norton, 2002). This approach balances financial and non-financial metrics based on four perspectives – financial, customer, process, and learning and growth – to enable the company to collaborate with customers, suppliers, and communities.

The cost management approach enables the chain members to find ways to reduce total costs through collaborative efforts (Carr and Ng, 1995; Cooper and Slagmulder, 1999a; Kaplan and Cooper, 1998). It assumes that reducing total costs of the entire supply chain provides more profits for the chain members to share. The cost management approach encourages the chain members to become more efficient in ways that benefit the entire supply chain. Collaborative programmes do not just reduce overall costs but also increase the ability of the chain members to serve customers better (Cooper and Slagmulder, 1998). They also need to share the additional profits resulting from improvements in order to ensure that adopting interorganisational cost management will benefit individual performance. According to Cooper and Slagmulder (1999a), there are three different ways to reduce costs by using interorganisational cost management: cost management during product development, cost management during manufacturing, and improving the efficiency of the buyer-supplier interface. The chain members coordinate the product development activities so that the products and components can be produced at their target costs. The coordination of product development relies on three enabling mechanisms of cost management: functionality-price-quality (FPQ) tradeoffs, interorganisational cost investigations, and concurrent cost management. Cost reduction during the manufacturing phase can be attained while the chain members

coordinate production activities so that products and components can be produced at their Kaizen costs. The chain members need to find ways to make the interfaces between their companies more efficient such as reducing the transaction costs by using EDI and reducing uncertainty by increasing information sharing and shortening cycle times. The cost management research varies around these three domains of cost reductions.

Cooper and Yoshikawa (1994) carried out an exploratory field study in the automobile industry and found that partnering firms have blurred their organisational boundaries to coordinate activities that reduce product development costs. Cooper and Slagmulder (1999b) identified three target-costing processes: market-driven costing, product-level costing, and component-level target costing. Cooper (1996) found that Japanese firms have adopted six different techniques to manage the costs of existing and future products. The first three techniques - target costing, value engineering, and interorganisational cost management systems - are designed to manage future products. To manage the costs of existing products, they used product costing, operational control, and Kaizen costing. Lockamy and Smith (2000) suggest that target costing for a supply chain consists of three approaches: price-based, value-based, and activity-based cost management. Berry *et al.* (1997) also initiated studies on the consequences of interfirm supply chains for management accounting practice in European companies. They identified several key features of interfirm cost management such as target costing, open book costing, common and shared cost reduction activities, the multiple balanced scorecard for performance measurements and monitoring, sharing profits and losses, and the sharing of budgets (Cullen *et al.*, 1999; Seal *et al.*, 1999).

Benchmarking is defined as the process of analysing the best products or processes of leading competitors in the same industry or leading companies in other industries (Camp, 1995). Benchmarking is relevant in studying the supply chain by measuring the company's products, services, and processes and comparing them against the relevant metrics of successful firms (Christopher, 1998). The advent of supply chain collaboration shifts the focus of benchmarking from a single company level to an interorganisational level (Simatupang and Sridharan, 2004a). Several research surveys have shown, for example, that the core of supply chain management is the

improvement process at the interorganisational level (Boyson *et al.*, 1999; Kopczak, 1997; Stank *et al.*, 1999). According to Stewart (1995), a best-in-class supply chain was characterised by the best achievement of both internal-facing measures and customer-facing measures. Christopher (1998) also argued that supply chain benchmarking includes joint practices and achievements of the chain members in the supply chain.

Stewart (1995) reported that Pittiglio, Rabin, Todd, and McGrath (PRTM) generated a comprehensive set of fact-based performance measures that can be used to accurately describe a world-class supply chain of planning, sourcing, making, and delivering activities. The benchmarking scheme covers four areas of performance metrics which are identified as the keys to unlocking supply chain excellence: delivery performance, flexibility and responsiveness, logistics cost, and asset management. This is the first known study that objectively links best practices employed with relative quantitative performance achievements. Additionally, the study results describe relevant trend information indicating the progress that companies have made towards improving their supply chain operations. Stewart (1997) provided the development of the supply chain operations reference (SCOR) model as the first cross-industry framework for evaluating and improving extended supply chain performance. Geary and Zonnenberg (2000) employed the SCOR model to show that the best-in-class performers gained considerable financial and operating advantages over the rest of the respective groups. By using system-wide revenues and costs, Ramdas and Spekman (2000) also examined collaborative practices between high performers among innovative-product supply chains and high performers among functional-product supply chains.

As companies move toward closer arrangements with their partners, they become involved in the progressive process of collaboration (Mentzer *et al.*, 2000a). Poirier (1999) proposed a progressive framework consisting of four levels of supply chain optimisation. The first two levels of progress are internally focused, namely "sourcing and logistics" and "internal excellence". The last two levels, "network construction" and "industry leadership", reflect the collaborative efforts amongst participating members that improve their value chain constellation in which the effectiveness is measured by the ultimate customers in terms of their purchases and continued loyalty. In a similar vein, Polese (2002) developed a supply chain maturity model that reflects

how companies progress in terms of operational capability. There are four stages in the supply chain maturity model. The first two levels are functional focus and internal integration. Collaboration is the key ingredient to reach stages three (i.e., external integration) and four (i.e., cross-enterprise collaboration). In conjunction with the SCOR model, the maturity model can be used to measure fact-based benchmarking for determining best-in-class performance opportunities. Most recently, Simatupang and Sridharan (2004a) have recommended an integrative benchmarking scheme for supply chain collaboration that links enabling practices (i.e., information sharing, decision synchronisation, and incentive alignment) and a collaborative performance system.

2.5. Discussion

This chapter makes two contributions to the understanding of different research streams in supply chain collaboration. The first contribution involves the classification of the existing literature and recognises the different amount of attention paid to each research stream. While different streams of collaboration have been previously studied as is shown by a great variety of literature, involving research on information systems, operations management, and management accounting, these literatures do not, in most cases, refer to each other. They have developed into separate bodies of work through the accumulation of individual studies, each of which focuses on a particular instrument. Most of previous research simply blurs or subordinates other instruments. For example, the focus on interorganisational business processes (cell 2) subordinates information systems (cell 1). There is a partial attempt to bring them together and thereby they provide overlapping focused instruments in the attempt to improve supply chain performance. This suggests the need for a broader approach to acknowledge these differences. The taxonomy proposed in this research thus provides a more comprehensive approach in classifying prior research on collaboration.

The second contribution is to locate the specificity of previous work in the taxonomy. In this way, the research subjects of previous work are clearly identified rather than broadly generalised. There are more than eighty previous works included in this research. By highlighting the importance and significance of specificity to previous work, it is expected that different variants would be seen within the taxonomy.

Similarly, it would be interesting to trace more specifically the ideas contained in the diverse literature inside the four cells of the taxonomy.

This research provides several implications for future research. At the general level of the taxonomy, one finding is that that there are different levels of interactions between the research streams: information, processes, incentive, and performance. Considering these interactions bring new insights to the chain members. Constantly balancing information systems, business processes, incentive schemes, and performance systems leads to an iterative design process, rather than a sequential one. Only if the four streams are in balance can a specific instrument of collaboration be used to leverage supply chain performance. The importance of the complementarity view between the research streams has received attention in previous studies (e.g., Milgrom and Roberts, 1995; Simatupang *et al.*, 2002). Future research is required to exploit the complementarity property between the four research streams.

Secondly, previous study on supply chain collaboration recognises the importance of change management (Callioni and Billington, 2001; Corbett *et al.*, 1999). The model of change management in supply chain collaboration is often typically structured towards a managerialist frame (Morgan and Sturdy, 2000). A managerialist frame broadly accepts that change is initiated on the basis of how the top managers of the chain members define the situation or problem (such as increased competition) and then their efforts to stimulate action. The authors advise how best to define and achieve goals, typically through universalistic prescription such as radical, incremental, top-down, bottom-up including a contingent approach to change methods. As many companies attempt to adopt supply chain collaboration such as CPFR, change management becomes an important topic for future research. Further research will reveal how the chain members analyse their interorganisational situations and the need for change, create the shared vision and direction for successful CPFR, create a sense of urgency, and develop enabling interorganisational structures. Different enabling factors in information systems, business processes, incentive schemes, and performance systems are required in different contexts of collaboration. More empirical work needs to be done to examine the issue of change management in supply chain collaboration.

Thirdly, in relation to change management, there are three other issues that need to be researched further, namely leadership, project management, and collaborative teams. Collaborative leaders such as Dell, HP, and Wal-Mart are well known examples that exhibit the importance of leadership in ensuring successful collaboration (Kumar, 1996; Sherman, 1998). There must be a collaborative leader to initiate and maintain interorganisational norms to achieve desired conditions (Andraski, 1998). The second issue relates to how the chain members apply project management to move from one state to another state that brings them closer to common objectives (Dearth, 2003; Patrick, 2002). Future research requires a novel project management that leads to successful implementation of supply chain collaboration. Third, while this study implies that interorganisational norms affect cross-functional teams that represent the organisations of the chain members, little attention has been given to the team approach in managing supply chain collaboration in previous studies. Christopher (1998) asserts the importance of multi-contacts across boundaries of the chain members. For example, logistics and marketing teams from the supplier need to cooperate with the retailer's logistics and purchasing teams. Ancona *et al.* (2002) also argued that cross-functional teams from different companies determine successful product development and delivery. This suggests the need for studying supply chain collaboration from the team perspective to examine how information systems, business processes, incentive schemes, and performance systems can be used to enhance the effectiveness of collaborative teams.

Fourth, little attention has been given to scrutinising the practice of supply chain collaboration from a critical perspective (Knights and Willmott, 2000). Previous research has often assumed that the adoption of supply chain collaboration is a technical change. However, the acceptance of supply chain collaboration is not only a technical matter but also a political change. Future work is needed to examine interorganisational politics amongst the chain members and this should be concerned with investigating how they question and interpret various instruments in supply chain collaboration.

2.6. Concluding Remarks

Supply chain collaboration has become an important cooperative strategy to enhance the collective advantage of independent companies belonging to a supply chain. Close collaboration enables the chain members to create the flexibility and responsiveness required to succeed in intense competition. However, supply chain collaboration is not viewed only as interorganisational business processes that match demand with supply. On the basis of interorganisational norms and the nature of the linkages between chain members, a taxonomy was developed to identify four distinct research streams that individually look at specific instruments used to leverage overall performance. The four research streams are interorganisational information systems, interorganisational business processes, interorganisational incentive schemes, and interorganisational performance systems. By drawing out the relations between interorganisational norms and the nature of linkage between the chain members, it is possible to unify these four streams that were formerly treated as if they were unrelated. This chapter is presented, therefore, as a stimulant for discussion both in terms of how to trace previous work on supply chain collaboration and providing directions for future research.

The research in this chapter suggests that the design task at each cell of the taxonomy needs to be assessed and aligned with other cells. It is through such a crosscheck that the use of instruments of collaboration can enable the chain members to achieve better performance. Although establishing the parameters of research focus is not a guarantee for collaborative success, the wrong structure will deflect the chain members from doing their jobs and attaining better performance. Because of this, it is believed that selecting appropriate instruments, on the basis of their abilities to influence productive behaviour while still enabling the chain members to share information and coordinate work processes with each other, will grow in importance.

While the review of previous work showed a large diversity of variants within the taxonomy, several authors have been critical of identifying the complementarity between different research streams and hence future research on characterising the interaction between the four research streams becomes important. However, the literature provides limited guidance on determining what factors are important in enabling interorganisational collaboration. The review of literature in this chapter has

identified the paucity of the complementarity concept in supply chain collaboration. Hence, further research is required to characterise interorganisational boundaries which help the chain members to understand the complementarity of supply chain collaboration. This thesis particularly attempts to fill the gap by identifying sources of supply chain discontent in order to better understand what prevents chain members from achieving better performance, formulating an integrative framework that specifies important features of supply chain collaboration, and providing empirical evidence based on the framework.

Chapter 3
Supply Chain Discontent

3.1. Introduction

A supply chain usually consists of multiple players, starting from multi-tier suppliers, and including manufacturers, distributors, retailers, and end customers. Increasingly fierce competition has driven most companies to seek a way to enhance performance beyond their four walls (Bowersox, 1990). The ability of a firm to collaborate with its upstream and downstream partners determines its success in attaining better performance (Christopher, 1992; Jap, 2001; Spekman *et al.*, 1998). With collaboration, a firm is able to serve fragmented markets in which end customers require more product varieties and availability. They also are better able to cope with shorter product life cycles and at the same time lower supply chain costs. Companies - such as Wal-Mart, Hewlett-Packard, IBM, Intel, Saturn, Procter & Gamble, McKesson, and Starbucks – have achieved better profitability as a result of supply chain collaboration (Fisher *et al.*, 2000; Kalakota, 2000; Lee *et al.*, 1997).

A supply chain is designed to achieve a chain goal that is the result of optimising total profits through functional differentiation and business process interdependence in offering products to customers (Chopra and Meindl, 2001). The main concern of supply chain management is to create seamless and agile supply-chain processes that enable the chain members to meet customer needs at the lowest costs (Kopczak and Johnson, 2003). However, the overall goal of optimising chain profitability is difficult to achieve because of conflicting interests such as specific wants, perceived needs, and expectations amongst chain members (Sabath and Fontanella, 2002). The participating members are goal-seeking entities that also need to attain their individual goals (Eliashberg and Michie, 1984). Supply chain discontent thus occurs when two or three parties working together along the same supply chain perceive differences in organisational settings that affect their ability to perform better. In this situation, actions taken by one party are often beneficial to it but have detrimental effects on other players. Supply chain discontent leads to efficiency losses such as high logistics

costs and unnecessary costs of demand uncertainty, including surplus inventory, markdowns, and stock-outs (Buzzell *et al.*, 1990; Fisher, 1997). Examples of chain discontent are prevalent in various industries such as electronics (Lee *et al.*, 1997; McCartney, 1994; Zarley, 1997), toys (Kravetz, 1999), and apparel (Fisher *et al.*, 2000). In the studied examples, supply chain "players" would often attempt to shift financial risks associated with demand uncertainty (for example, either shortages or surplus stocking costs) to other players.

Moberg *et al.* (2003) lament that although supply chain discontent devastatingly reduces overall performance, previous studies have paid little attention to *comprehensively* characterising sources or causes of supply chain discontent. Lee and Billington (1992) first highlighted several pitfalls of collaborative inventory management. They categorised them based on observations and interviews. After conceptualising the enablers, impediments, and benefits, Mentzer *et al.* (2000b) provided survey results about the barriers to successful implementation of supply chain collaboration. Most recently, Moberg *et al.* (2003) have identified seven barriers that consistently block chain members from supply chain success, including lack of trust, little commitment to SCM principles, fear of relinquishing control, different goals and objectives, inadequate information systems, a short-term "Wall Street" focus on outcomes, and involvement in too many supply chains. Their study was based on observations, surveys, and anecdotal evidence. While these studies provide a fine-grained analysis of supply chain discontent, none of them explicitly justified the basis for identifying and categorising sources of supply chain discontent. There is a consequent need for a research approach that addresses sources of discontent from a structural view before initiating appropriate ways for remedying the unfavourable situation.

Motivated by the shortcomings of previous studies, the purpose of this chapter is to conceptually examine multiple sources of supply chain discontent. It is argued that the main responsibility of the chain members is first to identify sources of discontent and then to find its antidotes, which help the chain members to maximise the total profits of their collaboration efforts. Consequently, the purpose can be broken down into two objectives: (i) to identify multiple sources of supply chain discontent and (ii) to propose an integrative framework of antidotes to discontent. This research is based on

the organisational economics view in which interorganisational settings influence the behaviour of actors at the boundary-spanning interfaces of their companies (Brickley *et al.*, 1995; Jensen and Meckling, 1992). The emphasis is on conceptual modelling and the use of anecdotal evidence from the real world as secondary data to illustrate and clarify the concept (Stablein, 1999). Secondary data were commonly used in previous studies of business process management and supply chain management (e.g., Barua *et al.*, 1996; Lee, 2002; Lee *et al.*, 1997).

Drawing on the organisational economics view (Jensen and Meckling, 1992), six sources of supply chain discontent are identified in this study: incongruent objectives, disintegrated performance measures, unsynchronised decision making, information asymmetry, misaligned incentives, and fragmented business processes. All these sources separately or collectively contribute to reduce the potential of total profits arising from collaboration. Furthermore, it is argued that to effectively mitigate supply chain discontent, the participating members need to collaboratively design antidotes for discontent, which consist of mutual objectives, appropriate measures of performance, information sharing, decision synchronisation, incentive alignment, and streamlined intercompany business processes. This integrative framework is based on the value creation path model and adopts the complementarity theory to ensure that antidotes or interorganisational design variables contribute maximally to the overall success of collaboration (Milgrom and Roberts, 1990). This study thus provides a novel conceptual model to understanding design variables in supply chain collaboration.

The remainder of the chapter proceeds as follows. The next section presents dysfunctional behaviour in supply chains. The subsequent section discusses multiple sources of supply chain discontent that prevent players from optimising chain profitability. Furthermore, an integrative framework of antidotes for mitigating discontent is presented. The discussion section provides insights about implications of the study for managers and researchers, and recommendations for future research. The chapter concludes with a summary of key ideas.

3.2. Dysfunctional Behaviour in Supply Chains

Although chain members have a common interest in expanding mutual advantage by collaboration, a chain member may perceive its individual goal attainment as being impeded by other members. Supply chain discontent is defined as a situation that occurs when two or three parties working together at the same supply chain perceive organisational differences that affect their ability to perform better to maximise potential profits. Supply chain discontent may involve issues such as pricing control, inventory control, operations control, control over the channel structure, information control, task completion, risk/reward splitting, and policy interpretation (Munson *et al.*, 1999; Simatupang and Sridharan, 2002). Supply chain discontent is often characterised by a zero sum orientation that means when one player wins, another chain member must lose (Nalebuff and Brandenburger, 1996). Detrimental effects of supply chain discontent can be inefficiencies in both operational and commercial sides of the supply chain. Operational inefficiencies include task duplication, long lead-times, unwanted stocks, and distorted information. Commercial inefficiencies may be pricing distortion, unnecessary inventory costs, lost sales, and disputed risk pooling.

Supply chain discontent is manifested in dysfunctional behaviour that can be observed during the ongoing relationship. The dysfunctional behaviour refers to decisions and actions - in the areas of forecasting, inventory, transportation, and pricing – taken by individual chain members that prevent the achievement of the chain goal. As the chain processes are interdependent, a particular action taken by one member often affects both the operational and commercial performance of other chain members. Individual actions such as adding a new distribution channel, reducing a wholesaler's territory, changing the discount structure, requiring existing trading partners to perform additional services, and changing the terms of a distribution agreement without considering the impacts of such changes on the achievement of the chain goal are examples of dysfunctional behaviour.

The chain members need to counter the pervasiveness of supply chain discontent as it frequently generates unnecessary inefficiencies (Lee *et al.*, 1997). Supply chain discontent not only erodes revenues and increases costs but also diminishes trust amongst members. Consequently, the detrimental effects of supply chain discontent

on the overall performance should be mitigated by first identifying underlying factors influencing the behaviour and then finding effective antidotes for improvements. The next section presents sources of supply chain discontent.

3.3. Sources of Supply Chain Discontent

The critical question of how to resolve supply chain discontent should begin with identifying sources that influence dysfunctional behaviours. As identified in the introductory section of this chapter, previous research has appeared to recognise sources of supply chain discontent. However, little attention has been given to comprehensively identifying various sources and their interactions on profitability. For instance, the rational behaviour of chain members in optimising their own performance instead of that of the overall supply chain is often viewed as a source of supply chain discontent (Fisher, 1997; Lee *et al.*, 1997). Fisher (1997) identified the fact that a lack of coordination in dealing with demand uncertainty contributes to unnecessary costs of markdowns and lost sales. Lee *et al.* (1997) discovered that the bullwhip effect, as the primary source of inefficiencies amongst chain members in the supply chain, was an example of supply chain discontent.

This current research in this chapter goes further to provide an alternative to previous research by applying the view of organisational economics in identifying multiple sources of supply chain discontent in an integrative manner. This view assumes that: interorganisational settings can influence participating actors, actors are rational and self-interested, and information is costly to produce and transfer among actors (Jensen and Meckling, 1992). A number of researchers have highlighted the importance of organisational settings that influence the behaviour of the participating members in making decisions and taking actions (Brickley *et al.*, 1995; Brickley *et al.*, 2003; Simatupang and Sridharan, 2002; Smith, 2001). This view can be adopted to explain that poorly designed boundary-spanning interfaces contribute to the failure of supply chain collaboration. As an independent entity, each participating member has its own strategic objectives, performance measures, decision authority, private information, internal costs and revenues structures, and business processes. When the chain members collaborate with each other, any misfits in these structural elements can contribute to lost profits (Brickley *et al.*, 1995).

Furthermore, changes in one element without considering its effect on other elements can result in failure in attaining potential benefits (Milgrom and Roberts, 1990). Based on this conception, Figure 3.1 provides a model of identifying multiple sources of supply chain discontent. The multiple sources of discontent include: incongruent strategic objectives, disintegrated performance measures, misrepresentation of decision authority, misaligned incentives, information distortion, and fragmented intercompany business processes. Incongruent objectives and disintegrated performance measures indicate a lack of shared commitment amongst the participating members. A lack of coordination incorporates factors that influence individual players to take decisions that deviate from supply chain profitability, namely unsynchronised decision making, information asymmetry, and inappropriate economic incentives. Fragmented intercompany business processes indicate a lack of collaborative attention to reducing wastes and inefficiencies from sourcing to selling activities across organisational boundaries. The remaining section discusses each source of supply chain discontent.
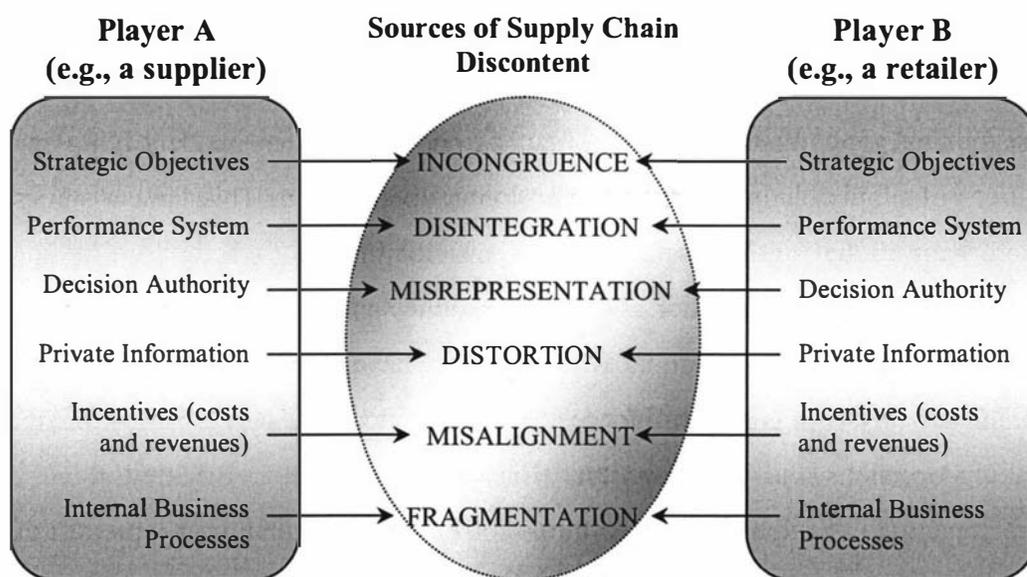
Figure 3.1. Identifying multiple sources of supply chain discontent

An incongruent strategic objective situation occurs when chain members place different emphasis on strategic options to enhance competitive positions (Bowersox, 1990; Eliashberg and Michie, 1984). This is because each player in the supply chain has a different position and role in the supply chain that leads to different strategic

priorities. For example, the strategic objective of a supply chain to maximise a profit margin can be perceived differently by a supplier and a retailer. For the supplier, maximising a profit margin can be achieved through reducing product lines in order to lower set-up costs. On the other hand, the retailer translates such an objective as providing more product lines to customers.

Disintegrated measures of performance mean that the performance measures are based on individual metrics isolated from the entire goal because each player has been managed as a single entity (Simatupang and Sridharan, 2002). There are several reasons for this disintegration. First, the chain members simply do not have performance measures of the entire supply chain. Second, there is a bias toward internal measures rather than overall measures. Any action directed at improving individual metrics, without appreciation of the overall system, is likely to have a detrimental effect on at least one of the other chain members (Goldratt, 1994). Internal measures of performance often mislead the individual members because the overall performance also depends on the performance of other members outside the individual member's four walls. Bain's survey found that only 44% of the sample tracked performance outside the company's four walls (Cook and Tyndall, 2001). Third, performance measures are often based on cost reductions rather than revenue enhancement for the entire chain. Cost reductions are often translated as cost shifting to other members rather than cost elimination (Betts, 1994).

Unsynchronised decision making - known as misrepresentation - refers to differences in decision-making procedures that lead to counterproductive decisions (Lee *et al.*, 1997). This is because the chain members have different decision authorities and different perspectives of responsibilities. In this situation, the player – who is responsible for making decisions in a particular stage – optimises only their local objectives without considering the impacts of such actions on other stages. Consequently, the chain members suffer from task duplications, lack of tacit knowledge, and delays in decision making. Total profits are thus less than what could be achieved through synchronisation (Lee *et al.*, 1997). For instance, in the context of a seller-buyer relationship, independent order decisions lead to suboptimal solutions. The literature recognises unsynchronised decision making between a retailer and a supplier as double-marginalisation. The retailer chooses to under stock inventories

lower than the optimal order number, whereas the supplier insists on supplying above the optimal number.

Information asymmetry occurs when one player has better access to certain information sources compared to other players (Lee and Whang, 2000). The member with superior information can take advantage from either hidden information and hidden action or both (Jensen and Meckling, 1992). The manufacturer, for instance, has superior knowledge about its own operations including product quality, production capacity, and delivery lead-time. The retailer, on the other hand, has better knowledge of product demand and customer preferences in the market, but not of individual goods. The problem of hidden information occurs if either the manufacturer or the retailer is reluctant to share relevant information – with the result that neither party can resolve conflicting decision criteria in inventory, transportation, lead-time, capacity, product variety, and quality (Simchi-Levi *et al.*, 2000). The problem of hidden action means that one party cannot observe actions taken by another party. For instance, a car manufacturer may depend on its dealers if its product sales depend on the dealer's level of efforts to serve customers. The existence of information asymmetry makes it difficult for the manufacturer to always monitor levels of efforts exerted by its dealers.

Inappropriate economic incentives refer to assigning rewards and punishments incompatible with optimising the performance of the supply chain as a whole (Simatupang and Sridharan, 2002). Misaligned incentives induce the individual players to intentionally make decisions which deviate from the satisfactory solution because the local solution provides more benefits - even though individual parties know the optimal solution (Lee *et al.*, 1997). It is often believed that incentives to reduce the costs of each part of a supply chain can optimise the overall profitability. However, since the chain members are interdependent, cost reduction for one member might be revenue reduction for others. Furthermore, any cost reduction has a lower bound (i.e., the theoretical limit of cost is zero, but the practical limit is greater than zero) because the individual member cannot produce outputs without incurring costs. Such perverse incentives for cost reduction motivates an individual member to suboptimise their own economic interests instead of striving to achieve overall profitability (Gjerdrum *et al.*, 2002). For example, a retailer prefers to maintain a low

level of a particular brand on store shelves because there is no incentive to avoid lost sales for that particular brand (Raman, 1998). A similar misaligned incentive situation occurs across departments in many retailing companies. A buyer, for instance, wants to reduce purchasing costs by attaining quantity discounts with large order sizes. On the other hand, a warehouse manager has an incentive to minimise inventory-holding costs including receiving, unloading, and put-away costs. In one case involving similar, conflicting incentives, a manufacturer of cell phones - dictated by full truckloads in order to minimise transportation costs – lost market value as high as twenty percent due to product unavailability (Cook and Tyndall, 2001).

Fragmented intercompany business processes often contribute to various wastes along the supply chain that lead to unnecessarily high operating costs and considerable unnecessary costs of supply-demand mismatch, which lead to poor profitability. Indicators of undesirable situations include long leadtime, unreliable delivery, overlapping ordering processes, considerable expediting activity and associated costs, high transportation costs, high process variability, markdowns, and high levels of inventories (Goldratt, 1994; Lee *et al.*, 1997; Simchi-Levi *et al.*, 2000). Kurt Salmon, for instance, estimated that an apparel retailing industry incurred over $16 billion of efficiency loss per year due to markdowns, out-of-stock items, and the cost of carrying excess inventory (Blackburn, 1991). This loss was primarily due to the fragmented pipeline processes in this industry, which resulted in a long "time-to-market" from the production stage to the consumer.

3.4. Antidotes for Supply Chain Discontent

The common feature of supplier-retailer relationships is a mutual understanding that the success of each player depends, in part, on other players (Frankel *et al.*, 2002; Sabath and Fontanella, 2002). The chain members need to understand which assumptions are flawed and prevent them from making further improvement. One prevalent example of a flawed assumption that allows supply chain discontent to persist during a relationship is that the participating members believe that the sum of local optimisation taken by individual members is equal to the total improvement. The current practice of the relationship overlooks the facts that a supply chain consists of interdependent processes that serve the same customers and total profits are not fixed.

It is not surprising that chain members behave either to diminish total profits or split total profits. In fact, the total profits are not fixed and can be enlarged through collaboration (i.e., we all win). Supply chain collaboration occurs when the participating members work together for solutions that maximise the gains for all parties. The total improvement thus depends on how the chain members diminish common constraints that prevent them from attaining better profitability (Goldratt, 1994).

In this study, antidotes for supply chain discontent are recommended. Each antidote is designed to mitigate the detrimental effects of a corresponding source of supply chain discontent. It is derived from the logic of identifying "what to change from" that represents a typical source of unwanted discontent to finding "what to change to" that represents effective solutions that lead to desirable effects. Figure 3.2 shows antidotes that operate at two different levels: a shared commitment and collaborative business drivers. At the level of a shared commitment, the chain members need to agree on developing and communicating mutual strategic objectives and appropriate performance measures of mutual success. At the level of business drivers, the chain members should collectively design appropriate business drivers for their collaborative efforts that are the most effective contributors to supply chain profitability. These business drivers include information sharing, decision synchronisation, incentive alignment, and streamlined intercompany business processes.

Having stated the antidotes of discontent, three important characteristics of the framework warrant further examination. First, each type of antidote serves as a design variable for intervention that can have profound effects on overall performance because this chosen antidote affects the behaviour of the chain members in pursuing overall profitability. Therefore, the redesigning of interface variables or antidotes should stem from mitigating the core problem that prevents the chain members from achieving optimum performance.

Second, Figure 3.2 provides a framework for designing more effective boundary spanning interfaces amongst the chain members. This integrative framework allows them to take advantage from redesigning combined antidotes that accelerate the

increase of total profits. This logic is consistent with the complementarity theory, which postulates that if two antidotes are complements then the marginal contribution of one increases as the level of the other one increases. Milgrom and Roberts (1990) have used it to explain that modern manufacturing firms adopted coordinated innovative activities rather than the traditionally separate activities of design, engineering, manufacturing, and marketing. Additionally, Barua *et al.* (1996) have developed a theoretical model to explain that the reengineering project should consider coordinating reengineering activities rather than isolated activities in order to obtain the complementarity effects of activities.
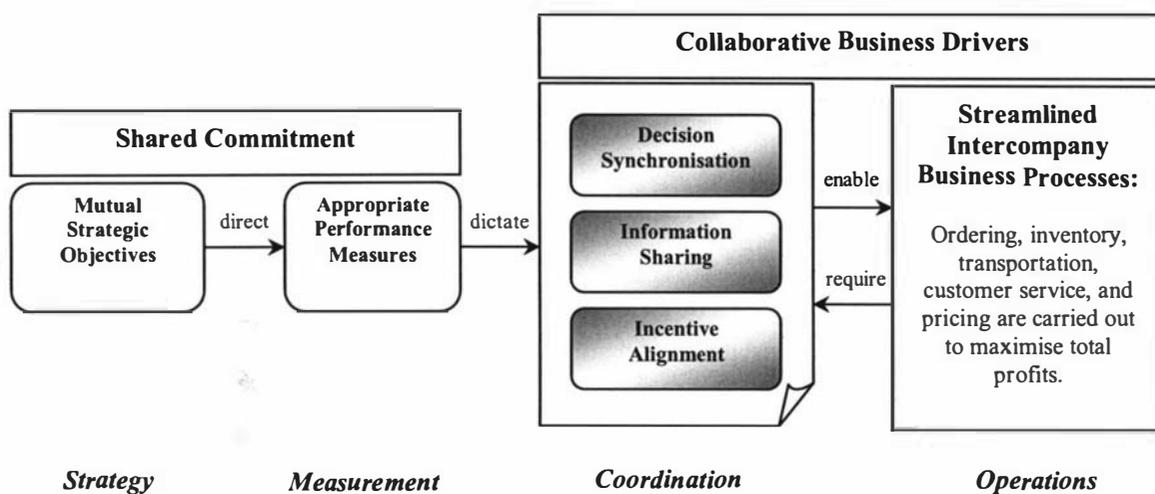
Figure 3.2. Antidotes for supply chain discontent

Third, the framework implies that the four business drivers ultimately affect total payoffs. The interactions between antidotes serve as input variables that determine operational outputs and ultimately contribute to overall performance. Figure 3.3 shows the interrelation between intercompany business drivers that affect intermediate measures, which in turn impact financial outputs (Simatupang *et al.*, 2002). This value creation path model allows the chain members to identify a set of collaborative business drivers that impact overall payoff including intermediate performance measures of their collaboration. They are also able to coordinate choices of the levels and improvement directions of the business drivers in a complementary manner. The model in Figure 3.3 is akin to business value modelling represented as a two-stage model as developed by Barua *et al.* (1995) in explaining that the economic benefits of information technology (IT) investments can be assessed through recognising that choice variables such as IT and other input investments affect intermediate measures

such as capacity utilisation and inventory turnover, which in turn contribute to financial performance measures such as return on assets and market share. The remaining section describes each antidote for mitigating supply chain discontent.

Collaborative Business Drivers	**Intermediate Measures**	**Collaborative Business Outcomes**
• Information Sharing • Decision Synchronisation • Incentive Alignment • Streamlined Business Processes	• Availability • Responsiveness • Leadtime • Flexibility • Inventory Turnover • Operating Costs • Time-to-Market	• Cash Flow • Net Profit • Return on Investment (ROI) • Market Growth • Market Share
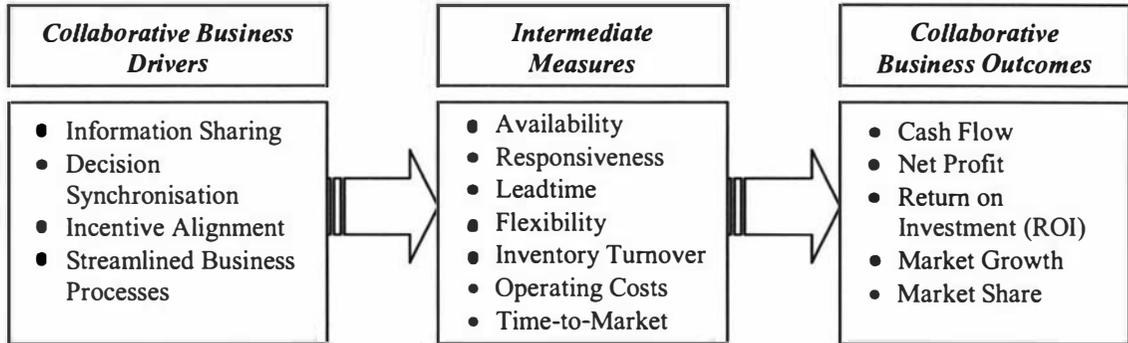
Figure 3.3. A value creation path model: from intercompany business drivers leading to financial outcomes

3.4.1. Mutual Strategic Objectives

Strategic objectives are specific targets of competitive positions that the chain members can apply in order to create competitive advantage through collaboration such as accurate response, inventory deployment, customer loyalty, target costs, rapid product development, and so on (Frankel *et al.*, 2002; Simchi-Levi *et al.*, 2000). The chain members need to specifically determine their strategic objectives that impart survival reasons for creating competitive responsiveness to market changes.

3.4.2. Appropriate Performance Measures

Appropriate measures of performance can be defined as a set of measures used to evaluate participating members' performance and overall performance. The measures should allow the chain members to judge the impact of every action on overall payoff (see Figure 3.3). The effectiveness of individual members in contributing to strategic objectives can be evaluated using intermediate or operational metrics that span across companies such as customer service, perfect order, new product introduction, speed, and operating costs (Banker and Snitkin, 2003; Lapide, 2000). Overall collaborative business outputs are usually measured in terms of net profit, cash flows, return on investment (ROI), market growth, and market share (Grey *et al.*, 2003; Simatupang and Sridharan, 2002).

3.4.3. Coordination Structure

At the level of coordination, chain members need to harmonise distributed decisions, information, and incentive amongst themselves in supporting their interdependent business processes that contribute to mutual objectives. As the chain members need to share decision authorities, each individual member is responsible for different decision variables and makes those decisions based on different information. The outcome of the supply chain depends jointly on the separate decisions taken by the members and on some environmental uncertainties. As mentioned before, information asymmetry, when combined with a divergence of interests of the individual decision makers, leads to inefficiencies of decision making. Therefore, addressing the problem of coordination means recognising that there are three kinds of diversity amongst chain members: (i) a diversity of decision rights, (ii) a diversity of private information, and (iii) a diversity of incentive. The problem of coordination thus can be summarised as: to choose a coordination structure which energises the chain members to pursue competitive outcomes, recognising the constraints imposed by the diversity of decision rights, private information, and incentives among the chain members.

In this study, a coordination structure is defined as a strategic choice of shared responsibility of decision right, level of information sharing, and level of incentive alignment in order to enhance the overall mutual benefits of the collaboration such as increasing customer value and lowering total supply chain costs. Initiatives that can be taken to mitigate supply chain discontent include decision synchronisation, information sharing, and incentive alignment. When combined, the intensity of decision synchronisation, information sharing, and incentive alignment determines the spectrum of the coordination structure, as shown in Figure 3.4. This spectrum level indicates the degree of collaboration at interface level amongst chain members. The chain members need to cooperate with each other to determine the appropriate spectrum level of coordination structure that enables them to effectively realise mutual advantage. For ease of description, each component of the coordination structure can be generally divided into three levels.

Decision synchronisation can be defined as the degree of cooperative decision making amongst chain members that jointly determine areas of responsibilities and allocation of decision rights (Jensen and Meckling, 1992; Simatupang *et al.*, 2002). The

allocation of decision rights (who decides what) should be accompanied by a set of rules or contracts to ensure that the recipient of decision rights exercises its rights in a way that results in collective mutual advantages such as better customer service and lowered costs. The intensity of decision synchronisation ranges from independent decision making (i.e., no allocation of decision rights), consultative decision making (i.e., joint exercise of decision rights and responsibilities), and synchronised decision making (i.e., redesigning decision rights and responsibilities).
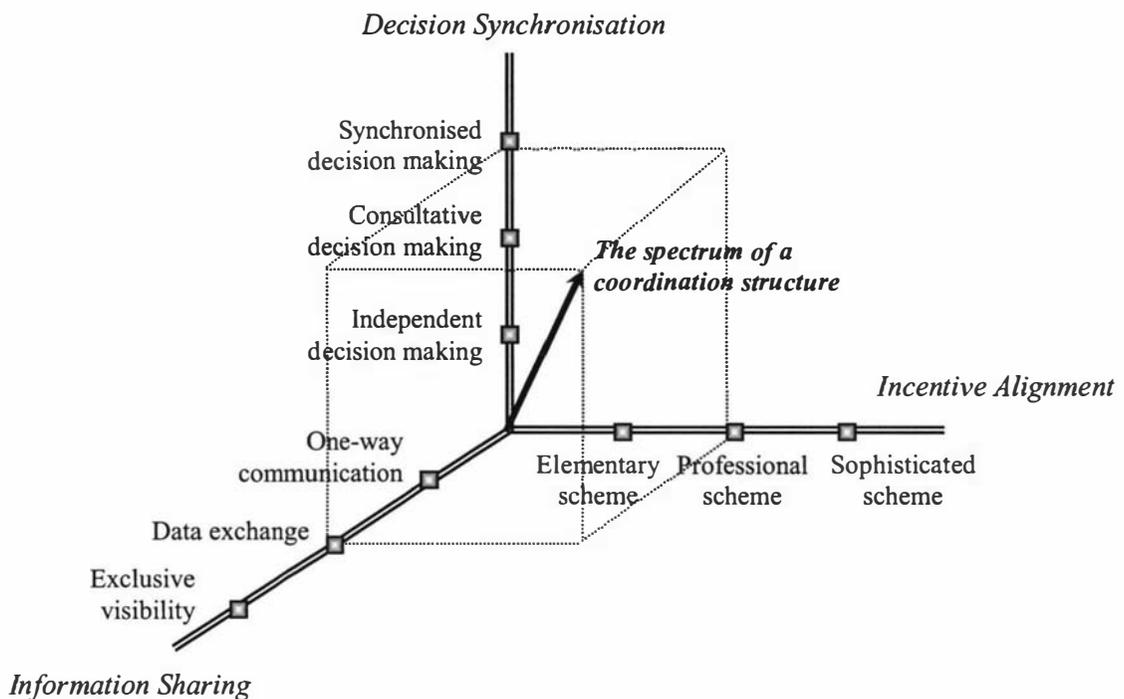
Figure 3.4. Displaying the spectrum of a coordination structure

The chain members should be able to choose which type of decisions they need to synchronise in order to ensure direct impacts on chain performance. Decision making along the supply chain relates to three general levels: strategic, tactical, and operational decisions (Simchi-Levi *et al.*, 2000). The strategic level is concerned with decisions that have strategic importance and involve the long-term game plan for a firm. This type of decision includes capability building (product design and technologies) and network configuration. Tactical decisions are concerned with short-term resource allocation such as collaborative product planning, forecasting, inventory planning, and distribution planning. These decisions are affected by customer service,

inventory, product pricing, and transportation costs. For example, a retailer gives the stocking decision right to a supplier like a vendor-managed inventory (VMI) system because the supplier knows better about its product characteristics, production capacity, and distribution system (Simchi-Levi *et al.*, 2000). Operational decisions must resolve all the issues of controlling daily activities on chain operations. Examples of this type of decision are routing vehicles, developing and modifying a production schedule and replenishment schedule, and filling customer orders on time.

Information sharing refers to a description of the range of each firm's private information (who knows what) and information dissemination among the members (Simatupang and Sridharan, 2002). The chain members need to determine information requirements that can be used to make effective decisions. Information sharing enables the chain members to consider a bigger picture in optimising supply chain operations. Previous studies demonstrate that information sharing leads to lowered inventory levels, effective allocation of resources, lowered operating costs, and improved total profits (Fisher, 1997; Lee *et al.*, 1997). For example, Thonemann (2001) showed that all participating members benefit from sharing advance demand information. The supplier mainly benefits from reduced inventory holding costs and retailers benefit from lowered shortage penalty cost and better product availability.

Information sharing facilitates data collection, documentation, computation, transfer, and access to various kinds of private information. It ranges from one-way communication to data exchange, and exclusive visibility. One-way communication means the chain members communicate with each other through transactional data such as purchase orders, order and delivery status, product catalogues, and price quotation (Lee *et al.*, 1997). Data exchange allows the sharing of private data in two-way communication and include such things as points-of-sale data, delivery schedules, inventory levels, forecasts, capacity planning, and performance status (Lee and Whang, 2000). Exclusive visibility includes sharing proprietary data such as strategic planning, market research, product blueprint, and sensitive costs-related data (Fisher, 1997). This enables chain members to carry out mutual optimisation of business process that enhances a distinct competitive edge (Konsynski and McFarlan, 1990).

Incentive alignment reflects various inducements (i.e., reward and penalty schemes) to sharing costs, benefits and risks to be applied by the chain members during the collaboration (Simatupang and Sridharan, 2002; Simatupang *et al.*, 2002). Since each member may bear a portion of the total chain costs, the agreement to optimise the chain performance may not automatically minimise individual member costs. Incentive alignment thus means to design proper incentives that motivate players in aligning individual decision making more closely to the overall goal by sharing costs, distributing risks, and sharing benefits. If the incentive scheme is not designed properly, the individual member will be tempted to deviate from the agreement in order to maximise its short-term gain. How should one take into account the private economic interest of the individual decision maker? Incentive alignment assumes that the individual member bases decision making on the compensation it receives from others. This compensation depends on the actions of the various decision makers, either directly (e.g., actions may be audited to see if they are correct, and incorrect actions may lead to penalty), or indirectly (e.g., profit sharing, bonuses based on sales, splitting the savings, and so forth).

The intensity of incentive alignment ranges from elementary, to professional and sophisticated schemes of inducements. An elementary scheme consists mainly of transfer payments based on current market mechanisms - such as zoning, quota, rebates, warranties, price discount, quantity discount, and so on - necessary to move products swiftly to end customers (Buzzell *et al.*, 1990). A professional scheme attempts to share costs and benefits tied to mutual objectives. Options can be made more economically attractive by applying inducements - such as accurate forecast, quick response (e.g., on-time or responsiveness related payment), shared cost-savings, and gain sharing - based on improved performance (Chopra and Meindl, 2001). A sophisticated scheme is a change of priorities within the partners' decision framework of risk sharing (Billington *et al.*, 2003). It clearly spells out obligations, expectations, and remedies. The calculation of this scheme often requires complex algorithms. Sophisticated schemes for risk sharing include flexible quantity contracts, returns policies, price protection, real options, and dynamic pricing (e.g., Billington *et al.*, 2003; Lee, 2002). For example, a manufacturer can offer two options of order delivery to a retailer in an attempt to share risks associated with demand uncertainty: lower unit price with long leadtimes and higher unit price for production and delivery

but with short leadtimes. Both options enable the retailer to improve the right product availability during a short selling season.

The spectrum of the coordination structure is useful to specify who the players are and what kind of coordination structure they might operate. For example, tight collaboration occurs when the chain members operate in a synchronised decision making process with exclusive visibility and sophisticated incentives. A clear picture of the whole coordination spectrum enables the chain members to identify the sources of supply chain discontent and devise initiatives to remove problems. Initiatives for decision synchronisation, information sharing, and incentive alignment should be carefully selected in order to ensure that they have direct impacts on total profits.

3.4.4. Streamlined Intercompany Business Processes

The chain members need to collaboratively eliminate waste across their supply chain processes in order to create the flexibility required to respond to constant market changes. Initiatives of intercompany business process reengineering can be in the forms of product redesign, process redesign, reducing on-time variability, reducing demand variability, lead-time reduction, improving forecast accuracies, cross-docking, and postponement (Blackburn, 1991; Christopher, 1992; Kalakota, 2000; Kopczak and Johnson, 2003). For example, Dell collaborated with its main suppliers to adopt various types of postponements and process improvements in order to create a flexible and lean supply chain with a minimum level of inventory pipeline, down to a few days' worth of sales (Dell and Fredman, 1999). As a result, Dell had a significant advantage in cash collection time and an increase in profit margin.

3.5. Discussion

This chapter contributes to the literature of supply chain management by providing a conceptual model for identifying and mitigating discontent as shown in Figure 3.5. The model begins with recognising dysfunctional behaviours that lead to scepticism about collaboration. The responsibility of the chain members is to identify potential sources of discontent that could have a detrimental impact on overall payoff. Revealing multiple sources of discontent helps the chain members to determine where their strategic objectives are not compatible; pinpoint performance problem areas;

build consensus around joint decision making, information visibility, and incentive issues; and set priorities for streamlining intercompany business processes. Eroding revenues and increasing costs must be prevented through applying the integrative framework of six antidotes for mitigating supply chain discontent. The chain members need to engage in dialogue and use the value creation path model and the complementarity theory to devise appropriate directions and levels of improvements. This dialogue ensures that time and resources are dedicated to implementing only those initiatives which will truly contribute to overall payoff (Grey *et al.*, 2003).
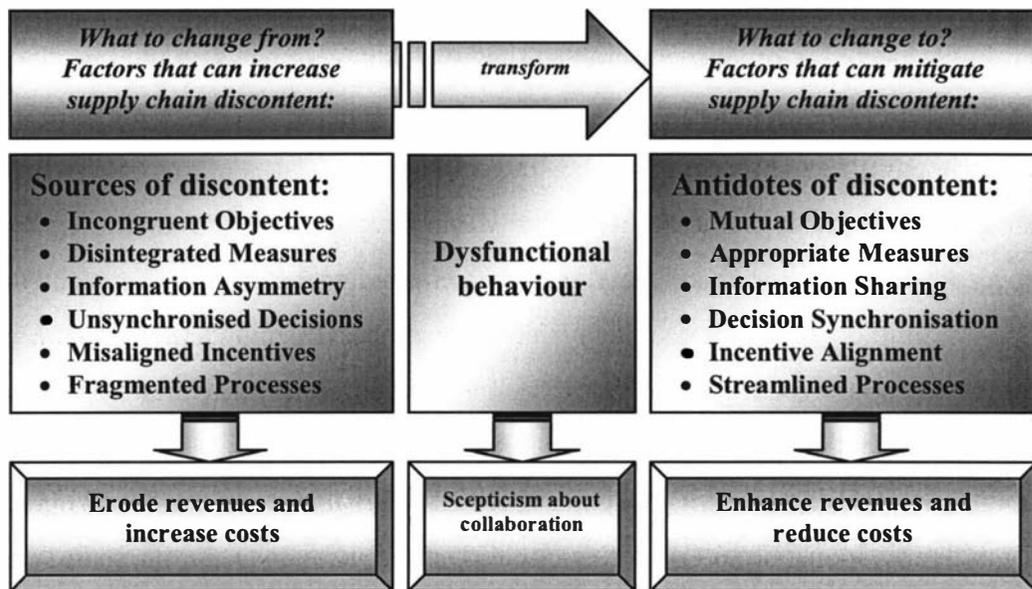
Figure 3.5. The discontent model: identifying and mitigating discontent

The framework of antidotes (see Figures 3.2, 3.3, and 3.4) provides several managerial implications on how to apply this concept in supply chain collaboration. First, the chain members need to determine an interorganisational business value of collaboration. The value creation path model suggests that all antidotes must be directed to supporting the goal of supply chain profitability. A top-down analysis can be carried out to first specify overall measures of success such as profitability, market share, and market growth, and then identify intermediate measures of performance which contribute to overall measures, and at the lowest level identify collaborative business drivers (see Figure 3.3). Second, the chain members should identify and validate complementarity relationships amongst the business drivers. This means, for instance, assigning decision rights to a particular member should encourage this

member to use its private information to make better decisions. If the chain members decide to redesign a performance system, they must ensure that they also redesign appropriate incentive schemes to motivate individual members to make decisions that support overall performance. A scenario analysis can be conducted to assess the combined effects of changing the levels of business drivers on profitability. Finally, the chain members need to devise how to effectively cause the change. They also need to identify a catalyst for the change such as choices of technologies that are suitable to the selected design variables of antidotes.

This study provides the first conceptual model that comprehensively incorporates elements of interorganisational designs used to mitigate detrimental impacts of supply chain discontent on overall payoff. Previous approaches have tended to focus on a single antidote, or on two antidotes such as information sharing and streamlined business processes (e.g., Kalakota, 2000; Lee *et al.*, 1997). Little attention has been given to explicitly exploiting the complementarity effects of antidotes in the process of attaining profitability. The first antidote is often called strategy making that specify mutual strategic objectives of collaboration, whereas the last five antidotes constitute interorganisational elements designed to fit the strategy. Table 3.1 compares the five design elements of collaboration to other common approaches used to mitigate supply chain discontent. Game theory, for example, provides a systematic way of developing strategies when one player's payoff depends on what other players do (Nalebuff and Brandenburger, 1996). Although this approach can be used to determine appropriate policies that maximise overall performance and ensure a Pareto optimal solution for all chain members (see Gjerdrum *et al.*, 2002), there is little guideline for determining what factors drive the collaborative payoff. To enhance the analysis of game theory, Figure 3.4 provides a more comprehensive approach for the chain members to understand and identify appropriate interorganisational business drivers that could affect overall payoff. Another example is business process reengineering, which is defined as the fundamental rethinking and radical redesign of business processes to improve business performance and to stay competitive (Hammer and Champy, 1993). Reengineering changes often involve a large amount of IT investments and the reassignment of decision rights. However, the reengineering approach pays little attention either to guidelines for tracing and measuring the

engineering changes on overall payoff (Barua *et al.*, 1996) or to redesigning incentive and performance systems.

Table 3.1. Comparisons with selected approaches for mitigating supply chain discontent

Selected approaches (influencers)	Description	The five elements of collaboration proposed in this chapter				
		Appropriate Performance System	Information Sharing	Decision Synchronisation	Incentive Alignment	Streamlined Business Processes
Quick Response (Blackburn, 1991; Kurt Salmon Associates)	A consumer-driven strategy that promotes pulling things through the pipeline and letting the consumers decide what they want.	A successful collaboration means higher inventory turns and improved ROI for each member. Little guidance is given to develop cross-boundary performance measures except time related measures.	Each link in the chain shares data about sales, orders, and inventories with others via electronic data interchange (EDI).	Quick response involves reassignment of decision rights and joint decision making in planning and execution.	Little attention is given to restructuring rewards, costs, and risks.	Quick response involves process improvements such as modular manufacturing, lead-time reduction, and smaller and more frequent orders.
Business Process Reengineering (Hammer and Champy, 1993)	The fundamental rethinking and radical redesign of business process to achieve overall payoff.	Little attention is given to redesigning intercompany performance measures.	Reengineering involves high investments in IT.	Reengineering involves reassignment of decision rights.	Little attention is given to restructuring rewards and punishments.	Reengineering involves radical redesign of business processes.
Game Theory (Nalebuff and Brandenburger, 1996; Gjerdrum *et al.*, 2002)	The choice of optimal strategy that combines competition and collaboration.	The payoff is the outcome of each strategy. Little attention is given to restructuring cross-boundary measures.	This approach assumes visibility on costs and revenues.	Each player makes strategic decisions to gain advantage over a rival. Little attention is given to reassignment of decision rights.	The focus is on fair sharing of risks, costs, and profits.	No guideline is given about improving business processes.
Accurate Response (Fisher, 1997; Fisher *et al.*, 1994; Fisher *et al.*, 2000; Raman, 1998)	Fitting the nature of the demand of products to the appropriate supply chain design strategy because of differences in production costs and the costs of a supply-demand mismatch.	The focus is on measures such as contribution margin, forecast error, stockout rate, markdowns, and lead-time. Little attention is given to restructuring cross-boundary measures.	Accurate response involves data sharing about advance demand information, sales, inventory levels, capacity, and lead-time.	Accurate response involves reassignment of decision rights and joint decision making in planning and control.	Guidance is given about rewarding responsiveness and sharing markdown costs.	Physical efficient process involves minimising inventory and shortens lead-time. Market-responsive process aggressively reduces lead-time and uses modular design.

Studies aimed at promoting an integrative framework of antidotes for mitigating supply chain discontent have recently emerged. The first stages of this new research are necessarily description and classification (Kerlinger, 1973). Simatupang and

Sridharan (2004b) provide empirical evidence of applying this approach to a study of benchmarking in supply chain collaboration. Nevertheless, several issues of further extensions, mathematical modelling, and empirical evidence of the framework proposed in this chapter warrant further research. While this study focuses on supplier-retailer collaboration, it can very easily be extended to include more than two participating members. Another extension of this research is to develop a portfolio of collaboration because not every business relationship in the supply chain is collaborative but varies in its intensity. Future research is also required to develop mathematical foundations to ensure the complementarity conditions (Topkis, 1995) of intercompany business drivers and the strong supermodularity conditions (Barua *et al.*, 1996) of the value creation path model. Finally, the integrative framework of antidotes proposed in this chapter uses a normative approach, which allows researchers to scrutinise how the chain members ought to manage collaboration given particular objectives. However, this approach must be balanced with the findings from descriptive research, which focuses on what managers actually do in the collaborative efforts. The remaining section provides directions for descriptive research.

Changing the mindset from the competitive supply chain (i.e., a bargaining relationship) to the collaborative supply chain (i.e., a win-win relationship) is a vital prerequisite to understanding the mutual benefits of improvement initiatives. Identifying sources of supply chain discontent provides a starting point to recognising deficiencies in the current practice of the relationship. The main trigger that drives the chain members to redesign their interorganisational structures is deficiency - indicated by the fact that realised outcome is much lower than might be expected. Future research is needed to elaborate upon methods for measuring deficiency and its linkage to sources of supply chain discontent. This includes how and why supply chain discontent exists amongst participating members. Since boundaries of the context and the phenomenon of supply chain collaboration are not obvious and investigators have little control over events, case study research is recommended as an appropriate method to better understand collaborative efforts (Yin, 2003).

The people factor plays a key role in the success of supply chain initiatives. However, little research has been dedicated to pinpointing the mental models of people who actually carry out the improvement process (e.g., Akkermans *et al.*, 1999; Covington,

1996). Further research is required to capture mental models of participating managers about interorganisational redesigns as an integrative way of improving overall performance. Cognitive mapping, for instance, can be used to elicit and describe mental models (Akkermans *et al.*, 1999).

3.6. Concluding Remarks

The difficulty of creating collective advantage from adopting supply chain collaboration as a strategic initiative is strongly related to supply chain discontent. Supply chain discontent occurs when the chain members cannot realise their potential due to differences in interest, and thereby the realised outcome is much lower than expected. Where supply chain discontent is prevalent, the individual member focuses on their private agenda to the detriment of overall chain profits. As a result, inefficiency loss such as excessive inventories, stockouts, markdowns, and resource misallocations are prevailing undesirable symptoms in many supply chains.

The research reported herein has revealed sources of supply chain discontent that include incongruent strategic objectives, disintegrated performance measures, unsynchronised decision making, information asymmetry, misaligned incentives, and fragmented intercompany business processes. These multiple sources are adequate to represent all discontent in supply chains based on the view of organisational economics (i.e., Brickley *et al.*, 1995). Furthermore, each source of chain discontent provides an opportunity for identifying a remedy or antidote. This study has also proposed the integrative framework of antidotes for mitigating supply chain discontent. Antidotes for supply chain discontent incorporate initiatives to resolve shared commitment and collaborative business drivers. Gaining shared commitment involves setting mutual strategic objectives and defining appropriate measures of performance. Collaborative business drivers incorporate decision synchronisation, information sharing, incentive alignment, and streamlined intercompany business processes. Furthermore, the value creation path model provides directions for improvements, whereas the complementarity theory serves as a basis for choosing the right levels of improvements among intercompany business drivers, which contribute maximally to the overall payoff of collaboration.

In this chapter, a new alternative for interorganisational redesign is proposed, which is based on the organisational economics view and the complementarity theory and thereby contributes to a novel understanding of supply chain collaboration. This new alternative explicitly conceptualises the complementarity effects of antidotes on intermediate performance measures, which in turn determine overall financial outcomes. Only when the chain members discuss and design coordinated antidotes can the real payoff of collaboration be traced and measured. The next chapter will elaborate and demonstrate the necessary and sufficient conditions for the antidotes.

72

Chapter 4
A Theoretical Framework for Supply Chain Collaboration

4.1. Introduction

The information age and globalisation are forcing companies to place a premium upon collaboration as a new source of competitive advantage (Dyer and Singh, 1998). Closely working together enables the participating members to create and capture mutual benefits for all members from matching demand with supply (Fisher, 1997). Mutual advantages often translate to a very positive return on investment and more efficient inventory management (Walker *et al.*, 2000). Wal-Mart, for instance, collaborated with Warner-Lambert to attain mutual benefits of collaborative planning, forecasting, and replenishment (Parks, 2001). Mutual benefits included an improvement in stock levels on Listerine to 98 percent from 87 percent, lead times were shortened from 21 days to 11, on-hand inventory was cut by two weeks, orders were more consistent, and sales increased by 8.5 million dollars. In a similar vein, General Electric (GE) collaborated with its retailers to respond to customer demand instead of inventory (Treacy and Wiersema, 1993). By focusing on virtual inventory, both parties eliminated the cost of holding inventory and assembling full truckload orders. GE was able to save about 12% of distribution and marketing costs and obtained half of the retailers' sales. The retailers were able to reduce out-of-stocks and gained increased profit margins on GE products.

The advent of supply chain collaboration creates the need, at the intercompany level, to pay special attention to the understanding of collaboration in order to prepare the chain members to create collaborative efforts successfully (Horvath, 2001). Previous research defined the nature of supply chain collaboration using different approaches. The performance approach, for instance, strives to design performance metrics for collaboration that drive chain members' behaviour to improve overall performance (Lapide, 2000). However, previous research holds the assumption that collaboration is a unilateral phenomenon that focuses on a specific element of collaboration such as

information sharing or co-managed inventory (Lee *et al.*, 1997). Little attention has been paid to capturing the different elements that represent multiple areas of collaboration. This lack of consideration partly explains why practitioners find it difficult to address the issue of understanding collaboration (Mentzer *et al.*, 2000b). Alternatively, a reciprocal approach is more appropriate for defining supply chain collaboration which explicitly reveals an interaction phenomenon between key main elements of collaboration (Lee, 2000; Simatupang *et al.*, 2002). Given the aim of improving overall performance, the reciprocal approach intends to ensure that the key elements match or complement each other.

The reciprocal approach advocates that the outputs of one element are inputs to other elements and a two-way interaction is achieved through ongoing mutual adjustments among elements. Previous research has implicitly acknowledged the interaction phenomenon. For example, Lee *et al.* (1997) argued that the chain members need to optimise their supply chain processes through redesigning the interorganisational decision-making procedure and related processes. Lee (2000) summarised several connecting elements of collaboration including process coordination, information sharing, and workflow realignment. Simatupang *et al.* (2002) distinguished four connecting drivers of collaboration, namely logistics synchronisation, information sharing, incentive alignment, and collective learning. They argued that these four drivers should be coordinated to enable the chain members to make significant joint improvements. Recently, Simatupang and Sridharan (2004a) applied the reciprocal approach to propose collaborative enablers in their study about supply chain benchmarking. The current research thus extends the reciprocal approach in explaining the integrative definition of supply chain collaboration.

The objective in this chapter is to develop a framework for understanding the interactive phenomena among different elements of supply chain collaboration from the interorganisational perspective. It is also intended to define and explain collaboration more precisely. The framework consists of five elements of collaboration, namely (a) a collaborative performance system, (b) information sharing, (c) decision synchronisation, (d) incentive alignment, and (e) integrated supply chain processes. It is shown that these five elements are necessary and sufficient to help practitioners improve collaboration through reflection upon the often

unexamined practice of the current relationship. These elements interact with each other with respect to overall performance. The chain members thus need to engage each other in a dialogue about these key elements of collaboration and to educate each other to their needs in the joint development of a mutually beneficial collaboration process. In this chapter it is also shown that the framework augments the collaborative planning, forecasting, and replenishment (CPFR) model.

4.2. Building the Framework for Collaboration

This research focuses on supply chains that consist of multiple players along the supply chain such as a retailer and a supplier or autonomous divisions in a company. Figure 4.1 shows a simple structure of a collaborative supply chain with two players. The retailer has decision rights (e.g., order placement and sales target), private information (e.g., end customer demand), and internal costs and revenue. The supplier also has its own decision right (e.g., delivery and production setting), private information (e.g., product characteristics), and internal costs and revenue. Supply chain collaboration links both players with a joint decision-making process for demand planning and order fulfilment, collective performance metrics to evaluate individual performance and collective performance, and information sharing in a mutually beneficial way. The basic proposition of collaboration is that the chain members are able to effectively fulfil customer demand at less cost. This is because seamless information sharing allows both players to create a demand driven supply chain that results in efficient use of production capacity, lowering of inventory levels, reduction of out of stocks, and customer satisfaction.

There are five elements that make up the core of the collaborative supply chain framework (CSCF) as shown in Figure 4.2. Both theoretical background and empirical evidence have been produced to justify and support this proposed framework (Simatupang and Sridharan, 2004a, 2005). The five elements include a collaborative performance system (CPS), information sharing, decision synchronisation, incentive alignment, and integrated supply chain processes. Each element can be seen as the enabling factor that facilitates collaborative actions. The arrows of Figure 4.2 represent an attempt to capture the dynamic nature of reciprocal relations among multiple connecting elements of the framework. The regular

evaluation of collaborative performance determines what must be changed in the elements of information sharing, decision synchronisation, and incentive alignment in an attempt to enable the chain members to create integrated supply chain processes.
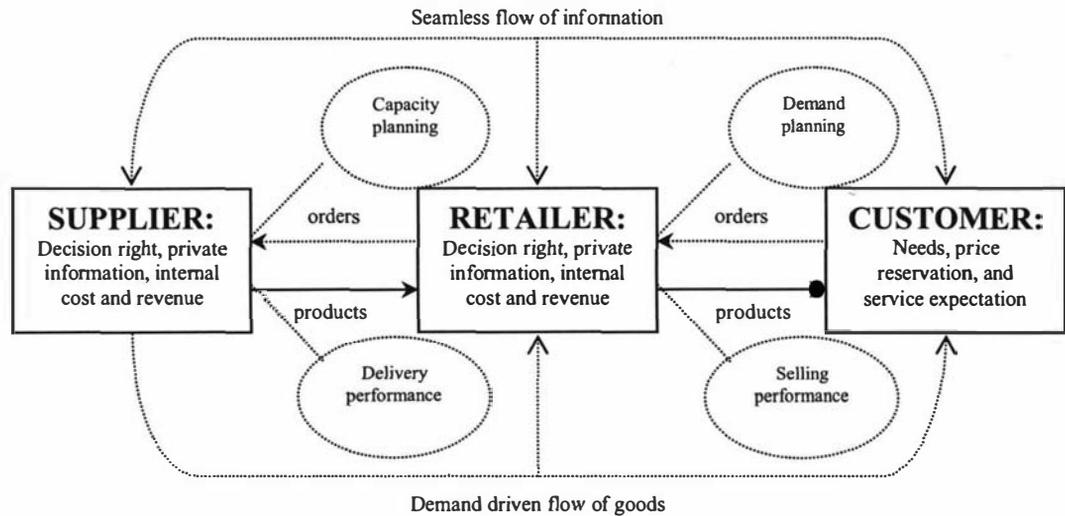
Figure 4.1. A simple structure of a collaborative supply chain

The reciprocal approach describes how CPS affects information sharing, decision synchronisation, incentive alignment, and supply chain processes and how each element affects every other in contributing to the achievement of collaborative performance. For example, the reciprocal approach suggests if information sharing is able to provide relevant, accurate, and timely data that are useful to make effective decisions, then two-way correspondence has been achieved between information sharing and decision synchronisation. Taking this point of view, the reciprocal approach is the balancing activity in the collaborative supply chain, which is particularly important in identifying and understanding enablers that facilitate collaborative actions. This explanatory process can clarify some of the longstanding problems associated with defining collaboration because the reciprocal approach adopts a dialogue as a way of understanding multiple elements of collaboration that affect supply chain performance. As discussed in the literature review section, the unilateral approach neglects the interaction of multiple elements of collaboration.

Theoretical justification for the reciprocal approach is reflected most strongly in the complementarity view of collaboration (Milgrom and Roberts, 1995; Simatupang *et*

al., 2002). Advocates of this perspective argue that collaborative actions must be defined within the context of multiple interactions among elements of attention. The chain members should be able to coordinate and match the five elements. Changing one element often requires changing the other elements. Incentive alignment, for instance, must be matched to performance metrics that are being measured. Moreover, defining collaboration with respect to the five elements is necessary and sufficient because it captures the complex practice of collaboration. It covers the types of joint decisions to make, information needed for decision-making and control, performance metrics, an incentive system that shares costs and benefits, and integrated supply chain processes. The five elements of the collaborative supply chain framework shown in Figure 4.2 are explained in the sub-sections that follow.
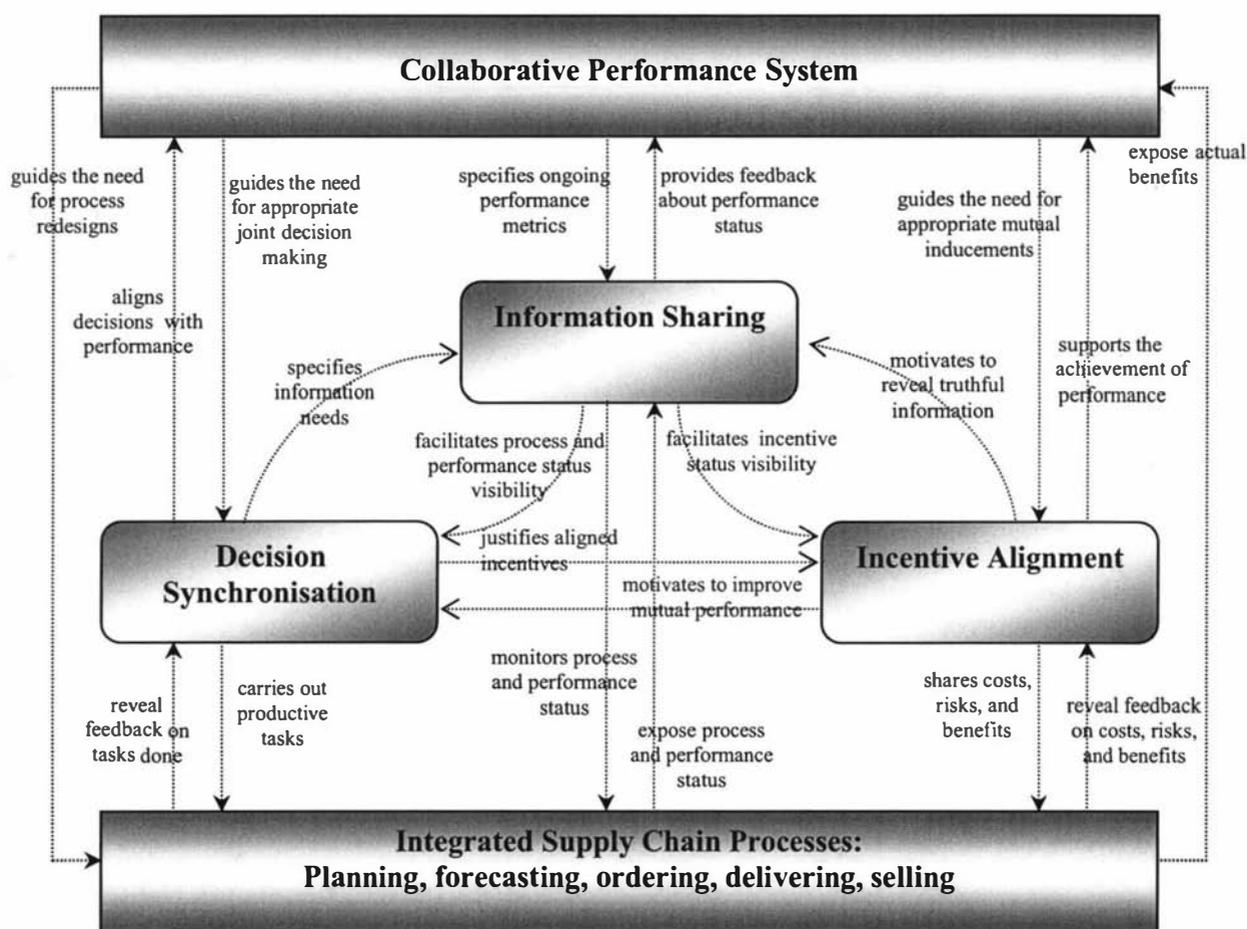
Figure 4.2. The collaborative supply chain framework (CSCF)

4.2.1. Collaborative Performance System

A collaborative performance system (CPS) can be defined as the process of devising and implementing performance metrics that guide the chain members to improve overall performance. The process also includes resolving two related issues: who should be involved in determining the mutual objective and what performance metrics should be specified with respect to the mutual objective. The mutual objective reflects the competitive factors that can be attained if the chain members build collaboration. Competitive factors can be in the form of product and service advantages, such as customer service, quality, price, supply chain costs, and responsiveness, recognised by the market as superior compared to competitors. These factors are assumed to enhance each chain member's profit, return-on-investment, and cash flow.

The chain members require different types of performance metrics that span the supply chain (Kaplan and Cooper, 1997). To address this need, Simatupang and Sridharan (2004a) propose three dynamic learning cycles that enables the chain members to examine their collaborative performance at different managerial levels, which provides an opportunity to improve overall performance. First, the exception cycle is defined as the collaborative process designed to ensure rapid response in fulfilling customer demands. This process is designed to protect actual sales from any market changes and disruptions. The main activities of the exception cycle include monitoring triggering events (i.e., deadline, inventory status, and demand condition), detection (i.e., the identification of a potential difficulty that impedes the supply chain execution), diagnosis (i.e., the evaluation of a most likely cause of supply chain malfunctions), and corrective actions (i.e., returning the process performance to a satisfactory level). The typical process metrics for the exception cycle entail metrics associated with inventory velocity, perfect order, and delivery time.

Second, the improvement cycle refers to the joint initiatives to carry out ongoing improvement. The main activities of the improvement cycle include identifying improvement targets, formulating improvement plans, and analysing and carrying out appropriate improvement options. The concurrent metrics for the improvement cycle include the half-life-curve of forecasting accuracy, flexibility, responsiveness, and cash-to-cash cycle.

78

Third, the review cycle is the process used to compare the expectation and the actual collaborative outcomes. The review cycle employs outcome metrics such as growth, sales, profits, and inventory turns.

In terms of interaction with other elements, CPS requires information sharing, decision synchronisation, and incentive alignment to monitor and improve actual performance. Information sharing reports data about performance status. Decision synchronisation enables the chain members to optimise performance metrics through effective joint decision making. Incentive alignment employs performance metrics to devise benefit- and cost-sharing agreements. Integrated supply chain processes provide feedback about the actual benefits of collaboration based on the status of physical events.

4.2.2. Information Sharing

Information sharing refers to the access to private data in partners' systems (Simatupang and Sridharan, 2002). This activity covers data acquisition, processing, representation, storage, and dissemination of demand conditions, end-to-end inventory status and locations, order status, cost-related data, and performance status. Visibility of key performance metrics and process data enables the participating members to elicit the bigger picture of the situation that takes into account important factors in making effective decisions. Effective decisions enable the chain members to address product flow issues more quickly, and thereby permits more agile demand planning to take place. Several criteria, such as relevancy, accuracy, timeliness, and reliability, can be used to judge the contribution of information sharing to supply chain integration. Advanced technology such as the Internet can be used to convey up-to-date data about planning, product movements, workflow, costs, and performance status.

The interaction of information sharing with other elements of the framework is crucial to its role as a glue that integrates other elements into a whole. The chain members are interested in the utility of information sharing rather than information for its own sake. What makes information sharing valuable to the chain members is ultimately the ability to make better decisions and take actions on the basis of greater visibility. Guiding principles are that visibility should inform action, and that action becomes

visible if the chain members understand better the underlying principles that link integrated information and performance drivers. Information sharing thus generally facilitates decision synchronisation through providing relevant, timely, and accurate information required to take effective decisions about supply chain planning and execution. It enables participating members to make use of integrated information to help fulfill demand more quickly with shorter order cycle times. For example, demand and inventory visibility can be used to eliminate stock-outs by accurately replenishing hot products (Fisher, 1997). In connection with CPS, information sharing provides data about the progress of collaboration and performance status to CPS. CPS can use this data to evaluate and devise new targets and performance metrics that are relevant to new situations. In conjunction with incentive alignment, information sharing provides visibility about the status of incentive scores amongst the chain members. It also reveals the actual link between performance measures and incentives. Finally, integration of supply chain processes provides field data about products, processes, and performance status.

4.2.3. Decision Synchronisation

Decision synchronisation can be defined as the extent to which the chain members are able to orchestrate critical decisions at planning and execution levels for optimising supply chain profitability (Simatupang *et al.*, 2002). The activity covers devising joint decision-making processes including reallocating decision rights in order to synchronise supply chain planning and execution that seeks to match demand with supply. The way to judge effective decision synchronisation is based on its effects on accurate response towards fulfilling customer demands (i.e., logistical benefits) and supply chain profitability (i.e., commercial benefits) (Corbett *et al.*, 1999). Face-to-face meetings and virtual discussion forums are examples of ways to implement decision synchronisation.

The importance of decision synchronisation lies in the fact that the chain members have different decision rights and expertise about supply chain operations. For example, the retailer may have the decision right to determine order quantity but not order delivery. Very often the chain members have conflicting criteria in making decisions resulting in solutions that are less than optimum for the overall chain (Lee *et al.*, 1997). The chain members thus need to coordinate critical decisions that affect the

way they achieve better performance. The use of joint decisions depends on the incremental sales that can be realised and the significant amounts of inventory costs that can be reduced from this joint decision making. Joint decisions may include sales and order forecasts, inventory, replenishment, order placement, order delivery, customer service level, and pricing. For example, vendor-managed inventory provides the supplier with decision rights to determine the frequency and quantity of orders that need to be delivered to the retailer's distribution centre. This scheme enables the supplier to match supply with demand from the supply-chain-wide perspective and thereby improves profits for both members.

The interaction of decision synchronisation with other elements of the framework is very important as it enables the chain members to orchestrate their decisions that contribute to the achievement of overall performance. Decision synchronisation provides feedback to CPS concerning how performance metrics guide the chain members to make effective decisions. In relation to information sharing, decision synchronisation aids information sharing to identify what kind of relevant data should be collected and transferred - and in what format - to the decision makers. In supporting incentive alignment, decision synchronisation provides justification for incentive alignment to devise appropriate incentive schemes because different chain members are responsible for different levels of decision making. Finally, decision synchronisation helps the chain members to carry out productive actions associated with integrated supply chain processes such as replenishment, transportation, and customer service.

4.2.4. Incentive Alignment

Incentive alignment refers to the process of sharing costs, risks, and benefits amongst the participating members (Simatupang and Sridharan, 2002). This scheme motivates the members to act in a manner consistent with their mutual strategic objectives, including making decisions that are optimal for the overall supply chain and revealing truthful private information. It covers calculating costs, risks, and benefits as well as formulating incentive schemes such as pay-for-performance and pay-for-effort (Simatupang and Sridharan, 2002). The contribution of incentive alignment can be judged based on compensation fairness and self-enforcement. Compensation fairness ensures that aligned incentives motivate the chain members to share equitably the

loads and benefits that result from collaborative efforts. An effective incentive scheme means that the chain members are self-enforcing for aligning their individual decisions with the mutual objective of improving total profits. Expert systems, activity-based costing, and web-based technology can be used to trace, calculate, and display incentive scores (Kaplan and Narayanan, 2001; Simatupang and Sridharan, 2002).

The theory underlying incentive alignment assumes that an individual chain member tends to act in a certain way based on the expectation that the act will result in a mutual benefit and on the attractiveness of that benefit to individual chain members (Simatupang *et al.*, 2002). An appropriate incentive scheme can be devised in a number of ways (Simatupang and Sridharan, 2002). Pay-for-effort is a scheme that links payment and effort. This assumes that rewarding effort would motivate the individual member to exert a given amount of effort which relates to a certain level of performance. Pay-for-performance is a scheme that links payment and performance. This scheme assumes that rewarding performance will motivate the individual chain member to achieve a particular level of performance. Equitable incentive is sharing the equitable load and benefits which result from exerting a certain amount of collaborative effort. The chain members accept the importance of the potential rewards that can be obtained from collaboration although costs need to be shared.

The interaction of incentive alignment with other elements is very significant as it motivates the chain members to align their actions to the mutual purpose of collaboration that would also enhance their individual profitability. Incentive alignment links performance scoreboards from CPS to incentives. The clearer the linkage between performance and incentives, the more effectively the given incentives are able to motivate the desired behaviour. Information sharing is required to signal the chain members that incentives are available, timely, equitable, and performance-contingent. In conjunction with decision synchronisation, incentive alignment provides incentives to motivate the chain members to make effective decisions that reinforce the desired level of performance.

4.2.5. Integrated Supply-Chain Processes

Integrated supply chain processes refer to the extent the chain members design efficient supply chain processes that deliver products to end customers in a timely manner at lower costs. Explicit description of this element helps the chain members synchronise the entire sequence of integrated work activities required to deliver products that fulfil customer needs (Croxton *et al.*, 2001). The supply chain processes need to be as flexible as possible in order to respond to the variety of customer requirements at minimum costs with respect to supply capacity. To create flexibility, the chain members can redesign the distribution system, product, production process, and inventory management to be cost effective and flexible to match supply with different conditions of customer demand (Fisher, 1997; Kopczak and Johnson, 2003).

In relation to other elements, the integrated processes aim to enable the chain members to achieve the key performance indicators stated in CPS. The chain members synchronise their decisions to create effective supply chain processes that lead to better performance and reliability. Activity costs and non-financial performance metrics of integrated processes are important inputs for incentive alignment. Finally, integrated processes provide visibility to information sharing on process status enabling easy detection and correction of problems.

4.3. Augmenting CPFR with CSCF

This section is concerned with how the proposed framework can be used to complement the collaborative planning, forecasting, and replenishment (CPFR) model. The original CPFR scheme attempts to provide a road map for applying supply chain collaboration (Ireland and Bruce, 2000). The use of the collaborative supply chain framework allows the chain members to discuss the critical elements of CPFR during the initiation and implementation of CPFR. The five elements of collaboration do not explicitly exist in the original model of CPFR.

The Supply Chain Council endorses CPFR as a building block for companies who want to improve performance in a collaborative way (Fliedner, 2003). CPFR is known as a collaborative business planning and execution process that aims to match supply and demand and to reduce total supply chain costs. This approach replaces the

traditional approach in which the chain members react differently to customer demands and focus on transfer price and margin. The CPFR initiative has been sponsored by the VICS (Voluntary Interindustry Commerce Standards) Association. Previous study showed that several pilot projects provided positive results (Stank *et al.*, 1999).

The participating members often consist of a retailer and a supplier who agree to collaborate in key supply chain processes using process and data standards. Figure 4.3 exhibits a generic model of CPFR that includes nine steps: develop front-end-agreement (box 1a), create joint business plan (box 1b), create sales forecast (box 2a), identify exceptions for sales forecast (box 2b), resolve on exception items (box 2c), create order forecast (box 2d), identify exception for order forecast (box 2e), resolve on exception items (box 2f), and order generation (box 3a). There are many business processes, technological and organisational changes required by this collaboration. The members need to commit to share resources to make these changes in order to achieve mutual objectives (Ireland and Bruce, 2000). Both chain members commit here also to keep confidentiality in the use of shared information.

There are two steps of initiation in CPFR. First, the CPFR initiative begins with a front-end-agreement (see box 1a in Figure 4.3) that forms the basis for measuring and evaluating performance, accountability, contingencies, and changes. The front-end-agreement defines strategic objectives, common metrics to be used, and assessment of collaborative impacts on each participating member. It also defines business functions that would be key executors of the collaboration plan and determines the outline of information to be shared, frequency of updates, and information technology. The strategic objective is often to obtain greater sales and increase mutual efficiencies in terms of lower total costs.

Second, the chain members must cooperate to share and develop a business plan (box 1b in Figure 4.3). The business plan clearly describes product profiles to be sold, strategic events such as promotions and advertisements, market targets, and the time frame in which sales would take place. The plan is implemented through partners' operational systems, which are monitored using approved communication standards. Any partner can adjust its plans within pre-determined parameters.

84

	Supplier	Collaborative Point	Retailer	Customer
Planning (1)	Supplier Business Strategy	1a. Develop front-end agreement	Retailer Business Strategy	
	Business Development Activities	1b. Create joint business plan	Business Development Activities	
Forecasting (2)	Supplier decision support data	2c. Resolves on exception items	Retailer decision support data	
	Supplier exception triggers	Updated data / 2b. Identify exceptions for sales forecast	Retailer exception triggers	
		2a. Create sales forecast		
	Supplier decision support data	2f. Resolves on exception items	Retailer decision support data	
	Supplier exception triggers	Updated data / 2e. Identify exceptions for order forecast	Retailer exception triggers	
	Material and production planning	2d. Create order forecast / Frozen forecast		
Replenishment (3)	Production Process	3a. Order generation		
	Shipment execution	3b. Delivery process	Distribution process	POS data
			Retail store process	Customer buys and pays

Figure 4.3. The generic model of CPFR

Although CPFR provides a reference model for the chain members to initiate and implement supply chain collaboration, it deals exclusively with decision synchronisation, information sharing, and intercompany business processes. Little guidance is given about the collaborative performance system or incentive alignment. It is not surprising that practitioners often view CPFR as a static programme of collaboration. Barratt and Oliveira (2001) found that the diffusion of CPFR was very slow especially in Europe. Skjoett-Larsen *et al.* (2003) also contend that there is a gap between the understanding of CPFR and its implementation in practice. To address this problem, CSCF can be used to augment the value of CPFR as it views CPFR as a dynamic process that can be improved over time by investigating the interaction between the five elements of collaboration. On the basis of CSCF, the CPFR can be represented as a set of five interrelated elements namely, a collaborative performance system, decision synchronisation, information sharing, incentive alignment, and integrated supply chain processes. The chain members become able to thoroughly discuss the five elements of collaboration and their interaction. This gives each member an opportunity to contribute to the design and implementation of proper elements.

Collaborative performance system: The CPFR programme does not exclusively address how the chain members reconfigure new performance metrics. CSCF explicitly specifies the need for reconfiguration of performance system that reflects the attainment of common success. Common metrics are the set of measures all members use for evaluation and benchmarking activities. All partners will seek to reduce stock-outs, reduce markdowns, increase sales, reduce business transaction costs, and reduce inventory. They need to discuss and agree on key results-oriented metrics such as retail in-stock, retail inventory turns, gross margin, fill rates, and forecast accuracy (box 1b in Figure 4.3). Collaborative metrics are also accompanied by details of performance scope, data source, responsibility for producing the report, frequency of reporting, and unit of measure. Furthermore, performance targets for specific products are discussed such as minimum percentage of retail in-stock, number of turns at retail, maximum sales forecast error, and maximum order forecast error. The chain members also agree to carry out quarterly face-to-face meetings to review actual performance against all of these targets.

Decision synchronisation: Joint operational decision points include the sales forecasts (see box 2a in Figure 4.3), the order forecast (box 2d), order generation (box 3a), and the delivery process (box 3b). Although the chain members synchronise their operational decisions, often the retailer has ultimate responsibility for the sales forecast and the supplier has ultimate responsibility for the order forecast and order generation. The interface team that is responsible for supporting this collaboration process consists of the retailer team (e.g., merchandising, purchasing, and distribution) and the supplier team (e.g., sales, planning/forecasting, and logistics). Collaboration on the sales and order forecasts is driven by the following item level exception criteria and values: (1) sales forecast exception criteria such as retail in-stock less than 95%, sales forecast error more than 20%, sales forecast differs from same week prior season by more than 10%, and change in promotional calendar and (2) order forecast exception criteria including retail in-stock less than 95%, order forecast error more than 20%, annualised retail turns less than targeted percentage, entry of new events that affect inventory levels, and emergency orders requested.

Information sharing: Information sharing outlines data types, frequency of updates, and method of data sharing. Both chain members agree to ensure timely, accurate, and relevant data. Data accuracy and timeliness are measured as the basis for improving the effectiveness of information sharing. Shared information includes item management profiles (see box 1b in Figure 4.3); data necessary to measure mutual success such as retail inventory turns, gross margin, retail sales, and forecast accuracy (see box 1b); data necessary to identify exceptions for sales forecast (see box 2b) such as sales forecast accuracy, retail in-stock percentage, and inventory turns and levels; and data necessary to identify exceptions for order forecast (see box 2e) such as current item retail in-stock percentage, order forecast accuracy, promotions, planned inventory actions and other events that impact on the forecast, points-of-sale data, historical shipments, and supplier order fill rate. A forecast is created and updated on a weekly basis. Exceptions, supporting data, and item management data are updated daily. Collaborative metrics are calculated and reported monthly. Data can be communicated using the Internet, e-mail, and EDI.

Incentive alignment: The CPFR programme does not explicitly encourage the chain members to consider the aspect of incentive alignment. CSCF encourages the chain

members to restructure how they distribute costs, risks, and benefits. Agreement on supplying and ordering commitments is important to ensure that both parties get benefits from CPFR. Commitments to supply and to consume are subject to a range of deviation. The chain members set and reevaluate the range of deviation periodically. The supplier, for instance, commits to support the agreed-to-forecast at a frozen period of seven days with timely shipments. In return, the retailer commits to consume the frozen forecast by placing orders. In case the actual delivery or orders exceed the limits, the respective party will notify the other as soon as possible and will determine a resolution plan. Both parties also commit the resources and technology necessary to facilitate the collaborative processes, which will in turn allow the timely identification and resolution of potential issues.

Integrated supply chain processes: This element helps the chain members integrate joint demand planning with execution to buy, make, move, and deliver products to end customers. The supplier is responsible for making products and delivering orders to the retailer's distribution centres or stores (see box 3b in Figure 4.3). It ensures on-time and reliable delivery performance. The retailer then distributes merchandise to the stores and sells the products to end customers. It ensures in-store product availability and eliminates out-of-stocks. The integration between delivering and selling processes enables both parties to reduce cycle times and improve customer service in terms of availability and responsiveness.

This section has shown that CSCF augments the missing elements of CPFR in terms of collaborative performance system and incentive alignment. The chain members become aware of explicitly restructuring the five elements when they initiate and implement CPFR. By doing so, all parties will be motivated to attain potential benefits of collaboration.

4.4. Discussion

This section discusses the justifications for the assertion that the five elements proposed in the framework are necessary and sufficient for defining supply chain collaboration. The discussion begins with contrasting collaborative relationship and adversarial relationship. After that, the necessary and sufficient conditions are

88

explained. Having provided this adequacy test, the five elements are used to analyse two popular collaborative schemes, namely vendor-managed-inventory and efficient-consumer-response. This reconstruction of these two existing schemes aims to demonstrate that the framework is adequate to define any type of supply chain collaboration.

Collaboration as a relationship strategy is totally opposite to the adversarial or arm's length relationship. The adversarial strategy puts the chain members into a zero-sum game situation that allows them to split a fixed amount of pie (i.e. rewards). Gains for one player often mean a loss for the others. For example, a supplier who reduces the wholesale price to attract its retailers would sacrifice its revenues. However, this compromise often incurs hidden costs for the winner. The retailer, for instance, who gets the lowered wholesale price from its suppliers, would tend to maintain a huge pile of inventory and will be exposed to the risk of price markdown (Fisher, 1997). Alternatively, the collaborative strategy creates a positive-sum game, which allows the participating members to redefine the issue as integrative. In this paradigm, the chain members work together to increase the size of the reward that could be shared between them. Their focus is no longer on their individual bargaining position over transfer price (or wholesale price) but on creating values for stakeholders such as increased total revenues and lower total supply chain costs. Therefore, the collaborative relationship amongst the chain members would be win-win (McNary, 2003).

The necessary condition for collaboration is that the chain members are able to expand the pie or total reward. The supply chain level synergies emerge in which the whole exceeds the sum of individual parts. The higher reward can come from several sources such as higher revenues, lowered supply chain costs, and better competitive advantage. Since sales occur only when products are sold to end customers, the chain members collaborate to define their end customers and the value proposition. To achieve competitive advantage in the eyes of end customers, the chain members need to carefully redesign and choose performance metrics, supply chain processes (i.e., product design, process design, and changes in operational rules and procedures), information sharing that brings relevant information to decision makers, and decision synchronisation that facilitates joint decision making and decision rights allocation.

For example, Zara - a Spanish fashion manufacturer - redefined its performance metric to focus on fast product delivery from sketch to stores in just 10 to 15 days (Walker *et al.*, 2000). This metric was critically dependent on the ability of its global production network to manufacture goods quickly and at low cost. Its key suppliers became collaborators in the strategy to respond to the changing tastes of end consumers. IBM also collaborates with its suppliers and resellers to create an extended supply chain that allows IBM to achieve quick response to customers with minimum inventory (Lin *et al.*, 2000). Redesigning demand planning provides visibility to customer orders and inventory stocks within the network that enables IBM and its suppliers to coordinate production and delivery activities.

Pie expansion as the necessary condition for collaboration is consistent with previous theory on collaboration. According to Barnard (1938), a cooperative system depends on the accomplishment of a common purpose to overcome most important limiting factors. Senge (1990) suggests that system viewpoint allows the chain members to understand that a common success can be attained if they collaborate to help each other. Game theory also argues that collaboration enables the participating members to grow the pie (Nalebuff and Brandenburger, 1996). Jap (1999) uses a resource-based view to explain that collaborations are designed to enlarge the size of the joint benefits and give each member a share of a greater pie that could not be generated by each member alone. The process of expanding the pie requires the chain members to share sensitive costs and process information and create unique investments to support collaborative efforts.

The necessary condition is not sufficient to guarantee that the chain members are willing to expand the pie. This condition ignores the decision-making situation and the person who makes the decisions. It assumes that decisions are made in the best economic interest of the supply chain as a whole. That is, the chain member is assumed to maximise the total pie, not its own slice. However, the chain members tend to operate under assumptions of self-interest. Another condition is thus required to accommodate the assumption of self-interest.

The sufficient condition for collaboration is that the chain members fairly distribute the pie which results from the collaborative efforts. The pie - or joint outcome - is an

important motivational reason for forming the interdependencies of close collaboration. Incentive alignment can be viewed as an enabler that motivates the chain members to reinforce the attainment of performance targets. This is the mechanism used to divide up the joint gains based on the process of evaluating the shared outcomes. Appropriately linking incentives to performance targets reinforces the desired changes in behaviour that support collaborative efforts.

Previous theory justifies the view that the benefit distribution is a sufficient condition for collaboration. Barnard (1938) argued that incentives are important to motivate participating parties to be willing to contribute to collaborative efforts. Lewis (1990) asserts that collaboration is a relationship amongst companies to build a substantial pie by recognising mutual needs and sharing risks to satisfy their common objectives. Nalebuff and Brandenburger (1996) affirm that collaboration occurs when the chain members come together to create value, but they still need to divide up the pie to avoid a tug of war over who is going to be the main beneficiary.

The collaboration value is the size of the pie when the participating members collaborate minus the size of the pie when they are not collaborating. The size of the pie can be varied on either of the two sides of the supply chain. On the demand side, the size of the pie can be in the forms of increased sales, less price markdowns, increased inventory turns, fewer stock-outs, reduced inventory, and lower operating costs. On the supply side, the size of the pie can be measured in terms of less inventory, faster response, lower supply costs, and smooth production schedules.

So far the previous section outlines the necessary and sufficient conditions of supply chain collaboration where the chain members should expand the size of the pie and distribute its resulted outcomes. The next section of this chapter applies the framework to describe two popular collaborative initiatives: vendor-managed-inventory (VMI) and efficient-consumer-response (ECR), in terms of how the chain members should scrutinise their key elements. VMI allocates stocking decision right to the supplier to specify decisions on when and how much of various products to deliver to the retailer's distribution centre or stores (Holmström, 1998). The retailer continues to possess the right to determine sales targets and the retail price. The use of information technology, such as EDI and the Internet, allows the supplier to obtain

early demand information and monitor the retailer's stock level. Wal-Mart and Procter & Gamble are the earliest adopters of VMI. The benefits of VMI include increased sales, higher inventory turns, improved demand forecasting, shorter delivery time, lowered inventory costs, and economies of scale in delivery (Buzzell and Ortmeyer, 1995).

Based on the framework proposed in this chapter, it can be seen that VMI emphasises reassignment of the stocking decision right, integrated process improvements, and information sharing. Little attention is given to creating a balanced performance measurement between the retailer and the supplier so both parties' performance can be evaluated. The framework suggests that the chain members, who adopt VMI, should explicitly develop and promote new performance measures that link individual performance to overall supply chain goals, so that each member is encouraged to focus on serving end customers. Additionally, the framework advocates that incentive alignment is a critical factor in increasing willingness to adopt VMI. For example, the transfer of goods ownership from the supplier to the retailer raises obvious incentive problems. If the transfer occurs when the retailer receives the products, the supplier tends to deliver as much inventory as possible. The framework thus suggests that the chain members need to modify this arrangement. A more stable arrangement is that the supplier bears associated inventory costs and is paid when the products are sold.

ECR is defined as working together to fulfil consumer needs better, more quickly, and at less cost (Frankel *et al.*, 2002). The key elements of ECR include efficient replenishment, efficient assortment, efficient product introduction, and efficient promotion. The chain members often work in three areas: enabling technology (e.g., EDI, electronics fund, item coding, and activity-based costing), operations improvement (e.g., continuous replenishment, automated store ordering, and cross-docking), and category management (e.g., efficient assortment, efficient promotions, and efficient product introduction). ECR allows the chain members to significantly decrease excess inventory, storage costs, supply chain disruptions, and stock-outs. It also offers many advantages to end customers including fresher merchandise and lower prices. Companies within the retailing industry, such as Wal-Mart, Nabisco, and Tesco, have been known to reap positive benefits from implementing ECR.

Based on our framework, it is clear that ECR brings fundamental changes to the joint decision-making process, integrated process improvements, and performance measures, but leaves the incentive alignment system relatively unmodified. As Brown and Bukovinsky (2001) found that there was no difference in performance improvements between adopters and non-adopters of ECR, the chain members need to explicitly discuss and redesign incentive alignment to reinforce new performance measures. For example, the retailer needs to share the cost of production postponement if this action aims to provide the responsiveness necessary to capture a surge in customer demand in the mid-season. Additionally, the supplier also needs to subsidise the retailer for a storage fee in the stores. The framework in this chapter thus suggests that the chain members need to develop appropriate incentive alignment such as pay-for-performance and consignment to encourage the participating members to focus on overall profitability.

In summary, the proposed framework indicates to the chain members who become involved in ECR or VMI that they need not only to redefine process improvements, joint decision making, and information sharing, but also need new performance measures and incentive alignment. Table 4.1 shows that the framework enables the chain members to reveal the weaknesses of VMI and ECR and encourages them to modify the traditional performance measures and incentive alignment. By discussing the balanced elements of collaboration, they will be able to meet the necessary and sufficient conditions of supply chain collaboration. Otherwise, the upstream members would see only that VMI and ECR are akin to shifting the burden of inventory management from the retailer to the supplier (Betts, 1994).

4.5. Concluding Remarks

Supply chain collaboration plays a crucial role in improving overall performance that benefits all chain members. In this chapter, a collaborative supply chain framework has been proposed which is composed of five connecting elements, namely a collaborative performance system, information sharing, decision synchronisation, incentive alignment, and integrated supply chain processes. The framework seeks to describe the five elements through which the chain members engage in defining specific actions to be taken collaboratively. In order to ensure effective collaboration,

93

the chain members are encouraged to clearly define mutual objectives and associated performance measures and link their performance systems with decision synchronisation, information sharing, and incentive alignment. Clear linkage will encourage the chain members to improve shared supply chain processes that benefit all members.

Table 4.1. The use of five elements of collaboration to characterise VMI and ECR

Key elements	Collaborative initiatives	
	Vendor-Managed-Inventory (VMI)	Efficient-Consumer-Response (ECR)
Collaborative Performance System	Little attention is given to developing collaborative metrics that enable the chain members to evaluate individual performance and global performance.	The chain members focus on collaborative efforts to increase sales to end customers.
Decision Synchronisation	The supplier gets decision rights to determine when and how much order to deliver to the retailer.	The chain members jointly coordinate replenishment, assortment, product introduction, and promotion.
Information Sharing	The retailer shares early demand information and point-of-sale data (i.e., sales and inventory status).	The chain members shared data necessary for category management and operations improvement.
Incentive Alignment	Little attention is given to developing incentives that ensure equitable benefits which result from collaboration.	Little attention is given to modifying existing incentive schemes that focus on cost reductions.
Integrated Supply Chain Processes	The supplier streamlines its inventory management that spans from the retailer's site to its production site.	The chain members capitalise seamless information sharing to create demand-driven production and distribution processes.

The current chapter offers three distinct contributions that extend other recent formulations of supply chain collaboration. The most significant contributions include: (i) developing a framework consisting of five collaboration elements that together are necessary and sufficient to define the occurrence of collaborative efforts, (ii) arguing that a reciprocal approach is appropriate to improving the understanding of interaction amongst the elements in supporting the achievement of overall performance, and (iii) applying the framework in describing the elements of popular collaborative schemes such as CPFR, VMI, and ECR. The reciprocal interaction among the five elements as a two-way correspondence provides a deeper understanding about the collaborative practice. By thinking about collaboration in this way, the chain members can be clearer about what element they have to change and

the consequences for other elements. Furthermore, the framework has been shown to augment the understanding of CPFR. Furthermore, the framework has been used to describe VMI and ECR that offers a different perspective on what the chain members should redesign.

Chapter 5
An Empirical Study of Supply Chain Collaboration

5.1. Introduction

Global competition has fundamentally changed the economic environment of firms along the supply chain. End customers have greater control over the buying process and the financial ability to make choices of product features. It is not surprising that the global market results in higher demand uncertainty with shorter product life cycles and greater variety. As interdependence increases between firms in a supply chain, they need to collaborate to effectively manage flows of products along the entire value-added supply chain to ensure product availability for end customers (Stock and Lambert, 2001). Collaboration enables both parties to combine knowledge and capability better than acting in isolation. Retailers, for instance, know consumer preferences due to their direct access to end customers, but lack knowledge of product design and delivery. Partnering suppliers, on the other hand, have better knowledge about product design, production capability, and delivery capability.

Supply chain collaboration has been defined as a process of working together among independent firms to deliver products and services to end customers for the purpose of optimising profit (Simatupang and Sridharan, 2002). Supply chain collaboration brings advantages to participating members and enables them to experience increases in their common market share and profitability (Parks, 2001). These advantages can be realised only if both parties work together to speed up decision-making process in delivering the right product to the right place at the right time in the right condition for the right cost (Fisher, 1997). For example, the cooperation between K-Mart and Lee Apparel shows that both parties reap the advantages of collaboration to match supply and demand. K-Mart shares points-of-sale (POS) data with Lee. Lee uses this data to monitor the exact Lee products sold, including colour, size, and style, in each K-Mart store. With this information in hand, Lee knows which products need to be restocked at each K-Mart location, and is thus able to coordinate its production and distribution plans to accommodate its major customer's needs. Lee can also identify

early warning signs of merchandising problems for Lee products at particular K-Mart locations. Early warning signs help both parties to devise quick responses that lead to reductions in stock outs and markdowns and thereby improve customer service and sales.

Supply chain collaboration has become a central issue in supply chain management as it enables a firm to work closely with other chain members (Spekman *et al.*, 1998). Although the basic tenet of supply chain management is the integration of key business processes along the supply chain that create value for end customers and other stakeholders, the main key is managing the interface process of decision making among interdependent firms that voluntarily work together as a supply chain (Stank *et al.*, 2001). Previous researchers have addressed the issue of supply chain collaboration as the central part of supply chain management. Bowersox *et al.* (2000) emphasise that the concept of integrated supply chain management is a collaborative-based strategy to link cross-enterprise business operations to achieve a shared vision of market opportunity. In a similar vein, Ballou *et al.* (2000) argue that supply chain management includes interfirm cooperation that coordinates product movements across the legal boundaries of independent firms. Cooper *et al.* (1997) also emphasise the fact that supply chain management involves some levels of coordination of activities and processes both intra and interfirm.

The bulk of empirical research shows that more firms are attracted to implementing supply chain collaboration (Bowersox, 1990). According to Mentzer *et al.*, (2000), the implementation of supply chain collaboration positively contributes to competitive advantage for all participating members in terms of reduced inventory, improved customer service, more efficient use of human resources, and enhanced public image. Other researchers also conclude that collaboration brings positive benefits to participating members (Buzzell and Ortmeyer, 1995). For example, Spekman *et al.* (1998) discovered that information sharing is a key ingredient to reducing costs and improving customer satisfaction. Furthermore, Stank *et al.* (2001) found that internal collaboration significantly influences logistical service performance.

Another stream of empirical research relies on the use of a collaborative management process to facilitate supply chain collaboration (Ireland and Bruce, 2000). Kurt

Salmon Associates promoted Efficient Consumer Response (ECR) that facilitates planning and execution for efficient promotions, efficient replenishment, efficient store assortment, and efficient product introductions (Barrat and Oliveira, 2001). Another initiative called vendor-managed inventory (VMI) delegates stocking decisions to main suppliers in such a way the suppliers are responsible for monitoring stock levels and replenishing products sold at the retailer stores (Holmström, 1998). Sherman (1998) reported a recent movement of Collaborative Planning, Forecasting, and Replenishment (CPFR). CPFR is proposed to enable participating members across the supply chain to remain competitive by taking an holistic approach to delivering products to ultimate customers. This approach has the potential to deliver increased sales, interorganisational streamlining and alignment, administrative and operational efficiency, improved cash flows, and improved return on assets.

However, previous research mainly draws from a viewpoint of a single enabling dimension of supply chain collaboration. Little attention has been paid to integrating enabling dimensions that affect overall performance. Although Poirier (1999) argued that the process of collaboration occurs at the interface boundaries between the members, his primary focus does not differentiate multiple enabling factors. These enabling factors should be considered altogether in order to ensure a positive impact of collaboration on supply chain performance (Simatupang et al., 2002). This suggests a need to consider the viewpoints of integrated enabling factors of supply chain collaboration in order to obtain a richer picture.

Given the significance of supply chain collaboration, this research contributes to the literature of supply chain collaboration through characterising the collaborative practice into three dimensions, namely decision synchronisation, information sharing, and incentive alignment. The research also tests hypotheses on whether or not the three dimensions of collaboration positively contribute to operational performance. Survey research was carried out to assess the relationship between supply chain collaboration and performance. The survey was chosen as an appropriate method because results from the varied responses of a sample exhibit high levels of generalisation (Pinsonneault and Kraemer, 1993).

This chapter is organised as follows. The next section proposes an operating definition for supply chain collaboration that consists of three dimensions, namely decision synchronisation, information sharing, and incentive alignment. Research hypotheses are also developed in this section to describe the influence of supply chain collaboration to realised performance. After that, the research method, consisting of data collection, development of measures, and analysis is given. Findings and discussion are subsequently presented. Finally, the chapter provides concluding remarks and recommendations for further research.

5.2. Conceptual Model

As the purpose of collaboration is to optimise profitability, chain members need to plan, execute, and control key decisions related to defining and delivering products to ultimate customers. It is important to identify different enabling factors (also referred to as the key dimensions) of supply chain collaboration that influence how chain members behave in achieving profitability. If such identification can be clearly made, it should be possible to recognise what contribution is expected from an individual member and what strategies might be followed to achieve those expectations.

The foundation of this research was discussed at length in Chapter 4. There are five prominent elements in supply chain collaboration: collaborative performance system, information sharing, decision synchronisation, incentive alignment, and integrated intercompany business processes as shown in Figure 4.2 (page 77). This framework suggests that the chain members need to synchronise decision making and share information to make effective decisions that improve performance. The chain members also need to ensure that the collaborative performance system has a clear link to incentive alignment in order to motivate individual members to align their decisions with overall performance. The three dimensions of information sharing, decision synchronisation, and incentive alignment determine the structure of ongoing collaboration. Based on this conceptualisation, this current research provides empirical evidence to confirm the concept.

The three dimensions of collaborative practice are expected to facilitate the chain members into cross-organisational cooperation in realising collaborative benefits. To

operationalise this concept, a hypothesis framework is developed as shown in Figure 5.1 regarding the relationship between the three dimensions of the collaborative practice and performance. The framework consists of three variables: (a) the collaborative practice, (b) consequences of the collaborative practice, and (c) a moderator variable that either strengthens or weakens the relationship between the collaborative practice and performance.

The Practice of Collaboration   *Moderator*   *Consequences*
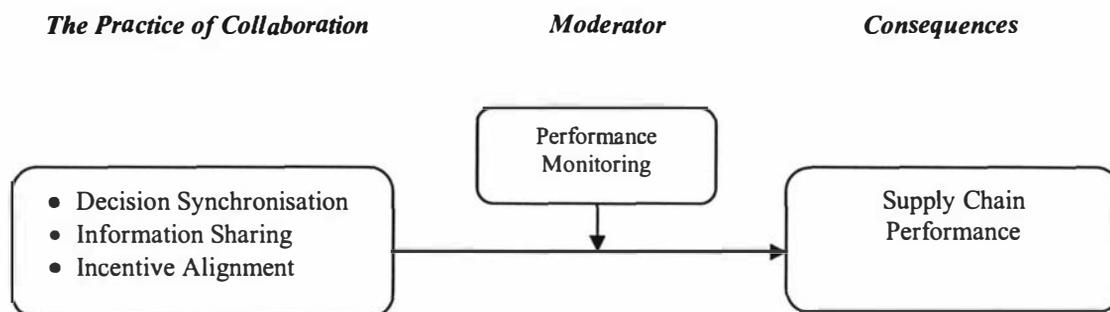
Figure 5.1. A hypothesis framework for supply chain collaboration

Briefly, it is suggested that the collaborative practice positively affects operational performance. Consequences of supply chain collaboration relate to the improvement in operational performance. The relationship between the practice of collaboration and operational performance is strengthened or weakened by the influence of a moderator. The degree of performance monitoring during the process of collaboration serves as a moderator variable. Hypotheses were developed based on this conceptualisation and previous work in supply chain collaboration. The remaining part of this section presents these hypotheses.

Information sharing aims to capture and disseminate timely and relevant information to enable decision makers to plan, execute, and control supply chain operations. Effective information sharing provides a shared basis for concerted actions by different functions across interdependent firms (Whipple *et al.*, 2002). Examples of shared information include points-of-sale (POS) data, updated forecasts, production and delivery schedules, inventory levels, delivery lead-times, and inventory carrying costs. Information sharing also facilitates clarity about demand, the fulfilment process, and common performance for all participating members. Fisher (1997) indicates that

101

supply chain collaboration leads to cohesive market focus, better coordination of sales and demand fulfilment, and minimum risks associated with demand uncertainty. Information sharing provides a unifying focus for the efforts of chain members, thereby enabling the chain members to create better performance (Lee *et al.*, 1997). Relevant to this conceptualisation as well as to the basis of this discussion, the following hypothesis is proposed.

Hypothesis 1. *Information sharing has a positive effect on operational performance.*

Decision synchronisation refers to joint decision-making within planning and operational contexts. The planning context integrates decisions about long-term planning and measures such as selecting target markets, product assortments, customer service level, promotion, and forecasting. The operational context integrates order generation and delivery process that can be in the forms of shipping schedules and replenishment of the products to the stores. Decision synchronisation encourages the chain members to have a sense of belonging in which all decisions work toward a common goal of serving end customers. This reduces the gap between delivery requirements and actual delivery, thereby improving customers' perceptions of fulfilment performance (Ramdas and Spekman, 2000). Customers are satisfied as they find products suited to their preferences and tastes at the right time and right price. Decision synchronisation thus contributes to a reputation of on-time delivery and consistent product availability (Bowersox *et al.*, 2000). This discussion suggests the following hypothesis.

Hypothesis 2. *Decision synchronisation has a positive effect on operational performance.*

Incentive alignment refers to the degree to which chain members share costs, risks, and benefits. The costs, such as administration and technology investment, need to be shared fairly amongst the chain members in order to maintain the commitment of each party to the collaborative efforts (Narus and Anderson, 1996). Moreover, chain members commit to the collaborative efforts if they can realise and capture relevant benefits that contribute to their future survival. Benefits of collaboration include both commercial gains, such as increased sales, and performance improvement, such as

102

lowered inventory costs (Corbett *et al.*, 1999). Incentive alignment also involves risk sharing among the chain members on managing demand, supply, and price uncertainties. Setting and applying appropriate incentives motivates the chain members to take decisions that align with the achievement of profitability. This observation suggests the following hypothesis.

Hypothesis 3. *Incentive alignment has a positive effect on operational performance.*

High reliable performance requires performance monitoring that regularly provides feedback for evaluation and control. Performance monitoring is used to monitor the effectiveness and the efficiency of chain members in attaining supply chain profitability (Stank *et al.*, 1999). It indicates things that work - or that are not going as planned - as well as explains why something goes wrong. This includes monitoring costs of delivering value to customers and benefits from delivering the value across functions such as designing, production, transportation, and distribution. Chain members, for instance, can use Activity Base Costing (ABC) to understand relationships between activities and required resources in an attempt to provide targeted customer service levels (Kaplan and Narayanan, 2001). Thus performance monitoring determines how well chain members assess the degree to which they create value and remedy gaps in performance. In other words, performance monitoring moderates the strength of the relationship between collaborative practice and performance. This observation suggests the following hypothesis.

Hypothesis 4. *The more detailed the performance monitoring, the stronger the relationship between supply chain collaboration and operational performance.*

In summary, supply chain collaboration involves information sharing pertaining to demand and supply conditions, joint decision-making activities, and incentive alignment that links the participant behaviour with achieving supply chain profitability. Interestingly, it appears to be more appropriate to conceptualise supply chain collaboration as a continuum rather than a dichotomy construct that lies on a continuum (Lambert *et al.*, 1999). This conceptualisation enables respondents to assess the degree of their supply chain collaboration rather than note it as simply being present or absent.

5.3. Research Method

A survey method was adopted for this research to gain responses from samples that reflect various degrees of collaboration between suppliers and retailers. In this setting, survey research is useful to accommodate diverse respondents and thereby has a high level of generalisability (Pinsonneault and Kraemer, 1993). In addition, linking interface coordination and key performance outcomes provides additional insights into the current practice of collaboration that affect performance. Empirical findings, which confirm this relationship, extend the validity of collaborative practice.

The development of research instruments followed three steps, namely literature review, conceptualisation, and pre-test. The first phase consisted of reviewing literature on supply chain collaboration. The literature indicated that the issue of supply chain collaboration was of substantial interest to many firms and served as an active research arena with the advent of information technology. Second, a preliminary conceptual framework was developed (Simatupang *et al.*, 2002; Simatupang and Sridharan, 2004a). From this conceptual framework, it was found that supply chain collaboration consists of three interface dimensions based on the interface processes between the chain members, namely decision synchronisation, information sharing, and incentive alignment. A questionnaire was developed to capture and represent the concept of supply chain collaboration. Scales for the study consisted of newly generated items and items that have been used previously in the literature. To develop a scale, the domain of a variable was itemised into a set of activities (Cavana *et al.*, 2001). Five items were developed to measure each dimension of supply chain collaboration. A panel of practitioners and academics was asked to review and modify initial items. These experts clarified and suggested useful terms and were confident that the questions posed in the questionnaire accurately reflected the concept of collaboration.

Finally, a pre-test was carried out to confirm the stability with which the items measure the concept of supply chain collaboration. A panel of practitioners and researchers was asked to identify ambiguous items, poorly worded questions, and poor instructions to answer the questionnaire. Several items were rewritten after

evaluation by the panel. The panel also found no major problems with any of the response format, directions, and other survey procedures. Additional evaluation was also made to ensure the consistency of the measures used in prior research. Several items were modified slightly after this evaluation. The final questionnaire reflected the changes.

The final questionnaire contained general characteristics of respondent, items relating to the measurement of the three dimensions of collaboration, and items relating to the measurement of the performance variables. The measures of the scale are described as follows. The decision synchronisation (DS) scale describes the extent to which the parties make decisions jointly rather than independently. The chain member's perception of DS was measured using five parallel items. These items captured joint decisions in reducing demand fluctuations, developing joint forecasts, co-managing inventory requirements, ensuring on-time delivery, and improving product availability. Each item was assessed on a five-point format ranging from 1 (strongly disagree) to 5 (strongly agree), with a defined neutral point at 3.

The information sharing (IS) scale describes the extent to which the chain members share private information required for planning, execution, and controlling supply chain operations. Items of the IS scale included data exchange about promotional events, demand forecasts, inventory holding costs, on-hand inventory levels, and order tracking. A five-point format (1 = strongly disagree, 5 = strongly agree) was used for each item.

The incentive alignment (IA) scale describes the extent to which the chain members share costs, risks, and benefits to encourage continuous improvement. The IA scale was measured by a five-item scale assessing risks sharing associated with demand uncertainties, shared savings of lowering inventory costs, investment sharing of collaborative efforts, joint effort for increasing sales, and benefit sharing. Each item was assessed with the range from 1 (strongly disagree) to 5 (strongly agree), with a defined neutral point at 3.

Performance monitoring shows to what degree the chain members monitor and track common performance metrics. Perceptual scales include monitoring forecast

deviations, measuring and controlling total costs of logistics activities, measuring the value of different customer service levels for generating sales, monitoring disruptions and unplanned events that may jeopardise on-time delivery, and measuring the financial performance of the relationship. A five-point format ranging from 1 (not at all effective) to 5 (extremely effective) was employed for all items.

The measures of supply chain performance used in this study include fulfilment, inventory, and responsiveness. Fulfilment measures the extent to which the collaborative practice affects the ability of the chain members to satisfy consumer delivery dates. This included on-time delivery (i.e., the percentage of all orders sent on or before the promised delivery date), accuracy (i.e., the percentage of correct orders), and fill rate (i.e., amount of an order that is filled as compared to the amount that is requested). Inventory refers to the extent to which the collaborative practice affects inventory and its associated costs. This included merchandise inventory turnaround, a decrease in inventory days-of-supply, and a decrease in inventory carrying cost. Responsiveness measures the extent to which the collaborative practice affects lead-time and flexibility to accommodate demand changes. A five-point format ranging from 1 (strongly disagree) to 5 (strongly agree) was used for each item.

The unit of analysis for this research was a specific retailer-supplier relationship. This unit of analysis was chosen for several reasons. First, the retailer is an agent who ultimately meets end customer demands of the entire supply chain (Stock and Lambert, 2001). The retailer's position is crucial in improving supply chain performance in terms of customer service for end customers (Poirier, 1999). The retailer also has intimate knowledge about demand conditions because of direct contact with end customers. Sharing current and advanced demand information with the supplier may mitigate the propagation of demand variation faced by the supplier (Lee *et al.*, 1997). If the retailer shares private information about advanced customer demand with the supplier, the supplier might be able to anticipate this demand by placing a material order in advance or maintaining an inventory buffer to avoid product stockouts. At the same time, the supplier can use point-of-sale (POS) data to create quick-response to the retailer's store shelves at predetermined levels (Parks, 1999).

106

Second, the geographical proximity of New Zealand companies tends to force the domestic manufacturers to ship products to their retailers direct rather than through distributors (Sankaran, 2000). This direct link makes the retailer's position significant for the swift flow of suppliers' products to end customers. Since distributor companies in New Zealand mainly accommodate products from overseas manufacturers, the distributor-manufacturer link was not included in this study. Nevertheless, the conceptual model of this study can be extended to explore the specific link of distributor-manufacturer as well.

Third, the retailer-supplier link as the unit of analysis is consistent with the previous research of advanced initiatives - such as efficient-consumer-response (ECR), vendor-managed inventory (VMI) and collaborative planning, forecasting, and replenishment (CPFR) – that employ a similar unit of analysis (Barratt and Oliveira, 2001; Spekman *et al.*, 1998). Finally, in this chapter, data were collected from the retailer's viewpoint as well as from the supplier's viewpoint and thereby more comprehensive insights about the retailer-supplier link were provided (Kopczak, 1997).

5.3.1. Data Collection

The conceptualisation of collaborative relationships as multidimensional in nature required a substantial amount of information regarding the two sides of the relationship. Collecting data about retailer-supplier relationships is necessary to complement both chain members' perspectives in examining the conceptual model. Therefore, data were sought from both supplier and retailer points of view. Supplier firms can be manufacturers who directly deliver their products to their retailers and distributors as the mediators between manufacturers and retailers. Respondent firms of this sample produce or sell consumer products. This sample restriction reduces the extraneous sources of variation that might lower consistency of responses. The questionnaire was then developed into two versions, one for suppliers and one for retailers.

The sample was selected from *The New Zealand Business Who's Who, The New Zealand Business Directory*, and *Kompass*. The respondents were selected by checking their company types and product descriptions that suited this research. Duplicate listings were deleted, leaving 400 potential firms. The targeted key

informants included general managers, marketing managers, logistics managers, and purchasing managers. Respondents were instructed to complete the entire questionnaire in reference to their relationship with a specific trading partner.

Several techniques were used to motivate respondents to participate in this research (Dillman, 1978). First, the survey was accompanied by a cover letter that described the objectives of the study and the contributions it makes to supplier-retailer collaboration. Second, the covering letter stated that the Massey University Human Ethics Committee (MUHEC) had approved the survey with PN Protocol 02/107, which increased the legitimacy of the survey. Third, all respondents were guaranteed anonymity and offered a summary report of the results in exchange for their participation. Fourth, a pre-addressed stamped envelope was provided to make it easy for the respondents to return the completed questionnaire. Finally, respondents who did not respond in four weeks were mailed a reminder letter and another copy of the questionnaire.

After the second round of sending questionnaires to the non-responding firms, the survey produced 140 responses. Twenty-eight respondents chose to decline to participate in the study on the basis of company policy. Twenty-one were returned due to missing addressees. Twelve respondents stated that their firms have inappropriate supply chain structures, which were irrelevant to this study. There were three questionnaires with excessive missing data. After eliminating these questionnaires, the valid responses were 76 out of 367 representative samples, resulting in a response rate of 21%. This response rate was comparable to the previous study on supply chain management in New Zealand (Basnet *et al.*, 2003) and provided adequate data for further analysis (Malhotra and Grover, 1998).

The non-response bias was tested by comparing early and late respondents (Armstrong and Overton, 1977). The data set was divided into thirds according to the number of days from initial mailing until receipt of the returned questionnaire. The basic rationale is that late respondents are more similar to non-respondents than are early respondents. There were no significant differences ($p > .10$) in the means responses between early and late respondents for all the included variables. This

108

finding provides reasonable evidence that non-response bias was not a problem in these data.

Across the sample, the respondents varied in terms of company types, annual sales, number of employees, and product types as shown in Table 5.1. Respondents represented mostly some form of retailing (50%) but also included manufacturers (38.16%), and distributors (11.84%). The average annual sales of the respondents were between NZ$ 25-50 million. The average number of employees was about 250 people. The respondents had been involved in the supplier-retailer collaboration for an average of two years. The respondents were spread across six broad product categories. Clothing and footwear comprised 22.37 percent, food and beverages 21.05 percent, home improvement and building supplies 19.74, electronics and appliances 18.42 percent, stationery and toys 10.53 percent, and health products 7.89 percent of the sample. The resulting sample reflects the diversity of the retailer-supplier link inherent in the marketplace.

Table 5.1. Descriptive statistics of respondents

Employees:	n	%
< 50	19	25%
51-100	17	22%
101-200	9	12%
201-500	24	32%
> 500	7	9%
Total frequency	76	100%

Firm type:	n	%
Manufacturer	29	38%
Distributor	9	12%
Retailer	38	50%
Total frequency	76	100%

Sales (millions):	n	%
< 9	13	17%
10-24	20	26%
25-49	15	20%
50-99	10	13%
100-500	9	12%
> 500	9	12%
Total frequency	76	100%

Product types:	n	%
Apparel, footwear, clothing	17	22%
Electronics, appliances	14	18%
Food, beverages, soft drink	16	21%
Stationery, books, toys	8	11%
Home improvement, tools	15	20%
Health products	6	8%
Total frequency	76	100%

5.3.2. Data Analysis

The collected data provided a basis for measurement validation and statistical analysis. For measurement validation, conventional methods were used including coefficient alpha, item-to-total correlations, and exploratory factor analysis (Bienstock *et al.*, 1997; Churchill, 1979). The threshold values of the criteria of assessing adequate measurement properties were greater than 0.7, above the minimum level

suggested by Nunnally (1978). Factor analysis was used to assess the measurement quality of the conceptual model because it allows a stringent test of the convergent and discriminant validity of the constructs in this study (Guinan *et al.*, 1998). Consistent with the conceptualisation, DS, IA, and IS were specified as three factors. Construct validity was supported by the fact that the loading of each item on its respective scale was greater than 0.5. Low correlation between a factor and its non-associated items indicated a support for discriminant validity. Table 5.2 lists the scale items, the factor loadings, the means, standard deviation, and coefficient alphas for the predictors. The result of factor analysis in Table 5.2 provides statistical evidence of the convergent and discriminant validity of the three dimensions in the study. Two items of information sharing and one item of decision synchronisation were deleted in the process of purifying the measurement scales (Hair *et al.*, 1998). After deleting the items that were not convergent to the predetermined scale, measures of alpha ranged from 0.71 to 0.82. As suggested by Cronbach's alphas, the scales demonstrate reasonable reliability of consistency.

Table 5.2. Measurement statistics for predictor variables

Scales	Rotated Component Matrix			Mean	Standard deviation	Cronbach Alpha (α)
	Factor 1	Factor 2	Factor 3			
Decision Synchronisation (DS)						
DS1: Reducing demand fluctuations	.757					
DS3: Co-managing stock/inventory	.638					
DS4: Ensuring on-time delivery	.742			2.13	.86	.816
DS5: Improving product availability	.729					
IS3: Inventory cost data (deleted)	.678					
IA3: Sharing collaborative cost (deleted)	.670					
Information Sharing (IS)						
IS1: Data about promotional events		.499				
IS2: Data about sales forecast		.590				
IS4: On-hand inventory levels data		.846		3.23	.89	.768
IS5: Order tracking data		.767				
DS2: Creating joint forecasts (deleted)		.492				
Incentive Alignment (IA)						
IA1: Sharing risks of uncertainty			.600			
IA2: Sharing saving from lowered stock			.688	3.36	.77	.711
IA4: Focusing on generating sales			.781			
IA5: Sharing benefits of collaboration			.709			

Cronbach's alphas for performance monitoring and performance variables were also estimated. The alpha for performance monitoring was 0.83. Performance criteria of fulfilment, inventory, and responsiveness had 0.77, 0.83, and 0.71 scores of alphas respectively. These reliability coefficients showed a high degree of internal consistency among these variables.

110

For each of the variables, scale scores were computed as the average of the individual items. The profile of the scores for predicted variables then served as the input for the regression analysis. The regression analysis was used in this research to test the effect of the three dimensions of collaboration on performance. This procedure determines whether there is a significant effect for the independent variables as specified in the hypotheses (Cohen and Cohen, 1983). For a complete statistical analysis pertaining to this chapter refer to Appendix A.

5.4. Findings

All hypotheses stated in the modelling section were tested by estimating the regression equation for each performance criterion. The estimation results for the first three hypotheses are summarised in Table 5.3. The F-test for the three regression equations indicated the linear relationship between predictor variables and realised performance with alphas less than 0.001. The regression equations varied in the values of adjusted coefficient determination. The first regression equation accounted for about 60 percent of the variation in fulfilment performance. The second regression equation accounted for about 54 percent of the variation in inventory performance. The third regression equation accounted for about 33 percent of the variation in responsiveness performance. The results indicated support for the three hypotheses. All being equal, realised performance is greater when information sharing is higher, when decision synchronisation is higher, and when incentive alignment is higher.

Table 5.3. Standardised beta coefficients for realised performance

Hypotheses	Performance criteria		
	Fulfilment	Inventory	Responsiveness
H1. Information Sharing (IS)	.225 **	.489 ***	.199 *
H2. Decision Synchronisation (DS)	.496 ***	.380 ***	.423 ***
H3. Incentive Alignment (IA)	.226 ***	-.077 -	.066 -
Adjusted R square	.602	.537	.329

Note: * $p < .10$, one-tailed test; ** $p < .05$, one-tailed test, *** $p < .01$, one-tailed test, - Not statistically significant.

Furthermore, Table 5.4 shows the result of moderated regression analysis as suggested by Sharma *et al.* (1981). The regression equations accounted for about 59, 57, and 34

percent of the variation in fulfilment, inventory, and responsiveness performance respectively.

Testing Hypothesis 1: Hypothesis 1 relates to the relationship between information sharing and operational performance. As expected, information sharing significantly helps the chain members achieve better fulfilment ($\beta = 0.225$), inventory ($\beta = 0.489$), and responsiveness performance ($\beta = 0.199$). This finding is consistent with the previous research (Fisher, 1997; Frankel *et al.*, 2002). Through information sharing, the chain members are able to take into account factors that affect the future requirements of fulfilment, inventory, and responsiveness.

Table 5.4. Standardised coefficients of moderated regression analysis

Predicted Variables	Performance criteria		
	Fulfilment	Inventory	Responsiveness
Information Sharing (IS)	.195	.592*	.464
Decision Synchronisation (DS)	.596	.766*	.640
Incentive Alignment (IA)	.207	-.688**	-.550
Performance Monitoring * IS	.069	-.606	-.891
Performance Monitoring * DS	-.141	-.563	-.313
Performance Monitoring * IA	.026	1.157**	1.175*
Adjusted R square	.585	.571	.342

Note: $* p < .10$, $** p < .05$, $*** p < .01$.

Testing Hypothesis 2: Hypothesis 2 states that decision synchronisation influences better performance. It was found that decision synchronisation significantly contributes to fulfilment ($\beta = 0.496$), inventory ($\beta = 0.380$), and responsiveness performance ($\beta = 0.423$). This finding is consistent with the previous research (Morash and Clinton, 1998; Stank *et al.*, 2001). The chain members synchronise their decisions about product planning, demand forecasts, ordering, and replenishment that enable them to fulfil current demand and future demand with minimum inventory. Synchronisation also helps them to carry out certain improvements such as shortening cycle time that affects their ability to respond more quickly to demand changes.

Testing Hypothesis 3: Hypothesis 3 states that incentive alignment affects operational performance. It was found that incentive alignment contributes only to fulfilment performance ($\beta = 0.226$). There was no significant impact of incentive alignment on inventory and responsiveness. This finding indicated that the chain members consider fulfilment as the basic criterion to satisfy customer needs and a means of incentive

alignment. This is because fulfilment performance specifies clearly an agreement between two parties that the supplier delivers orders by a predetermined due date including the payment arrangement. For example, a large retailer in New Zealand often requires their suppliers to send orders within pre-specified delivery time windows. The supplier will be charged for sending orders early or tardy of this time window. Furthermore, as both parties enjoy inventory and responsiveness from collaboration, the benefits of inventory and responsiveness serve as self-imposed incentives. In other words, incentive alignment is often embedded in this collaborative effort. This means both parties would reap the benefits of lowered inventory and fast responsiveness if they were to closely cooperate in information sharing and decision synchronisation without devising incentive alignment (Achabal *et al.*, 2000; Stank *et al.*, 1999).

Testing Hypothesis 4: Hypothesis 4 states that the impact of the collaborative practice on performance is contingent on the level of performance monitoring. There was no moderating effect of performance monitoring on fulfilment performance. A possible explanation for this finding is that the chain members have stringent performance measures when they are involved in the fulfilment process, such as delivery time windows and payments. They use the contract as a means of performance monitoring. However, performance monitoring exhibited a significant moderating effect ($p < .10$) on the relationship between incentive alignment and both inventory ($\beta = 1.157$ in Table 5.4) and responsiveness performance ($\beta = 1.175$ in Table 5.4). This finding thus partially supported performance monitoring as a moderating effect between incentive alignment and operational performance. Previous research on incentives also indicates that the chain members need to follow up the agreement of incentive alignment by closed performance monitoring (Bergen *et al.*, 1992; Jensen, 1998). This is consistent with the finding that the use of incentive alignment in supply chain collaboration has a learning process (Callioni and Billington, 2001; Kaplan and Narayanan, 2001). Since the monitoring of realised performance serves as a basis for calculating and sharing incentives amongst the participating members, incentive alignment becomes meaningful where there is a proper use of performance monitoring (Simatupang and Sridharan, 2002).

5.5. Discussion and Concluding Remarks

The main purpose of this study is to provide a new insight into the conceptual link between the interface dimensions of supply chain collaboration and performance. The hypotheses were tested through analysis of data.

The managerial implications of major findings are examined as follows. The three dimensions of supply chain collaboration provide opportunities to improve supply chain performance. It has been found that information sharing and decision synchronisation consistently contributed to fulfilment, inventory, and responsiveness performance. Incentive alignment significantly affected fulfilment performance. However, when performance monitoring was in place, incentive alignment significantly contributed to inventory and responsiveness performance. The findings suggest that information sharing, decision synchronisation, and incentive alignment were important determinants of operational performance. Consequently, it appears that the chain members should put together information sharing, decision synchronisation, and incentive alignment if they want to improve their fulfilment performance. Information sharing and decision synchronisation are both important in attaining better inventory and responsiveness. However, to increase the benefits of lowered inventory and responsiveness, the chain members have to establish performance monitoring to ensure the usefulness of incentive alignment.

The research questions addressed in this study include: what is the extent of collaborative practice, what is the strength of relationship between collaborative practice and realised performance, and what is the effect of a moderating variable on the relationship between collaborative practice and operational performance. A conceptual model and an empirical study were undertaken to answer these research questions.

The study sought to make a contribution to the theory and practice of supply chain collaboration. The first contribution is the demonstration that supply chain collaboration can be measured by using three dimensions, namely decision synchronisation, information sharing, and incentive alignment. Information sharing enables the chain members to realise that it is important to take into account a global

114

perspective in making optimal decisions. Decision synchronisation enables the chain members to agree upon joint decisions, such as collaborative forecasting, ordering, and delivery. Incentive alignment encourages the chain members to pursue mutual strategic objectives that yield better profits to all members through sharing costs, benefits, and risks. The study's second contribution lies in its demonstration of the empirical examination of the impact of supply chain collaboration on operational performance.

The study statistically describes some important findings on supply chain collaboration. Results show that information sharing, decision synchronisation, and incentive alignment significantly contribute to fulfilment performance. Information sharing and decision synchronisation consistently affect fulfilment, inventory, and responsiveness performance. In conjunction with performance monitoring, incentive alignment has a positive effect on inventory and responsiveness.

116

Chapter 6
The Collaboration Index: A Measure for Supply Chain Collaboration

6.1. Introduction

Supply chain collaboration facilitates the cooperation of participating members along the supply chain to improve performance (Bowersox, 1990). The benefits of collaboration include revenue enhancements, cost reductions, and operational flexibility to cope with high demand uncertainties (Fisher, 1997; Lee *et al.*, 1997). Hewlett-Packard, IBM, Dell, and Procter & Gamble, who have worked closely with their partners, are several examples of companies that have captured the advantage of collaboration (Barratt and Oliveira, 2001; Callioni and Billington, 2001; Dell and Fredman, 1999; Parks, 2001).

Although supply chain collaboration has obtained increasing popularity, it is surprising to note that limited attention has been given to measuring supply chain collaboration (Lambert and Pohlen, 2001; Simatupang and Sridharan, 2004a). Previous research has tended to propose measures to gauge the degree to which a company collaborates with its partners in a supply chain. Stewart (1997) presented the development of the supply chain operations reference (SCOR) model as the first cross-industry framework for evaluating and improving extended supply chain performance. Geary and Zonnenberg (2000) employed the SCOR model to show that the best-in-class performers gained considerable financial and operating advantages over the rest of the sampling groups. Bowersox *et al.* (2000) developed subjective measures of supply chain competence at both operational and strategic levels. By using system-wide revenues and costs, Ramdas and Spekman (2000) examined collaborative practices between high performers among innovative-product supply chains and high performers among functional-product supply chains.

In another stream of research, attempts have been made to propose the maturity model of collaboration as an instrument to measure the degree of movement of supply chain

collaboration from internal focus to interorganisational focus. Poirier (1999) proposed a progressive framework consisting of four levels of supply chain optimisation. The first two levels of progress namely "sourcing and logistics" and "internal excellence" are internally focused. The last two levels (i.e., 'network construction' and 'industry leadership') reflect the collaborative efforts amongst participating members that improve their value chain constellation in which effectiveness is measured by the ultimate customers in terms of their purchases and continued loyalty. Furthermore, Polese (2002) developed a maturity model that reflects how companies progress in terms of operational capability. Collaborative capability is the key ingredient in reaching external integration and cross-enterprise collaboration. According to Polese (2002), the maturity model based on the SCOR model can be used to measure fact-based benchmarking for determining best-in-class performance opportunities. However, these two studies have not identified and differentiated multiple dimensions of supply chain collaboration. This chapter not only provides a better representation of supply chain collaboration but also shows empirical evidence of its new concept.

The wide adoption of supply chain collaboration requires a scientific means of assigning values to statements that indicate various levels of collaboration amongst participating members (Barratt and Oliveira, 2001; Mentzer *et al.*, 2000a). This chapter describes attempts to develop scales to measure the practice of supply chain collaboration. An instrument to measure supply chain collaboration was conceptualised using three dimensions, namely information sharing, decision synchronisation, and incentive alignment (Simatupang and Sridharan, 2004a). Research instruments were developed around this conceptualisation. Several supplier and retailer companies in New Zealand were chosen to test the instruments. A total of 76 companies participated in the research. The survey results proved that the scale of collaboration was highly reliable and adequately valid. The research also showed the positive effect of the collaboration index on operational performance. This research contributes to the development and testing of scientifically formulated measures of the practice of supply chain collaboration.

6.2. Collaboration Index

The concept of collaboration can be categorised into three interrelated dimensions, namely information sharing, decision synchronisation, and incentive alignment (Simatupang and Sridharan, 2004a). Information sharing refers to the act of capturing and disseminating timely and relevant information for decision makers to plan and control supply chain operations. Decision synchronisation refers to joint decision-making in planning and operational contexts. The planning context integrates decisions about long-term planning and measures such facets as selecting target markets, product assortments, customer service level, promotion, and forecasting. The operational context integrates order generation and delivery processes that can be in the forms of shipping schedules and replenishment of the products in the stores. Finally, incentive alignment refers to the degree to which chain members share costs, risks, and benefits. These three dimensions are important for enabling the participating members to improve the swift flow of products to end customers.

In this chapter a collaboration index is proposed to measure the collaborative practice based on information sharing, decision synchronisation, and incentive alignment as shown in Figure 6.1. The index score simply equals the mean scores of the three dimensions of collaboration for the chain members in the sample. The rationale is that responses to Likert scales can be treated as quasi-ratio data (Gaski and Etzel, 1986). A higher score on this index indicates that the chain members are involved in a higher level of supply chain collaboration.

The collaboration index helps the chain members to discover the most important collaborative practices, as they would have a higher score on the collaboration index. In the same way, the least important collaborative practice would have a lower collaboration index. There is often a mismatch between the priorities expressed by different chain members across the three dimensions of supply chain collaboration. It is also true that different levels of collaborative practices imply different levels of operational performance achieved by the chain members. It is hypothesised that respondents whose collaboration index is high would have better operational performance compared to those with a lower collaboration index. This research thus also assesses the concurrent validity of the collaboration index in which this index

positively affects operational performance as theoretically expected (Churchill and Iacobucci, 2002).
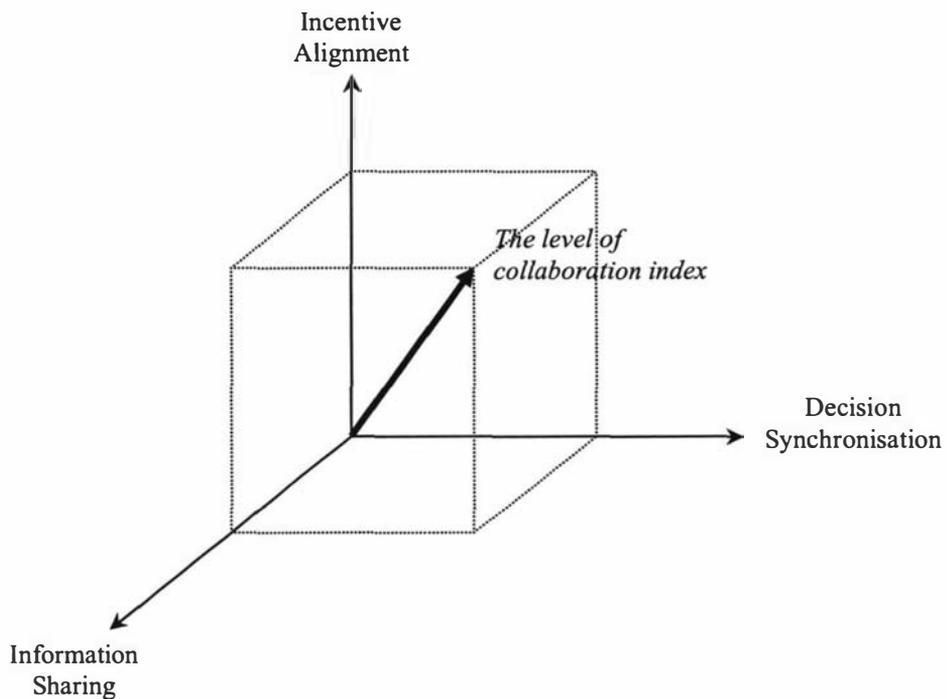
Figure 6.1. The concept of collaboration index

6.3. Research Method

Given the centrality of supply chain collaboration to the practice of supply chain management, the aim of this study was to develop measures to evaluate the level of supply chain collaboration. This section presents the procedure used to develop a measure of supply chain collaboration by following the recommended procedures for scale development (Churchill, 1979). The complete research method can be seen in Section 5.3 in Chapter 5.

The procedure consists of three interrelated steps: conceptualisation, development of the measurement instrument, data collection, and statistical analysis. The conceptualisation phase identified key dimensions of supply chain collaboration that incorporate information sharing, decision synchronisation, and incentive alignment (Simatupang *et al.*, 2002; Simatupang and Sridharan, 2004a).

120

The scale for the concept of supply chain collaboration was generated by itemising the domain of a dimension into a set of activities (Cavana *et al.*, 2001). Item statements were clarified by examining the literature on supply chain collaboration. A panel of practitioners and academics with substantial knowledge about the topic was asked to review and modify original items that reflect the dimensions of supply chain collaboration. From this process, twelve item statements for each dimension were identified. Furthermore, pretesting of the instrument involved the use of a panel of experts to identify ambiguous items, poorly worded questions, and poor instructions for answering the questionnaire. Several item statements were rewritten after evaluation by this panel. The panel found no major problems with the response format, directions, or other survey procedures. Additional evaluation was made to ensure consistency with the measures used in prior research. Several items were modified slightly after this evaluation. The final questionnaire sent to the respondents reflected the changes.

Statistical tests were conducted to confirm the reliability and validity of the measurement (Churchill, 1979). Consistent with the conceptualisation, information sharing, decision synchronisation, and incentive alignment were specified as three separate factors. The measurement items were purified by corrected item-to-total correlations and factor analyses. Two items from the information sharing scale, three items from the decision synchronisation scale, and six items from the incentive alignment scale were dropped because of significant improvement in item-to-total correlation after deleting those items. All the retained items had corrected item-total correlations greater than 0.3. Factor analysis was run to examine the convergence of the items to measure the intended concept. The Eigen values for each factor would suggest that there was only one predominant factor. Interitem consistency reliability of the scale, the extent of measurement error in a measure, was estimated through Cronbach's coefficient alpha (Cronbach, 1951). Table 6.1 lists the scale items, the corrected item-total correlations, the means, standard deviation, and coefficient alphas. Reliability analyses in Table 6.1 showed a high degree of internal consistency among research variables (Nunnally, 1978).

The measurement items for each variable were developed as follows. The practice of information sharing refers to the extent to which the chain members shared their

private information about supply chain operations over time. Twelve items of information sharing were identified through a review of previous studies (Lee and Whang, 2000) and the panel's suggestions. Each item was assessed on a five-point format from 1 to 5, 1 representing the minimum level of practice, and 5 representing the maximum level of practice. Ten items remained after checking item-total correlation. Factor analysis showed that the scale of information sharing would explain 45.2% of the total variance of items. The Eigen value of this dimension was 4.52. The reliability coefficient for information sharing was 0.86. Both factor analysis and Cronbach's alpha confirmed the goodness (reliability and validity) of the developed instrument for measuring information sharing practice.

Table 6.1. Measurement for the three dimensions of collaboration

Items of the scale	Mean	Standard deviation	Item-total correlation	Alpha
The information sharing scale:	2.89	.75		
1. Promotional events	3.69	1.02	.33	
2. Demand forecast	2.91	1.12	.62	
3. Points-of-sale (POS) data	2.55	1.27	.70	
4. Price changes	2.04	1.17	.60	
5. Inventory holding costs	1.88	1.09	.56	.86
6. On-hand inventory levels	2.50	1.21	.67	
7. Inventory policy	2.84	1.08	.72	
8. Supply disruptions	3.46	.94	.66	
9. Order status or order tracking	3.37	1.22	.48	
10. Delivery schedules	3.66	1.19	.36	
The decision synchronisation scale:	2.58	.80		
1. Joint plan on product assortment	3.00	1.06	.45	
2. Joint plan on promotional events	3.34	1.16	.58	
3. Joint development of demand forecasts	2.61	1.07	.73	
4. Joint resolution on forecast exceptions	2.44	1.08	.66	.88
5. Consultation on pricing policy	1.93	1.17	.66	
6. Joint decision on availability level	2.37	1.12	.67	
7. Joint decision on inventory requirements	1.98	1.11	.75	
8. Joint decision on optimal order quantity	2.51	1.19	.59	
9. Joint resolution on order exceptions	3.01	1.05	.61	
The incentive alignment scale:	2.57	.79		
1. Joint frequent shopper programmes	2.25	1.32	.56	
2. Shared saving on reduced inventory costs	2.19	1.19	.41	
3. Delivery guarantee for a peak demand	3.65	1.03	.31	.72
4. Allowance for product defects	3.08	1.44	.45	
5. Subsidies for retail price markdowns	2.38	1.34	.62	
6. Agreements on order changes	1.84	.93	.38	

Decision synchronisation was operationalised as the degree to which the chain members become involved in joint decision making at planning and operational

levels. Twelve items of decision synchronisation were identified through review of previous studies and the panel's recommendations. Each item was assessed on a five-point format. Nine items were retained after checking item-total correlation. Factor analysis showed that the scale of decision synchronisation would explain 52.4% of total variance of items. The Eigen value of this dimension was 4.71. The reliability coefficient for decision synchronisation was 0.88. Both factor analysis and Cronbach's alpha confirmed the goodness of the developed instrument for measuring decision synchronisation practice.

Incentive alignment was operationalised as the degree to which the chain members share costs, benefits, and risks of collaboration. There were twelve items of incentive alignment identified in this study based on the literature and the panel's suggestions. Each item was assessed on a five-point format. Six items were retained after checking item-total correlation. Factor analysis showed that the scale of incentive alignment would explain 42.2% of the total variance of items. The Eigen value of this scale was 2.53. The reliability coefficient for incentive alignment was 0.72. Both factor analysis and Cronbach's alpha confirmed the goodness of the developed instrument for measuring the incentive alignment practice.

Performance criteria were operationalised as the degree to which the chain members achieve better fulfilment, inventory, and responsiveness (Ramdas and Spekman, 2000). All responses were ranked from 1 to 5, 1 representing the minimum level of performance, and 5 representing best performance. The scores on the core questions were used to construct indices measuring different performance levels. Fulfilment measures the extent to which the collaborative practice affects the ability of the chain members to satisfy consumer delivery date. The scale includes on-time delivery (i.e., the percentage of all orders sent on or before the promised delivery date), accuracy (i.e., the percentage of correct order), and fill rate (i.e., amount of an order that is filled as compared to the amount that is requested). The reliability coefficient for fulfilment was 0.77. Inventory measures the extent to which the collaborative practice affects inventory levels. This includes merchandise inventory turnaround, a decrease in inventory days-of-supply, and a decrease in inventory carrying cost. The reliability coefficient for inventory was 0.83. Responsiveness measures the extent to which the

collaborative practice affects lead-time and flexibility to accommodate demand changes. The reliability coefficient for responsiveness was 0.71.

Refer to Appendix B for a complete statistical analysis relating to the Collaboration Index.

6.4. Findings

This section presents findings from the survey that can be summarised into reliability and validity of the instrument, profiles of collaboration index, and the effects of collaborative practices on operational performance.

6.4.1. Reliability and Validity Tests

Coefficient alphas for the scales of supply chain collaboration were more than 0.7, indicating that the scales had a good level of internal consistency (Nunnally, 1978). A panel consisting of researchers and practitioners examined the clarity of the item statements. This pilot test was carried out to increase the stability of the measure (Cavana *et al.*, 2001). Additionally, operational performance was measured by asking the respondents to indicate the outcomes of collaboration. Items for measuring operational performance showed a high internal consistency. It would appear that the instrument provided an indication of high reliability.

In this study content validity indicates the adequacy with which a specified domain of a construct is captured by the measure (Churchill, 1979). This was assessed by defining the domain of the dimensions of supply chain collaboration based on the literature and by asking a panel of experts to assess how well each item statement captured the corresponding concept. The panel made suggestions to modify the items in order to ensure their adequacy to represent the concept. Based on a review of the literature and the use of a panel, it is thus believed that the instrument satisfies content validity to adequately represent the concept of supply chain collaboration. Additionally, factorial validity confirmed the convergence of items to form the corresponding dimensions of collaboration.
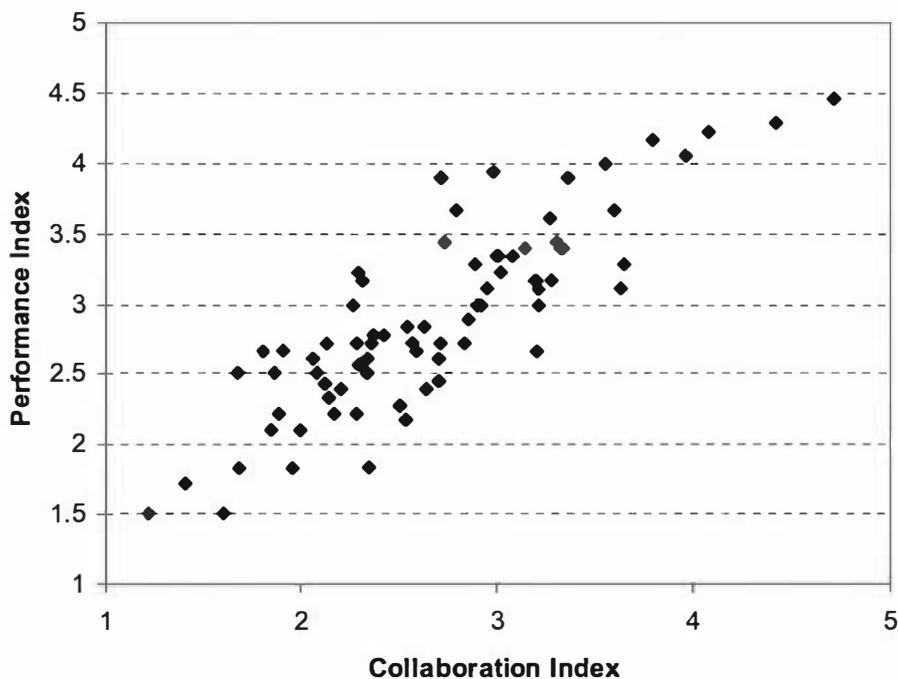
Construct validity, related to the question of whether or not the results obtained from the use of the instrument fit the theories underlying the test (Churchill, 1979), was assessed by convergent validity. High correlation between the scores obtained by two different instruments measuring the same concept indicates the level of convergent validity. The three dimensions of collaboration had significant correlations with each other at the 0.01 level. Information sharing correlated 0.70 with decision synchronisation and 0.57 with incentive alignment, whereas the coefficient of correlation between decision synchronisation and incentive alignment was 0.66. These correlations indicate a moderate level of convergence.

Criterion-related validity ensures that the measure differentiates respondents on a criterion it is expected to predict (Cavana *et al.*, 2001). This can be done by estimating predictive and concurrent validity. Predictive validity, which indicates the ability of the instrument to differentiate among respondents as to a future criterion, was assessed by the correlation between the time length of collaboration and collaboration index. The collaboration index should differentiate those who collaborate closely from those who have minimum collaborative efforts. The correlation between the collaboration index and the time length of collaboration was 0.49, which was significant at the 0.01 level. This proves that the level of predictive validity is adequate. Concurrent validity, which indicates a correlation between a measure and a criterion of interest at the same point in time. In this study, the concern is with the concurrent validity of collaborative practice and operational performance. Concurrent validity was thus assessed by examining whether or not respondents who had a high collaboration index were expected to have better performance. The next subsection outlines this concurrent validity.

6.4.2. Profiles of Collaboration Index
The achievement of a collaborative relationship refers to the extent to which the chain members implement the collaborative practice that contributes to higher performance. Two indices were developed to assess the relationship between collaborative practices and performance. A collaboration index was developed as an average of the scores aggregated across three dimensions of collaboration. A performance index was developed as an average of fulfilment, inventory, and responsiveness.

Figure 6.2 indicates a distribution of results on the collaboration index and the performance index (a scatter graph). The mean of the collaboration index was 2.67 with standard deviation equal to 0.68. The mean of the performance index was 2.91 with standard deviation equal to 0.66. As expected, the correlation between the collaboration index and the performance index was 0.858 and significant at the 0.01 level. The coefficient of determination was 0.736, which indicates that the collaboration index accounted for 74% of the variation in performance index. Furthermore, the result of analysis of variance showed that respondents who had a high collaboration index (more than 3) outperformed respondents with a lower collaboration index. This finding confirmed that respondents who have a higher degree of collaboration practice were able to attain better performance (Spekman *et al.*, 1998).

Figure 6.2. A scatter plot of collaboration index versus performance index

The calculation of the collaboration index above assumed equal weight for each dimension of collaboration. The respondents assigned relative weights when they were asked to allocate 100 points on the three dimensions of collaboration. Different weights given to dimensions by respondents indicate different priority of importance. Respondents placed information sharing with the highest degree of importance among the three dimensions of collaboration. Based on these responses, it was found that

126

information sharing had a weight of 0.45, decision synchronisation had a weight of 0.34, and incentive alignment had a weight of 0.21. Figure 6.3 shows unweighted and weighted mean scores of the three dimensions of collaboration. The weighted scores in information sharing (IS) and decision synchronisation (DS) were slightly higher than the unweighted scores. The weighted score of incentive alignment was lower than the unweighted score. It seems that respondents emphasise joint information sharing and decision making before they practise incentive alignment (see Callioni and Billington, 2001). The discrepancy between the unweighted and weighted scores in each dimension suggests a potential opportunity for improving the levels of collaborative practices by shifting attention to the more important dimension of collaboration.
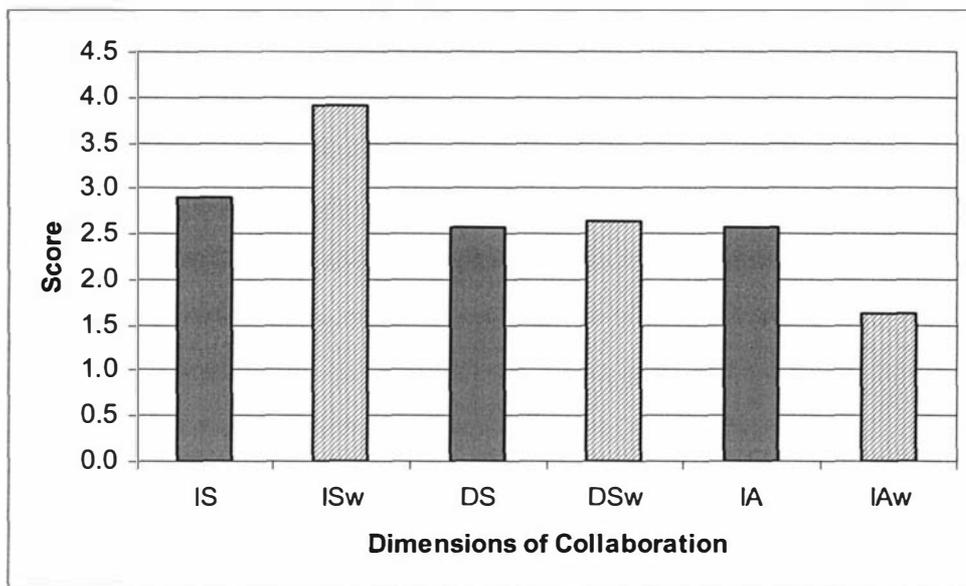
Figure 6.3. Unweighted and weighted mean scores of information sharing (IS and ISw), decision synchronisation (DS and DSw), and incentive alignment (IA and IAw)

The mean of the weighted collaboration index was 2.72 with standard deviation equal to 0.68. The correlation between the weighted collaboration index and the performance index was 0.851 and significant at the 0.01 level. The coefficient of determination was 0.724, which indicates that the collaboration index accounted for 72% of the variation in the performance index. The correlation and the coefficient of determination of the weighted collaboration index were slightly less than the results based on the unweighted collaboration index.

To ensure internal consistency, a *t*-test was carried out to test the performance difference between respondents who prioritised information sharing ($n = 52$, mean = 2.85) and respondents who prioritised decision synchronisation or incentive alignment ($n = 24$, mean = 3.02). The *t*-test showed no mean performance differences between these two groups with *p*-value equal to 0.34. This finding suggests that as long as the chain members collaborate in the three dimensions of collaboration, they can improve operational performance.

Table 6.2. The sensitivity test

Weighting Rule	Ratio $W_{is}:W_{ds}:W_{ia}$	Score	Standard Deviation	R^2	ρ	Z-test
Unweighted index: Equal importance (base case)	.33:.33:.33	2.6785	.68014	.736	.858	
Weighted index (data): IS = 2.1*IA, DS = 1.6*IA	.45:.34:.21	2.7165	.68278	.724	.851	-.157 -
Weighted index scenario 1: IS = 2*IA, DS = 1.5*IA	.44:.33:.23	2.6875	.67492	.727	.852	-.135 -
Weighted index scenario 2: IS = 2*DS, DS = 2*IA	.57:.29:.14	2.7549	.68873	.707	.841	-.369 -
Weighted index scenario 3: IS = 2*DS = 2*IA	.50:.25:.25	2.7316	.67768	.736	.858	.000 -
Weighted index scenario 4: IS = 3*IA, DS = 1.5*IA	.55:.27:.18	2.7481	.68391	.719	.848	-.222 -
Weighted index scenario 5: IS = 3*IA, DS = 2*IA	.50:.33:.17	2.7326	.68567	.716	.846	-.265 -
Only IS	100:.00:.00	2.8908	.74961	.590	.768	-1.633 -
Only DS	.00:100:.00	2.5789	.80109	.521	.722	-2.259 **
Only IA	.00:.00:100	2.5658	.78791	.574	.757	-1.792 *

Note: IS = information sharing, DS = decision synchronisation, IA = incentive alignment, * $p < .10$, ** $p < .05$, *** $p < .01$, - Not statistically significant.

A sensitivity test was also carried out to confirm that the collaboration index provides the best explanatory aspect of operational performance. Table 6.2 shows the results of the sensitivity test across different weighting rules. The unweighted collaboration index served as a base case with an equal ratio for the three dimensions. The weighted collaboration index was obtained from the sample. The weighted collaboration index in scenario 1 means that information sharing (IS) is twice as important as incentive alignment, whereas decision synchronisation is one and half times more important than incentive alignment. Similarly, the weighted collaboration index in scenario 5 means that information sharing (IS) is three times more important than incentive alignment, whereas decision synchronisation is twice as important as incentive

alignment. The last three scenarios showed that one dimension was dominating the index.

The Z-test showed that there were no differences in correlation coefficients between unweighted and weighted collaboration index (Walpole and Myers, 1978). This indicated that the collaboration index was robust in explaining realised performance under different weighting rules. When using different weighting rules, the three dimensions of collaboration have a compensating effect. This result suggests that the chain members need to explore the complementary effect of the three dimensions rather than the compensating effect.

However, the explanatory aspect of the collaboration index was reduced when only one dimension was used to compute the index. The coefficients of determination dropped dramatically for the last three weighting rules. The dominating dimensions of decision synchronisation and incentive alignment had significantly lower correlation coefficients compared to the base case. This finding suggests that the three dimensions were important in determining the collaboration index and the chain members could not rely on just one dimension.

6.4.3. Effects of Collaborative Practices on Performance

After the instrument had been developed and tested, it was important to further assess the concurrent validity by examining the effects of different levels of collaboration on operational performance. The concept of collaboration theoretically envisages that the chain members who become involved in collaborative efforts outperform those with less involvement in collaboration (Barratt and Oliveira, 2001; Simatupang and Sridharan, 2002). Mean scores were computed for the measures over the three dimensions of collaboration. Respondents were divided according to their levels of collaborative practices. The cut-off value of three was chosen to differentiate between low and high collaborative practices. Based on this threshold value, there were 35 respondents with a high level of information sharing practice, 25 respondents with a high level of decision synchronisation practice, and 22 respondents with a high level of incentive alignment practice. Analysis of variance (ANOVA) was carried out to examine the effects of different levels of collaborative practices on operational performance. Table 6.3 shows the results of analysis of variance. Analysis of variance

tested the effects of information sharing, decision synchronisation, incentive alignment, and interactions on fulfilment, inventory, and responsiveness. Adjusted R squared for fulfilment performance was 54.3 percent with F-value of the corrected model equal to 13.7 and significant at the 0.01 value. Adjusted R squared for inventory performance was 40.0 percent with F-value of the corrected model equal to 8.2 and significant at the 0.01 value. Adjusted R squared for fulfilment performance was 33.8 percent with F-value of the corrected model equal to 6.5 and significant at the 0.01 value. These results suggested that the use of analysis of variance for each dependent variable was satisfied.

Table 6.3. Analysis of variance for the effects of collaborative practices on operational performance

| Source of variance | Operational performance | | | | | |
| | Fulfilment | | Inventory | | Responsiveness | |
	F-value	Sig.	F-value	Sig.	F-value	Sig.
Information Sharing (IS)	11.312	.001 ***	3.889	.053 *	1.622	.207 -
Decision Synchronisation (DS)	8.025	.006 ***	5.540	.021 **	3.726	.058 *
Incentive Alignment (IA)	3.055	.085 *	6.351	.014 **	6.275	.015 **
IS*DS	.286	.598 -	.154	.696 -	.897	.347 -
IS*IA	2.526	.117 -	2.640	.109 -	.522	.473 -
DS*IA	6.693	.012 **	.383	.538 -	.081	.777 -
IS*DS*IA	.017	.895 -	2.242	.139 -	.015	.903 -
Corrected Model (Adjusted R^2)	13.7 (54%)	.000 ***	8.2 (40%)	.000 ***	6.5 (34%)	.000 ***

Note: * $p < .10$, ** $p < .05$, *** $p < .01$, - Not statistically significant.

The three dimensions of collaboration significantly influenced fulfilment performance. This finding was consistent with the conceptualisation that close collaboration enables the chain members to improve their ability to fulfil customer needs (Barratt and Oliveira, 2001; Simatupang and Sridharan, 2004a). Previous research also supported the finding that information sharing (Frankel *et al.*, 2002), joint decision making (Bowersox, 1990), and incentive alignment (Narus and Anderson, 1996) facilitate the process of fulfilment improvement. It was also found that the combination of decision synchronisation and incentive alignment had a significant influence on fulfilment.

It appeared that the chain members would be able to realise the benefits of collaboration if there was a link between joint decision making and incentive alignment. This finding strongly supports the idea of combining decision synchronisation and incentive alignment to support improvement in fulfilment performance. It is also in line with Kaplan and Narayanan (2001) who contend that chain members need to tie decisions on delivery schedules to associated costs-to-serve in order to avoid misaligned incentives that inhibit them from improving fulfilment performance.

The three dimensions of collaboration were positively associated with inventory performance. This finding was consistent with the conceptualisation that close collaboration enables the chain members to improve their ability to lower inventory (Simatupang and Sridharan, 2004a). Previous research also supported the finding that information sharing (Whipple *et al.*, 2002), joint decision making (Ramdas and Spekman, 2000), and incentive alignment (Corbett *et al.*, 1999) facilitate the process of lowering inventory. There were no interaction effects of collaborative practices on inventory performance.

Only two dimensions of collaboration significantly influenced responsiveness performance, namely decision synchronisation and incentive alignment, while information sharing has a moderate effect on responsiveness. Previous research indicated that joint decision making and incentive alignment enable the chain members to create better responsiveness (Fisher, 1997; Narus and Anderson, 1996). This is because the chain members need to ensure that they will gain financial benefits by increasing responsiveness, especially for innovative products (Fisher, 1997). There were no interaction effects on responsiveness.

To investigate why information sharing had only a moderate effect on responsiveness, it is important to assess whether or not the levels of the items of information sharing scale affect responsiveness. Table 6.4 shows mean differences in responsiveness between low and high levels of the information sharing practices. Then the *t*-test of the mean of responsiveness was carried out to see which item really differentiates between low and high levels of information sharing. Interestingly, information sharing practices in order status and delivery schedules did not differentiate between low and

high levels of information sharing. It appeared that responsiveness depended more on how the chain members share information to control or execute supply chain process and less on information sharing at the planning level. The chain members thus could take advantage of capturing early demand data to ensure continuous replenishment under demand changes (Fisher, 1997).

Table 6.4. The mean differences in responsiveness between high and low levels of information sharing practices

Information Sharing Items	Means of responsiveness at two levels of practices		Mean differences in responsiveness	
	Low	High	Δ	t-value
1. Promotional events	2.045	2.707	.662	3.366 ***
2. Demand forecasts	2.277	2.795	.518	3.104 ***
3. Points-of-sale (POS)	2.273	3.029	.755	4.558 ***
4. Price changes	2.425	3.068	.642	3.191 ***
5. Inventory carrying costs	2.817	2.916	.399	2.025 *
6. Inventory levels	2.289	2.934	.644	3.901 ***
7. Inventory policy	2.241	2.840	.599	3.716 ***
8. Supply disruptions	2.181	2.684	.502	2.315 **
9. Order status	2.382	2.678	.295	1.594 -
10. Delivery schedules	2.321	2.677	.356	1.447 -

Note: low = a low level of collaborative practice, high = a high level of collaborative practice, Δ= means differences between high and low levels, * $p < .10$, two-tailed test; ** $p < .05$, two-tailed test, *** $p < .01$, two-tailed test, - Not statistically significant.

6.5. Concluding Remarks

As the result of this research, a means for measuring the extent of supply chain collaboration has been provided and the effects of collaborative practices on operational performance have been examined. The concept of supply chain collaboration was characterised into three dimensions, namely information sharing, decision synchronisation, and incentive alignment. Instruments were developed and sent out to the sample of New Zealand companies. There were 76 valid responses, which provided a 21% response rate. The survey results showed that the instruments had high reliability and moderate validity. A collaboration index was introduced to

represent the average score across the three dimensions of collaboration. A performance index was also developed as a composite of operational measures in fulfilment, inventory, and responsiveness. A correlation analysis showed the strong relationship between the levels of the collaboration index and the performance index.

Furthermore, analysis of variance showed that each of the three dimensions affected some aspect of operational performance. This confirmed the concurrent validity of the instrument. Decision synchronisation and incentive alignment consistently influenced fulfilment, inventory, and responsiveness. This indicates that decision synchronisation and incentive alignment are not only important to enable the chain members to fulfil demand on-time and maintain lower inventory but also to create responsiveness to react to demand changes. Interestingly, the interaction of decision synchronisation and incentive alignment significantly related to fulfilment performance. Decision synchronisation and incentive alignment had significant additive effects to enable the chain members to improve fulfilment effectively. Information sharing positively influenced fulfilment and inventory, but had a less significant effect on responsiveness. This explains why, once the chain members are committed to responsiveness, information sharing practices are expected to automatically take place to facilitate decision synchronisation and incentive alignment. In summary, the findings strongly support the view that the chain members who had higher levels of collaboration practices were able to achieve better operational performance.

Three contributions to research about supply chain collaboration appear from the results of the study. First, the study has developed a reliable and valid instrument to measure the extent of collaboration that incorporates information sharing, decision synchronisation, and incentive alignment. The item statements can be tailored to the specific relationship to gauge the levels of collaboration practices and used to identify the gaps that need to be eliminated. Second, the study shows that there is a significant correlation between collaboration index and operational performance. It is suggested that the chain members build collaborative efforts to seek opportunities to improve overall performance. Third, the study also shows empirical evidence that the three dimensions of collaboration significantly affect fulfilment and inventory performance, though information sharing had only a moderate influence on responsiveness.

Chapter 7
A Conceptual Model for Benchmarking Supply Chain Collaboration

7.1. Introduction

The motivation for supply chain collaboration is to improve overall supply chain performance (Horvath, 2001; Simatupang and Sridharan, 2002). Internal and external metrics are monitored to enable the chain members to assess the progress of performance improvements (Stewart, 1997). An integrated performance system is thus required by all members to facilitate their monitoring of, and response to, actual performance status along the supply chain (Lapide, 2000). This includes a clear linkage between individual and collaborative metrics at different managerial levels because the participating members become committed only if their individual performance is clearly linked to collaborative performance (Lambert and Pohlen, 2001). To ensure that they move on the right track of the best-in-class practice, they need also a collaborative benchmarking that provides ideas of improvement based on comparisons between their collaborative performance against customer and competition requirements (Boyson *et al.*, 1999; Cox *et al.*, 1997; Watson, 1993).

Benchmarking is relevant in studying the supply chain by measuring the company's products, services, and processes and comparing them against the relevant metrics of successful firms (Christopher, 1998). Previous research into supply chain benchmarking shows that it may lead to increased productivity of the supply chain as managers compare their practices to the best in the field. Stewart (1995) reported that Pittiglio, Rabin, Todd and McGrath (PRTM) generated a comprehensive set of fact-based performance measures that can be used to accurately describe a world-class supply chain of planning, sourcing, making, and delivering activities. Their benchmarking scheme covers four areas of performance metrics which are identified as the keys to unlocking supply chain excellence: delivery performance, flexibility and responsiveness, logistics cost, and asset management. This is the first known

study that objectively links best practices employed with relative quantitative performance achievements. Additionally, the study results describe relevant trend information indicating the progress that companies have made towards improving their supply chain operations.

The PRTM's concept of supply chain benchmarking has been extended to the supply chain operations reference (SCOR) model by the Supply Chain Council (Stewart, 1997). The SCOR is the first cross-industry framework for evaluating and improving enterprise-wide supply chain performance and management. It provides standard process definitions, terminology, and metrics that enable companies to benchmark themselves against others and influence future improvement efforts to ensure real progress. The metrics include key areas such as delivery performance, order fulfilment, production flexibility, and cash-to-cash cycle time. By using the SCOR model, Geary and Zonnenberg (2000) reported that the benchmarking study, conducted by the Performance Measurement Group (PMG), showed that the best-in-class supply chain performers were gaining considerable financial and operating advantages over the rest of the respective groups. The top performers had a clear supply chain strategy that was closely aligned with the overall business objective and customer requirements. The best practice can be decomposed into five primary levers to consider: configuration, enabling practices, supply chain network, organisational structure, and information technology architecture. In this survey, PMG examined the best-in-class industry performance of customer-facing measures and internal-facing measures. Customer facing measures, such as upside production flexibility and delivery performance to request, quantify how well a supply chain delivers product to customers. Internal-facing measures, which include total supply chain management cost and cash-to-cash cycle time, portray how effectively an organisation uses resources in creating value for the customer.

Other supply chain benchmarking studies have also attempted to measure supply chain processes and propose ways of identifying and applying ideas for improvements. Gilmour (1999) described a group of benchmark measures based on a set of capabilities, which incorporate process capabilities, information technology capabilities, and organisation capabilities. There are four levels representing a continuum of sophistication for each capability component. Using this benchmarking

136

scheme, the participants were able to identify considerable room for improvement. Hanman (1997) argued that supply chain benchmarking is an improvement technique that considers how others perform a similar activity, task, process or function. By comparing the company's operations with those of other organisations, there is potential to learn and improve performance. The leaders-laggers analysis was used to compare a firm's performance to best practice. The benchmarking network program among participating members was explained as a way of assisting companies to implement improvements. Furthermore, Van Landeghem and Persoons (2001) developed a causal model as a means for identifying initiatives to remedy the performance gap between a given company and the best-in-class performers. This causal model links the use of best practices to the resulting performance. A logistic audit is proposed as a systematic review of logistics performance by using the causal model to explain which best practices are most likely to improve the specific lagging metrics. It thus allows the company to obtain an idea about its rate of use of best practices and its effectiveness based on key metrics.

However, previous research on benchmarking often emphasises internal performance metrics and has paid little attention to the importance of collaborative metrics that have intercompany significance. A new relationship amongst independent but related members in the supply chain requires a novel type of benchmarking (Cox *et al.*, 1997; Gunasekaran, 2002) and is thus a relevant topic for study in relation to collaboration. In addition, traditional benchmarking study often provides ideas on what to improve rather than how and why improvements should be made (Bogan and Callahan, 2001). Since achieving actual performance improvement depends on knowing "how", rather than on "what" metrics to improve, a novel scheme is required to help companies to identify clearly what areas need improvements and provide direction for improvement.

This research aims to conceptualise a benchmarking scheme that assists the chain members to understand the linkage between supply chain performance metrics and possible enablers of performance improvement. The proposed scheme can be used to compare performance not only with the best-in-class practice but also with customer expectations in order to reinvent key levers used to enhance performance. Compared to previous research in benchmarking, this research moves away from the intra-

company level to the intercompany level and thereby provides a novel approach to the study of benchmarking in supply chains.

7.2. Benchmarking Supply Chain Collaboration

Previous research mainly relates to benchmarking schemes for a specific single company as a part of the supply chain. Little attention has been paid to tailoring a benchmarking scheme to supply chain collaboration at the intercompany level. The concept of intercompany level means joint activities by chain members that enable the supply chain to be more responsive to customer demands. Christopher (1998) confirms the fact that supply chain performance depends on the quality of the relationship that extends from upstream to downstream partners. It is thus essential for participating members to call for collaborative benchmarking that enables them to understand the linkage between their collaborative practices and the overall aim of improving supply chain performance as a whole. According to Cox *et al.* (1997), collaborative benchmarking has been viewed as a process for facilitating organisational learning amongst participating members. However, the development of such a collaborative benchmark is still at the infant stage. One of the reasons that might explain this fact is that there is no robust method and performance measurement system that would help participating managers to identify areas that need improvement as well as the magnitude of the improvement needed.

There are two studies that propose collaborative benchmarking for the supply chain (Poirier, 1999; Polese, 2002). Both benchmarking schemes acknowledge the importance of the level of implementation of best practice. According to Davies and Kochhar (2002), representing how companies move forward through sequential stages of the implementation process provides a more realistic scheme for benchmarking study. As regards a benchmarking scheme involving more than one chain member, the study by Poirier (1999) appears to be the first to move towards addressing the need of collaborative benchmarking in the supply chain. He proposed a progressive framework consisting of four levels of supply chain optimisation. The first two levels of progress are internally focused, namely "sourcing and logistics" and "internal excellence". The last two levels (i.e., 'network construction' and 'industry leadership') reflect the collaborative efforts amongst participating members that

improve their value chain constellation in which the effectiveness is measured by the ultimate customers in terms of their purchases and continued loyalty.

Polese (2002), likewise, proposed a maturity model that reflects how companies progress in terms of operational capability. There are four stages in the supply chain maturity model. The first two levels are functional focus and internal integration. Collaboration is the key ingredient to reach stages three (i.e., external integration) and four (i.e., cross enterprise collaboration). Based on the SCOR model, the maturity model can be used to measure fact-based benchmarking for determining best-in-class performance opportunities. The performance gap between internal and external benchmark provide performance targets that can be linked to operational levers. These levers are used to implement the best practice that contributes to the most favorable financial outcomes.

This current research addresses the settlement of three primary issues of supply chain benchmarking. One is the task of assuring that the portfolio of performance metrics helps chain members to continuously improve performance in the same direction of optimising supply chain profitability as a whole from generating sales (Goldratt *et al.*, 2000). Performance metrics should allow the clear linkage between global metrics and individual metrics. This is the issue of the hierarchical nature of performance metrics. Moreover, performance metrics can be time sensitive such as leading or diagnostics metrics, concurrent metrics, and lagging or outcomes metrics (Kaplan and Cooper, 1998). The author therefore proposes a collaborative performance system to facilitate learning amongst the chain members. Another issue relates to the linkage between performance metrics and their enablers that represent actionable underlying drivers of performance. In extending the emerging benchmarking scheme for supply chain collaboration, in this chapter three dimensions of collaborative enablers are proposed to define the operational interfaces amongst the chain members that contribute to supply chain performance. The third issue involves selecting collaborative enablers to meaningfully determine the collaborative efforts relative to best-in-class collaborative supply chains. A framework of benchmarking scheme is proposed to define the linkage between the collaborative performance system and collaborative enablers. The next section presents a collaborative performance system.

139

7.3. Collaborative Performance System

The critical issue in a collaborative relationship is the commitment of participating members to accelerating improvements that contribute to both individual and mutual benefits. Previous research shows that the commitment to improvement amongst chain members is dependent on the selected performance metrics (Caplice and Sheffi, 1995; Gunasekaran et al., 2001; Holmberg, 2000). Performance metrics encourage the participating members to tie improvements to the most profitable customer segments with lowered costs (Geary and Zonnenberg, 2000). The use of key performance indicators to monitor the efficiency and effectiveness of different levels of supply chain operations has been discussed at length by Caplice and Sheffi (1995) and Gunasekaran et al. (2001). However, the performance metrics mainly found in the previous literature are focused internally. Lambert and Pohlen (2001) argued that there is little evidence about the existence of the metrics that span across multiple members along the supply chain. Van Hoek (1998) also lamented the lack of aligned performance metrics that direct participating managers to pay attention to areas requiring improvements.

The main concern in addressing collaborative metrics amongst the participating members is to design appropriate metrics that ensure trustworthiness and accountability (Goldratt et al., 2000). The participating companies also have to ensure the usefulness of the selected portfolio of performance metrics and the performance statistics that are derived from the raw performance data. This means that the portfolio should be readily understandable by decision makers to motivate them to support improvement initiatives that contribute to better customer services and lowered logistics costs as well as providing a guide for action to be taken (Simatupang and Sridharan, 2002; Van Hoek, 1998).

The author proposes a collaborative performance system (CPS) as the learning process by which to achieve key performance results (i.e., operational and financial metrics) and strategic objectives amongst participating members. A CPS is the first step toward developing meaningful supply chain collaboration because it establishes a common language for measuring progress in providing mutual services to end customers and giving the participating members the freedom to rapidly or even

140

immediately improve the supply chain operations as a whole. In this sense, a CPS refers to the process of measuring and facilitating collaborative learning to improve overall performance that stimulates win-win relationships (Garvin, 1993; Hyland and Beckett, 2002; Senge, 1990).
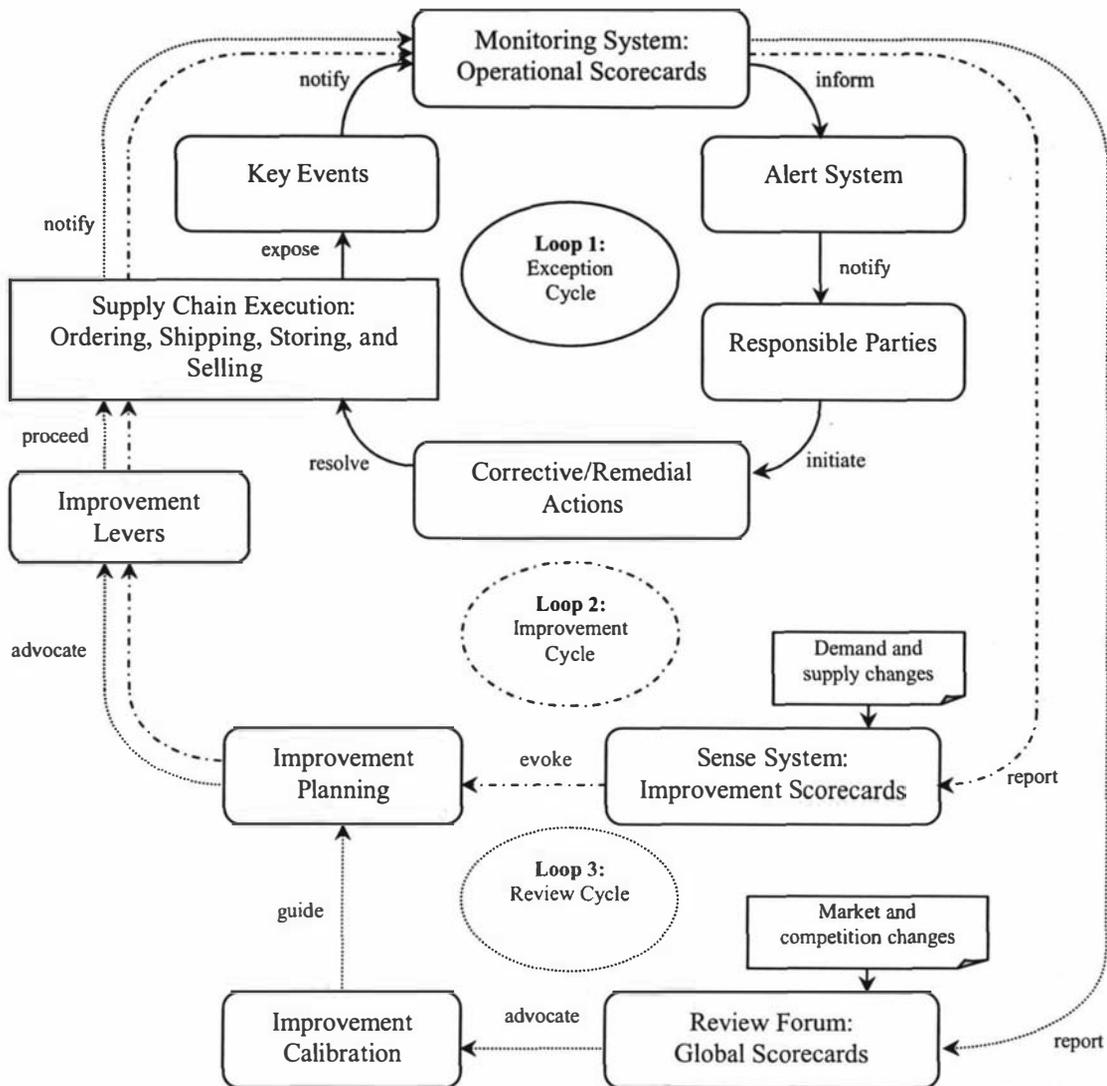

Figure 7.1. A conceptual model for collaborative performance system

A CPS is designed to enable the participating members to define and choose appropriate performance metrics at three different managerial levels relevant to their collaborative efforts. The framework for a CPS thus consists of three dynamic learning cycles (see Figure 7.1), namely, the exception cycle, the improvement cycle, and the review cycle. Each learning cycle helps the chain members to identify an

appropriate set of metrics to examine their supply chain performance at different managerial levels and provides an opportunity to improve supply chain performance. The exception cycle occurs when the chain members act together to provide better mutual rapid response for satisfying customer needs and wants. The improvement cycle takes place when the chain members act together to carry out ongoing improvement initiatives. The review cycle refers to the process of strategy making that guides the improvement cycle.

The three learning cycles are chosen for two reasons. First, performance metrics are hierarchical in nature and time sensitive. Different managerial levels require different types of performance metrics in order to be able to meaningfully assess their actions towards supply chain profitability. Performance metrics can be distinguished also by their timeliness: leading, concurrent, and lagging indicators (Kaplan and Cooper, 1998). Second, a CPS is often developed at different implementation stages reflecting the strength, depth, and maturity of the interfirm relationship (Davies and Kochhar, 2002). Initially, the exception cycle, which contains audits of operational metrics, is typically conducted to improve the supplier's delivery capabilities and the retailer's customer service capabilities. As the relationship expands, participating members become involved in the improvement cycle to agree upon mutual improvement levers that have the potential to enhance mutual benefits. Over time, the improvement cycle increases trust and ongoing achievement of high performance standards. Eventually, participating members establish global scorecards that reflect agreement on strategic objectives and improvement calibration. Table 7.1 provides the detailed attributes of the three collaborative learning cycles.

7.3.1. Exception Cycle

The exception cycle is designed with explicit learning objectives to improve the process of collaborative order fulfillment and at the same time to protect sales from any market changes and supply disruptions along the supply chain. This cycle integrates collaborative planning with supply chain execution. Chain members jointly gather information about their common customers' needs and wants, plan supply chain activities, execute plans, and manage exceptions. Since the supply chain environment is characterised by an increase in customer expectations, ongoing demand spikes, an increase in product variation, and shorter product lifecycles, it is

clear that participating members should adopt the exception cycle to anticipate any change that might occur upstream and downstream of their supply chains before deviations damage customer sales. The exception cycle thus enables chain members to detect deviations from planned supply chain activities and helps them to make better decisions to respond to unplanned events within their supply chains.

Table 7.1. Characteristics of collaborative performance system

Attributes	Collaborative Learning		
	Loop 1: Exception Cycle	Loop 2: Improvement Cycle	Loop 3: Review Cycle
Aim	Controlling supply chain operations for ensuring value creation.	Accelerating the process of value creation.	Recalibrating the improvement target.
Definition	The shared process of mutual response to define and satisfy end customer needs and wants.	The shared process of carrying out ongoing improvement and directing the exception cycle.	The shared process of strategy making for guiding the improvement cycle.
Mechanism	Monitoring key events, diagnostics metrics, and buffer status at the critical points; using a root cause analysis to identify problems; and carrying out corrective actions.	Reflecting from the exception cycle; agreeing upon improvement levers (i.e. acquiring new capabilities); and measuring the impact of levers on concurrent metrics.	Reflecting from the improvement cycle; observing competition environment; monitoring outcomes metrics; and advocating performance target recalibration.
Rationale	Monitoring leading or diagnostics indicators about customer needs, demand changes, and supply disruptions provides anticipatory actions to protect profit.	Learning from the exception experience and focusing on collective improvement levers help in removing conflicting metrics and accelerating the improvement progress.	Recognising the shift of competitive imperative and inertia especially obsolete policies would help in focusing on growth.
Advantage	Creating quick response before disruptions and unplanned events damage total profits.	Continuously redefining performance levers that positively impact supply chain performance and encouraging co-problem solving.	Identifying breakthrough improvement, removing outdated policies, and facilitating co-evaluation of the collaborative progress.
Actors	Intra-functional team and interface team.	Interface team and cross-company managers.	Cross-company managers and executives.
Typical metrics	Operational Scorecards: On-time delivery, product availability, inventory velocity, quality, customer satisfaction, throughput-dollar-days, inventory-dollar-days.	Improvement Scorecards (the half-life curve): Forecast accuracy, responsiveness (e.g., quoted lead times), flexibility, and cash-to-cash cycle.	Global Scorecards: Common (intercompany) scorecards and individual company scorecards such as growth, profits, sales, and inventory turns.
Primary references	Fisher (1997); Goldratt *et al.* (2000); Lapide (2000); Walker (1999)	Farris and Hutchison (2002); Fisher (1997); Garvin (1993); Lapide (2000)	Lambert and Pohlen (2001); Simatupang and Sridharan (2002)

Furthermore, learning occurs when a mismatch between plans and outcomes is identified and is corrected by remedial actions - that is, a mismatch is turned into a match (Senge, 1990). Therefore, the exception loop creates value to supply chain collaboration by developing remedial alternatives and notifying responsible parties to carry out the selected remedial actions in response to unplanned supply chain execution level events.

The exception loop consists of activities starting with monitoring key events of supply chain execution, examining performance deviations, tracking problems, providing alternative remedial actions, notifying responsible parties to resolve problems, and implementing remedial action. As shown in Figure 7.1, the generic components of the exception loop include a monitoring system, an alert system, responsible parties, and corrective actions. A monitoring system observes and records key events of supply chain execution, as well as acquiring relevant data for decision-making. Responsible parties most likely need this relevant data before committing to a remedial action. An alert system provides trends and determines whether or not remedial action is needed. If a performance deviation requires corrective actions, it notifies responsible parties about deviations from planned activities. If a corrective action is needed, responsible parties retrieve information regarding alternatives and conduct risk analysis to select the best remedial action from a list of alternatives. By using a decision support system, participating members will be able to measure the benefits generated by the selected remedial action. After the corrective actions have been carried out, a monitoring system provides an evolving picture of the remedial action being implemented. The loop starts again with a similar pattern.

Performance metrics used in the exception cycle are mainly leading or diagnostics indicators such as delivery performance, inventory velocity, product quality, and product availability. These metrics are used to indicate deviations from delivering the perfect order to end customers during the supply chain execution (Goldratt *et al.*, 2000; Lapide, 2000). At the level of the individual company, the local managers have to make sure customer orders are satisfied and assets are used effectively. The leading metrics provide detailed feedback information to assist local managers to do the best they can and to engage in focusing corrective efforts to improve supply chain

performance (Walker, 1999). Since the metrics indicate the performance of recent activities, the chain members can carry out a root cause analysis of performance gaps based on leading indicators, set an expectation, and monitor their ability to implement remedial actions to achieve this expectation.

As an illustration in a supplier-retailer collaboration, the retailer shares the best forecast about market trends and information about upcoming promotions with its supplier. The supplier shares product planning, production plans, and transportation capabilities. They cooperatively determine the target inventory level at the store. Collaboration between these two parties is based on the fact that as long as the end customer does not buy, no party in the supply chain has sold (Blackstone, 2001; Goldratt *et al.*, 2000). If the retailer requires the supplier's products, this means that the retailer will rapidly move those products to end customers. According to Goldratt *et al.* (2000), a good measure is required to bind each party to be accountable to improve supply chain performance as a whole. They propose the inventory-dollar-days (IDD) as a metric to be used to enable the supplier to judge the retailer's inventory performance. IDD equal the sum of the dollars of inventory times the number of days on hand. The supplier can also offer the same measure to its vendors so they can measure the supplier's inventory performance. On the other hand, the retailer can judge the delivery performance of its suppliers by using the throughput-dollar-days (TDD) that equal the sum of sales dollars times the number of days' delay beyond the agreed due date. The retailer then attempts to reach zero TDD with as few IDD as possible. In the same way, the supplier can use TDD to judge the delivery performance of its vendors. The supplier will be responsible for the results as measured by TDD and IDD. In this way, IDD and TDD are performance metrics that help participating members to have uniformity of accountability. This means that if the retailer wants fast delivery of certain products, the supplier will fulfil this request and is able to judge how rapidly the retailer sells the products. At the same time, the supplier can also require its vendors to provide the same delivery service. This chain of accountability stimulates participating members to improve the mutual response to end customers.

The exception cycle encourages the supplier to replenish products sold by the retailer (Goldratt, 1994). In other words, this pull system synchronises the rate of sales with

the rate of replenishment. What the supplier needs to do is to watch the points of sale at the stores. The supplier will ship whatever the retailer sells. The exception cycle also assists participating members to protect sales (i.e., by eliminating lost sales) if supply disruptions and unplanned events strike during the execution process. For example, if the members know there will be a delivery delay but have adequate lead-time to carry out remedial action, then the cost of remedial action can be minimised. This remedial action is less likely to cause more troubles to other planned supply chain activities because it resolves problems locally before they jeopardise sales. In other words, actual demand can be satisfied without increasing emergency shipping costs. Fisher (1997) advocates that the retailer and the supplier need to collaboratively take advantage of early sales data during the selling season to minimise demand and supply mismatch. The retailer observes and shares demand data with the supplier in a timely manner. The supplier then provides a fast product delivery in order to enable the retailer to fulfil demand during the remaining time of the selling season. Both parties reap the benefits of increased profits from matching supply and demand.

However, operational metrics have three inherent pitfalls. First, once the participating members become accustomed to operational metrics, they are most likely to manipulate numbers to meet expectation. Second, since operational metrics indicate immediate deviations from an original plan, the chain members fail to notice concurrent metrics that would help them to improve their response capability. Third, the dynamic nature of demand and supply conditions causes the location of the supply chain constraint to shift and thereby the leading indicators associated with the constraint also need to be relocated to the new constraint (Goldratt, 1994; McNair and Leibfried, 1992). To overcome these pitfalls, the improvement cycle is required to increase the ability of the chain members to concert their ongoing improvement and direct the exception cycle.

7.3.2. Improvement Cycle

The improvement cycle provides the ability to continuously learn from implementing new capabilities required to improve supply chain performance. Performance gaps can be identified if there is a lack of capability to satisfy customer demand. The chain members observe the supply chain execution and the changing markets to obtain information for improvement ideas. Ideas should be translated to define improvement

levers that can be used to lessen the performance gaps. Improvement levers include mutual capabilities such as accurate response (Fisher, 1997), lean retailing (Abernathy *et al.*, 2000), and ongoing improvement method (Goldratt, 1994) required by the chain members to accelerate the improvement process. Measuring improvement progress indicates how well the interface team is solving problems together with such new capability. Garvin (1993) proposed the half-life curve, originally developed by Analog Devices (Schneiderman, 1988), as a way of measuring improvement progress. A half-life curve measures the time it takes to achieve a fifty per cent improvement in a specified performance metric. This curve can be presented graphically using a logarithmic scale. An improvement metric such as delivery performance, inventory velocity, quoted lead-times, cash-to-cash cycle time, and time-to-market (Farris and Hutchison, 2002; Fisher, 1997; Lapide, 2000) is plotted on the vertical axis and the time scale (e.g., days, weeks, months, quarters) is plotted horizontally. Steeper slopes then represent faster learning. If the participating members take less time to improve supply chain metrics, they must be learning more quickly than their competitors. The same metrics can be used to gauge the impact of acquiring new capabilities on supply chain metrics over time. Moreover, this improvement cycle also assists the chain members to identify and remove conflicting operational metrics and redefine appropriate metrics that motivate them to engage in the exception cycle.

7.3.3. Review Cycle

The review cycle is dedicated to monitoring lagging performance metrics and competition environment that can be analysed to assess and modify collaborative strategy. Lagging performance metrics are measurement of results collected only after an event has occurred – for example, growth, sales, profits, return on investment, cash flows, and inventory turns. These metrics are meaningful for the executives of participating members to track monthly or quarterly progress in achieving mutual strategic objectives (Lambert and Pohlen, 2001). The outcome of this evaluation can be addressing important issues that inhibit the chain members from achieving their mutual objectives, identifying and removing outdated polices, and conducting the continuous recalibration of improvement targets (Neely and Al Najjar, 2002; Simatupang and Sridharan, 2002). New improvement targets are used to translate the strategic objectives into meaningful performance gaps that help to guide the

improvement planning. For example, Dell Computer regularly reviews and displays the intercompany scorecard for all suppliers to see (Dell and Fredman, 1999).

In summary, a CPS is designed to enable the participating members to define and choose appropriate performance metrics at three different managerial levels relevant to their collaborative efforts. However, the implementation of CPS requires collaborative enablers (i.e., information sharing, decision synchronisation, and incentive alignment) that drive the supply chain operations to be performed in the same direction as the overall supply chain goal. The next section discusses the components of collaborative enablers.

7.4. Collaborative Enablers

Traditional benchmarking enables companies to compare their own performance metrics against those of their competitors. This metric-focused benchmarking provides incomplete comparisons as they merely describe performance gaps without explaining why the gaps exist (Bogan and Callahan, 2001). Collaborative benchmarking needs to go beyond metrical benchmarking to the critical process enablers that underlie and drive performance metrics. In this way, performance gaps analysis can provide a real foundation for identifying enablers that contribute to better supply chain performance. Therefore, the participating members should learn how to tie performance metrics to collaborative enablers. The clear linkage between performance metrics and enablers determines what must be changed to eliminate performance gaps.

The author proposes three collaborative enablers to reflect the intensity of operational interfaces amongst the participating members, namely information sharing, decision synchronisation, and incentive alignment (Simatupang and Sridharan, 2005). Collaborative enablers dictate the amount of mutual actions used to drive supply chain performance. Figure 7.2 depicts the linkage between these three collaborative enablers and a collaborative performance system. A collaborative performance system requires information sharing, incentive alignment, and decision synchronisation to facilitate the improvement process. For example, decision synchronisation uses key operational metrics to drive the process of improvement. Information sharing provides visibility

of the performance metrics and process status used to make better decisions. Incentive alignment motivates participating members to make decisions that contribute to the mutual strategic objectives. These three collaborative enablers drive the shared supply chain processes that lead to better supply chain performance. Eventually, actual performance will provide feedback to the collaborative performance system.
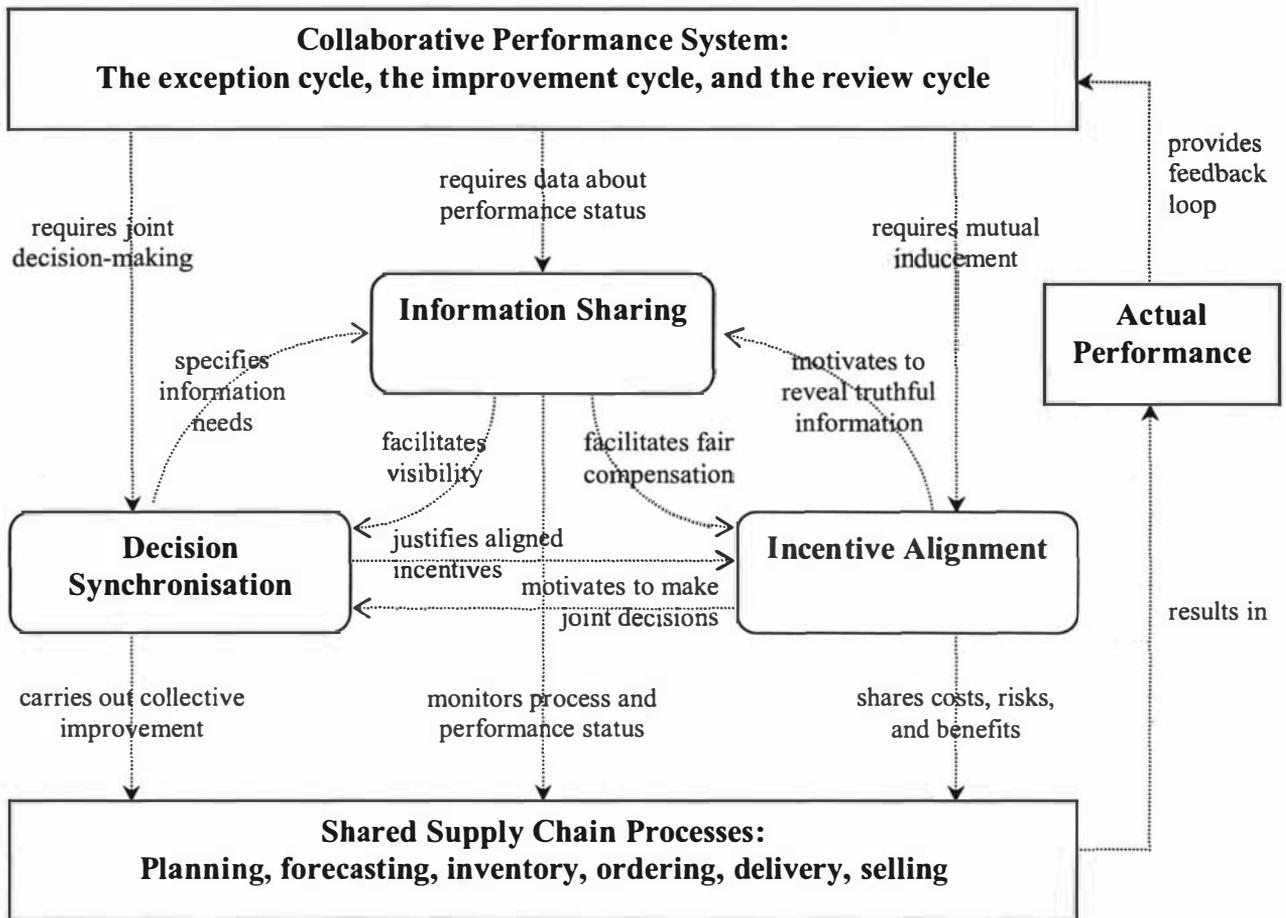

Figure 7.2. The framework for collaborative enablers

7.4.1. Information Sharing

Information sharing refers to the ability to see private data in a partner's systems and monitor the progress of products as they pass through each process in the supply chain (Simatupang and Sridharan, 2005). This activity covers monitoring (data capturing), processing, and dissemination of customer data, end-to-end inventory status and locations, order status, costs-related data, and performance status. Visibility of key performance metrics enables participating members to address production and quality issues more quickly, and thereby permits more agile demand planning to take place.

Information sharing ensures that participating members will be able to make use of shared information to help fulfil demand more quickly with shorter order cycle times. For example, sharing timely promotional information can be used to reduce out of stocks on the store shelves. In addition, delivery lead-time can be reduced because demand visibility substitutes inventory. Information sharing generally facilitates the decision-making process, the collaborative progress assessment, and incentive alignment. For example, demand and inventory visibility can be used to eliminate stock-outs and remove products that are not selling (Fisher, 1997). Several criteria, such as speed, accuracy, timeliness, and reliability, can be used to judge the contribution of information sharing to supply chain integration. Advanced technology such as the Internet can be used to convey up-to-date data about product movements, workflow, costs, and the performance scoreboard.

7.4.2. Decision Synchronisation

Decision synchronisation can be defined as the ability to orchestrate decisions at different managerial levels and time horizons for pursuing the common goal of optimising the supply chain profitability (Simatupang *et al.*, 2002). This activity covers aligning strategic objectives, policies, and metrics amongst the chain members (the review cycle), synchronising mutual improvements (the improvement cycle), and synchronising supply chain planning and execution (the exception cycle).

The way to judge the act of decision synchronisation can be based on the responsiveness of the chain members towards fulfilling customer demands and the effectiveness of joint decisions in enhancing supply chain profitability. Advanced technology such as a decision support system and virtual discussion forum can be used to implement decision synchronisation effectively. For example, the use of an automated alert system in the exception cycle supports mutual response across the supply chain for satisfying customer demands.

7.4.3. Incentive Alignment

Incentive alignment refers to the process of sharing costs, risks, and benefits amongst the participating members (Simatupang and Sridharan, 2005). This scheme motivates the members to act in a manner consistent with the mutual strategic objectives such as

making decisions that are optimal for the overall supply chain and revealing truthful private information. It covers calculating costs, risks, and benefits as well as formulating incentive schemes such as pay-for-performance (Simatupang and Sridharan, 2002). The contribution of incentive alignment can be judged based on compensation fairness and accountability. Compensation fairness ensures that aligned incentives motivate the chain members to share equitably loads and benefits that result from collaborative efforts. An effective incentive scheme means that the chain members are accountable for aligning individual decisions with the mutual objective of improving the total profits. Expert systems, activity-based costing, and web-based technology can be used to trace, calculate, and display incentive scores (Simatupang and Sridharan, 2002).

The three collaborative enablers can be used to measure the level of the best enabling practice. For example, real-time information sharing is expected to drive better performance than piecemeal information sharing. Since supply and demand conditions often change over time, the participating members need to assess the best practice of their collaborative enablers regularly. This necessity leads to the use of internal assessment of collaborative enablers and relating the assessment results to the performance gaps. The next section presents a framework for benchmarking that can be used by participating members to link the internal assessment of collaborative enablers to a benchmark database.

7.5. A conceptual Framework for Benchmarking Collaboration

The participating members involved in supply chain collaboration are not interested only in measuring the status of their collaboration but also in how it can be improved. Benchmarking supply chain collaboration provides a means for them to measure and compare their collaborative efforts against best-in-class performers. This benchmarking process implies the presence of a collaborative process amongst participating companies. Therefore, collaborative benchmarking can be defined as the process of investigating the metrical gaps and associated collaborative enablers that drive performance excellence. This benchmarking is a kind of learning-from-others activity (Cox *et al.*, 1997; Garvin, 1993). The chain members look outside their practice to gain a new perspective from the best-in-class performers (Geary and

Zonnenberg, 2000). To conduct collaborative benchmarking, the chain members need to carry out collaborative audits that aim to describe the collaborative enablers and their contributions to produce superior results. Studying the best practices of collaborative enablers, rather than results only, provides the opportunity to uncover, analyse, and implement the best collaborative relationship.

A framework for collaborative benchmarking in the supply chain is shown in Figure 7.3. It contains three components: internal assessment report, collaborative performance system, and external benchmarking. There are four steps that need to be taken to integrate the three components of collaborative benchmarking. First, the chain members need to conduct an internal assessment to obtain clear understanding about the current collaborative enablers used by the participating members to drive their shared supply chain processes. The internal assessment report portrays the extent to which the participating members use the best-in-class practices of collaborative enablers. Second, the chain members need to monitor their collaborative performance system to assess the current level of collaborative performance. The current levels of performance metrics include operational scorecards (diagnostics metrics), improvement scorecards (concurrent metrics), and global scorecards (outcomes measures). Third, the chain members need to conduct external benchmarking to identify and reveal the current level of best-in-class performance. Fourth, the chain members need to analyse any gap between current performance and best-in-class performance in order to monitor and control the exception process at the exception cycle, drive ongoing improvement at the improvement cycle, and achieve alignment with collaborative strategic objectives at the review cycle.

As depicted in Figure 7.3, the chain members conduct external benchmarking to obtain a benchmarking database collected from surveying customers, competitors, and world-class practices. Surveying customer wants and needs can provide up-to-date product data, quality expectations, competitive comparisons, insight into changing preferences, and immediate feedback about service and pattern of use. The chain members need this customer information at all levels from the executive suite to the retail floor because this information can be used to deduce target levels that need to be met by the chain members (Garvin, 1993). More ambitious targets can be set from benchmarking data that exist in competitor supply chains. These data can be surveyed

152

through the use of consultants. Moreover, the chain members can obtain data about competition requirements from respective trade associations. The ultimate performance target is based on best-in-class benchmarks. However, most of these data are available only inside private companies and access can be very costly. Chain members could employ third party services to conduct a world-class survey as well as to provide a critical analysis of their current supply chain performance.
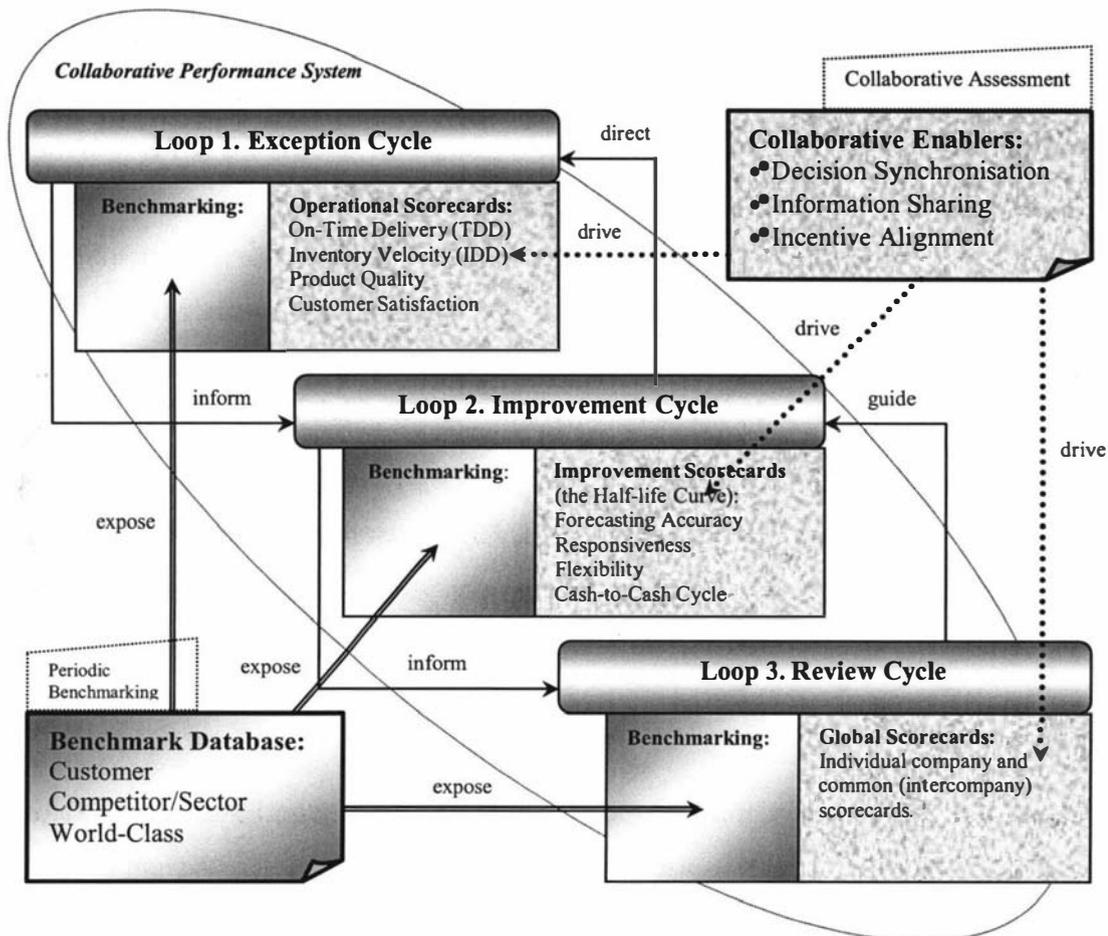

Figure 7.3. A conceptual framework for collaborative benchmarking

The conceptual framework for collaborative benchmarking helps the chain members to choose the performance metrics which are most appropriate to the context of their collaborative arrangements. For example, the exception cycle promotes metrics that span cross-functional supply chain operations such as inventory-dollar-days and throughput-dollar-days (Goldratt *et al.*, 2000). Once participating members agree on appropriate performance metrics, they will be able to compare the current level of their collaborative performance with benchmarking data in order to identify any

153

performance gaps at the three managerial levels. First, the review cycle adopts outcomes metrics that align with the mutual strategic objectives. In this way, the chain members are able to create integrated metrics rather than maintain functional-cost-oriented metrics that are often achieved at the expense of another member (Simatupang and Sridharan, 2002). Second, the improvement cycle helps to focus on learning capability, such as responsiveness and flexibility, required to improve performance. Third, the exception cycle can be used to improve the execution level by adopting new operational metrics necessary to ensure rapid response to customer needs. Any performance gaps at these three managerial levels provide a list of improvement initiatives. Chain members deduce from the internal assessment report which will enable them to prioritise improvement initiatives on the list. Some thinking tools, such as thinking process (Goldratt, 1994), systems dynamics (Senge, 1990), and the causal model (Van Landeghem and Persoons, 2001), can be used to justify and select the most effective enablers to support improvement initiatives. In doing this, the participating members are able to translate initiatives into required enablers used to drive supply chain processes in achieving performance excellence.

The real value of collaborative benchmarking lies in addressing problems that prevent participating members from responding effectively to customer needs. Otherwise, collaborative benchmarking can fall into implementing best practices which are good only in the other supply chains' circumstances and thereby it fails to address actual problems inside the supply chain. Collaborative benchmarking therefore requires mutual inquiry and actions to find where performance gaps are and how they should be bridged or filled. The process of mutual inquiry is a way of providing significantly different perspectives to explore improvement ideas and create better practices that work for their supply chain's circumstances. In this sense, collaborative benchmarking not only identifies performance gaps relative to competitors but also encourages the chain members to find and solve core problems that inhibit them from improving the overall performance.

Goldratt (1994), for instance, provides a generic inquiry process that consists of identifying problems, finding effective solutions, and implementing the solutions. In this sense, a collaborative performance system can be seen as the way of implementing the proposed solution at the three learning loops. The exception cycle

helps the members to concentrate on ways to improve rapid response to customer needs and wants. The improvement cycle enables the chain members to debate the current practice of the exception loop and define improvement levers that they should choose. The review cycle covers approaches on the appropriateness of improvement directions by asking, why this target and/or that lever. By combining these three learning cycles, the chain members will be able to focus improvement process and remove outdated policies and conflicting metrics that lead to counterproductive behaviour.

7.6. Concluding Remarks

This chapter has provided an extension of the benchmarking scheme for supply chain collaboration that incorporates the collaborative performance system and collaborative enablers. The collaborative performance system has been proposed to outline interactions among performance metrics ranging from diagnostics metrics and concurrent metrics to outcomes metrics. These metrics are important to enable the chain members to evaluate progress and measure the value of collaboration. The framework also provides the way to choose an appropriate set of metrics to guide decision-making and align metrics with mutual strategic objectives. It addresses primarily three important learning issues. First, the exception cycle aims to protect value creation for generating sales through mutual rapid response. Generic activities of this cycle include monitoring key events and operational scorecards, examining performance deviations, tracking problems and building alternative remedial actions, and notifying responsible parties to carry out remedial actions. Second, the improvement cycle assesses ongoing improvement levers. Third, the review cycle examines the changing competitive environment, the progress of achieving strategic objectives, and interorganisational policies. The hierarchic evaluation of the three learning cycles brings opportunities to conduct global benchmarks for mutual improvement.

Collaborative enablers assist the chain members to examine the current enabling practices that drive performance metrics. There are three collaborative enablers proposed in this chapter, namely decision synchronisation, information sharing, and incentive alignment. The chain members use these three enablers to identify enabling

practice deficiency and design new levels of enablers. Finally, collaborative benchmarking has been proposed to outline the mechanism of linking best enabling practices to the performance gaps. This benchmarking scheme helps the chain members to determine the levels of performance they plan to achieve and the means by which to achieve them. This benchmarking scheme serves to answer the question of how companies can move to more scientifically managed supply chain practices and to improved performance through assessing collaborative enabling practices, measuring competitors and best-in-class performers, and measuring customer expectations. Therefore, collaborative benchmarking addresses not only the questions "how do we compare to others?" but also that of "what areas need to be improved?"

Compared to the previous research in benchmarking that focused mainly on the intra-company level, this study promotes a benchmarking scheme at the intercompany level, which involves joint activities of the participating members in improving their supply chain processes. The basic argument is that supply chain benchmarking should address the intercompany level activities that incorporate collaborative enablers and collaborative performance metrics in order to allow the chain members to achieve better supply chain performance as a whole. The contribution of this study thus could provide some very useful managerial insights into the evaluation and improvement of collaborative practices in the supply chain that involves more than one company. The extension of this study is presented in Chapter 8 that provides an empirical study to investigate collaborative practices.

Chapter 8
Benchmarking Supply Chain Collaboration:
An Empirical Study

8.1. Introduction

Supply chain collaboration requires a reasonable amount of effort from all participating members to ensure the attainment of potential benefits (Barratt and Oliveira, 2001; Corbett *et al.*, 1999). The chain members also search for better practices and ideas through benchmarking their current collaborative practices to other collaborative supply chains. Benchmarking provides them with opportunities to identify excellent standards in processes and performance and make necessary improvements to match or exceed these standards. However, previous study on supply chain collaboration has paid little attention to conceptualising prominent collaborative practices that help the chain members to understand performance drivers. The focus is usually on internal business practices from a single company's perspective (Basnet *et al.*, 2003; Knuckey *et al.*, 2002). A novel type of benchmarking is required for supply chain collaboration because the chain members are concerned with both performance drivers and targets (Gunasekaran, 2002). As a consequence, it is crucial to carry out a benchmarking study that identifies collaborative practices that contribute to performance improvements. This makes it relevant to study benchmarking in supply chain collaboration.

The advent of supply chain collaboration shifts the focus of benchmarking from a single company level to an interorganisational level (Simatupang and Sridharan, 2004a). Several research surveys have shown, for example, that the core of supply chain management is the improvement process at the interorganisational level (Boyson *et al.*, 1999; Kopczak, 1997; Stank *et al.*, 1999). According to Stewart (1995), a best-in-class supply chain was characterised by the best achievement of both internal-facing measures and customer-facing measures. Christopher (1998) also argued that supply chain benchmarking includes joint practices and achievements of

the chain members in the supply chain. Stewart (1997) provided the development of the supply chain operations reference (SCOR) model as the first cross-industry framework for evaluating and improving extended supply chain performance. Geary and Zonnenberg (2000) employed the SCOR model to show that the best-in-class performers gained considerable financial and operating advantages over the rest of the respective groups. By using system-wide revenues and costs, Ramdas and Spekman (2000) examined collaborative practices between high performers among innovative-product supply chains and high performers among functional-product supply chains.

As companies move toward closer arrangements with their partners, they become involved in the progressive process of collaboration (Mentzer *et al.*, 2000a). Poirier (1999) proposed a progressive framework consisting of four levels of supply chain optimisation. The first two levels of progress are internally focused, namely "sourcing and logistics" and "internal excellence". The last two levels, "network construction" and "industry leadership", reflect the collaborative efforts amongst participating members that improve their value chain constellation in which the effectiveness is measured by the ultimate customers in terms of their purchases and continued loyalty. In a similar vein, Polese (2002) developed a supply chain maturity model that reflects how companies progress in terms of operational capability. There are four stages in the supply chain maturity model. The first two levels are functional focus and internal integration. Collaboration is the key ingredient to reach stages three (i.e., external integration) and four (i.e., cross-enterprise collaboration). In conjunction with the SCOR model, the maturity model can be used to measure fact-based benchmarking for determining best-in-class performance opportunities. Most recently, Simatupang and Sridharan (2004a) have recommended an integrated benchmarking scheme for supply chain collaboration that consists of enabling practices and a collaborative performance system.

Given the importance of sharing the best practices, the objective of this chapter is to compare the collaborative practices between suppliers and retailers. As discussed at length in Chapter 7, the concept of collaboration consists of three dimensions, namely information sharing, decision synchronisation, and incentive alignment. Research instruments were developed around this conceptualisation. Data were sought from a sample of New Zealand companies. The survey results provide benchmarking data on

the profile of collaborative practices and operational performance. This research promotes interorganisational benchmarking rather than a focus on a single company and thereby provides a significant contribution to the study of benchmarking in supply chains.

8.2. Conceptual Model

Supply chain collaboration implies that the chain members become involved in coordinating activities that span boundaries of their organisations in order to fulfil end customer needs (Bowersox, 1990). This collaboration shifts the focus of supply chain management away from simply looking at the four walls of the individual member to how the chain members interact with each other to create an agile supply chain which contributes to competitive advantage. There are three key assumptions underlying the study of supply chain collaboration. First, the supply chain performance is explained by how the chain members manage across their boundaries. Previous studies provide empirical evidence that support this first assumption (Bowersox, 1990; Lee *et al.*, 1997; Spekman *et al.*, 1998; Stank *et al.*, 1999). Second, the key to effective supply chain collaboration depends on the careful selection of the levels of coordination structure that drive supply chain performance (Simatupang and Sridharan, 2004a). The chain members need to choose interorganisational design variables that mostly contribute to overall performance. Previous literature recommends that the chain members need to design the supply chain strategy that fits to various levels of demand uncertainties (Fisher, 1997; Lee *et al.*, 1997). Third, interorganisational settings across boundaries of the chain members change over time because of competitive and environmental changes.

Based on these assumptions, this research thus attempts to explore the relationship between drivers of collaboration and supply chain performance. The primary task prior to data collection is to develop a conceptual model (Cavana *et al.*, 2001). The conceptual model offered in this chapter was developed in two stages. The first stage is a theoretical development as presented in Chapter 4. The result of this stage indicates that supply chain collaboration can be characterised by five elements including appropriate performance system, information sharing, decision

159

synchronisation, incentive alignment, and streamlined intercompany business processes (see Figure 4.2 in page 77).

The three dimensions of information sharing, decision synchronisation, and incentive alignment constitute the structure of coordination that can be designed at different levels by the participating members. The second stage is to incorporate the conceptualisation of collaboration into the benchmarking study as presented in Chapter 7. This stage provides a comprehensive view of linking collaborative enablers to supply chain performance. It is hypothesised that the three enablers of collaboration, namely information sharing, decision synchronisation, and incentive alignment, are required to facilitate the chain members engaging in a cross-organisational cooperation that enables them to realise better overall performance.

8.3. Research Method

A survey was conducted to assess the level of collaboration practice and its impact on performance. The research method has been discussed at length in Chapter 5. The survey instrument was developed which included conceptualisation, itemisation, pilot test, purification, and validation. Chapter 6 has showed that the instrument for this benchmarking study is reliable and valid.

Appendix C contains a complete statistical analysis pertaining to benchmarking supply chain collaboration.

8.4. Findings

This section presents findings from the survey that can be summarised into reasons for collaboration, patterns of collaborative achievement, and comparisons of collaborative practices between low and high performers.

8.4.1. Reasons for Collaboration

Respondents varied in reasons for collaboration. There were ten top reasons for respondents to establish close supplier-retailer relationships, in order of importance:

- increasing sales (80%)
- ensuring on-time delivery (76%)

- lowering inventory costs (74%)
- reducing out-of-stock (72%)
- creating accurate forecasts (53%)
- better return-on-investment (50%)
- reducing obsolete inventory (49%)
- reducing lost sales (49%)
- cutting order cycle time (42%)
- increasing market shares (34%)
- and reducing markdowns (32%).

Retailers were more concerned with out-of-stock, on-time delivery, sales, and inventory. On the other hand, suppliers focused on sales, on-time delivery, inventory, and accurate forecast. It appears that sales, on-time delivery, and inventory costs were the three top reasons for respondents to initiate collaboration.

8.4.2. Patterns of Collaborative Achievement

The achievement of collaborative relationship refers to the extent to which the chain members implement the collaborative practice that contributes to better performance. The distribution profile of the collaborative practice versus performance indicates to what extent the chain members realise the benefits of collaboration. To assess the position of each respondent in the profile, a collaboration index was developed in Chapter 6 as an average of the scores of three dimensions of collaboration. Similarly, the performance index represents the average of fulfilment, inventory, and responsiveness. The profile of collaboration index versus performance index shows how the collaborative practice contributes to the achievement of performance.

The correlations between the three dimensions of collaboration and performance criteria are significant at the 0.01 level. Information sharing correlated with fulfilment at 0.83, inventory at 0.58, and responsiveness at 0.56. Decision synchronisation had a 0.66 coefficient correlation with fulfilment, 0.66 with inventory, and 0.52 with responsiveness. Incentive alignment correlated with fulfilment at 0.56, inventory at 0.71, and responsiveness at 0.64. All correlations were significant at the 1% level. Furthermore, the result of analysis of variance showed that respondents who had a high collaboration index (more than 3) outperformed respondents with a lower collaboration index in terms of their performance index. This finding confirmed that

respondents who have a higher degree of the collaboration practice were able to attain better performance.

As shown in Figure 6.2 (page 126), a scatter graph indicates a distribution of results on the collaboration index and performance index. Interestingly, the correlation between the collaboration index and the performance index was 0.85 and significant at the 1% level. The coefficient of determination was 0.736, which indicates that the collaboration index accounted for 74% in the variation of performance index.

Based on the collaboration index and performance index, four types of collaboration can be identified as shown in Figure 8.1, namely synergistic, efficient, prospective, and underrating. Figure 8.2 shows the original scatter plot where the respondents in each of the four types are identified. A relatively large number of respondents truly achieved synergistic collaboration, a very small number had the potential to achieve this status, a small number had developed efficient collaboration, and another large group lagged behind in the race to achieve synergistic collaboration. This profile suggests that a large number of companies are attempting to develop their collaboration relationship and those who developed a high degree of collaboration were successful in attaining a higher level of performance.

		Collaboration Index	
		Low	*High*
Performance Index	*High*	Efficient Collaboration (maintain and extend)	Synergistic Collaboration (harvest and sustain)
	Low	Underrating Collaboration (develop and reengineer)	Prospective Collaboration (improve and leverage)

Figure 8.1. The collaboration-performance profiles

Synergistic collaboration: 23 respondents, or about 30%, from the survey reached the high mark on both the collaboration index and performance index (i.e. the score of 3 for both indexes is a cut-off point for the high mark). These companies have adopted a

162

range of best collaborative practices, resulting in a high level of operational performance.
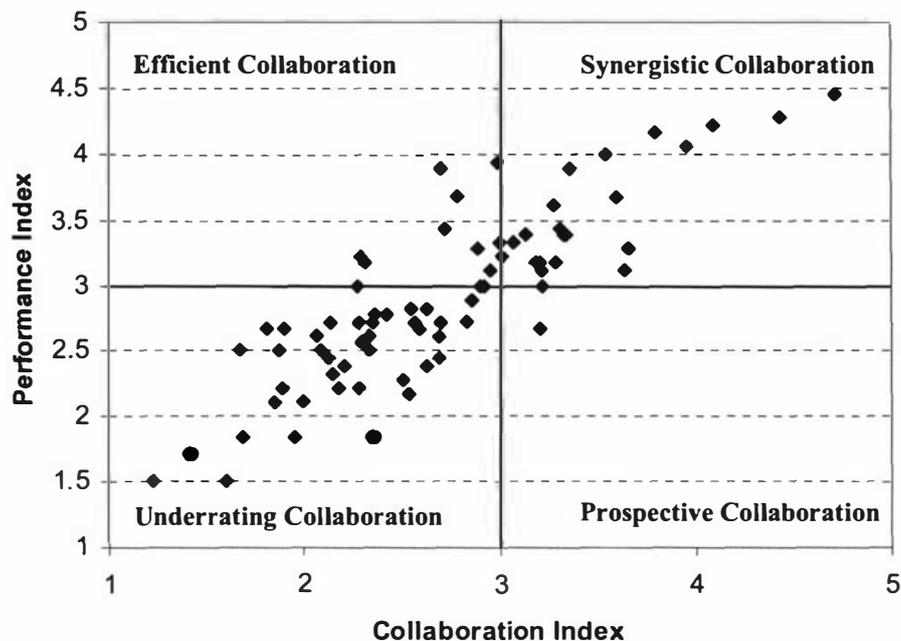

Figure 8.2. The four types of collaboration

Efficient collaboration: The results for this category were more disappointing: 14% (11 companies) reached a high level of performance with respect to collaboration. These respondents seem to have strong performance scores, but are vulnerable because they have achieved these without having established strong collaborative practices. This suggests that these respondents will be able to move into the synergistic collaboration category with some maintenance and extensions.

Prospective collaboration: In this group, only 3% (2 companies) of the sample have developed a strong set of collaborative practices, but are not yet attaining better operational performance. These respondents could expect to improve their performance in the future. They need to transfer the high level attained on the collaborative index into better operational results through learning acceleration and continuous improvement.

Underrating collaboration: 53% of respondents (40 companies) occupy the lowest position on both the collaboration index and the performance index compared to other respondents. These companies seem to be in an unfavourable position, but they have the potential to identify their shortcomings and develop collaborative practices to move to the category of synergistic collaboration.

8.4.3. Comparisons of Low and High Performers

This section attempts to benchmark the collaborative practices that drive high performance. The responses were listed in ascending order according to their ranking on the performance index. The respondents with an index of more than 3 were classified as high performers and those with an index below 3 as low performers. Statistical tests showed that the score 3 was a significant cut-off value for differentiating low and high performers ($p < .01$). This classification enabled one to compare the collaborative practices of high performers with those of low performers. Collaborative practices in the areas of information sharing, decision synchronisation, and incentive alignment were compared between low and high operational performers as follows.

The differences in means in the practice of information sharing, decision synchronisation, and incentive alignment between high and low performers are shown in Tables 8.1 to 8.3. The mean difference of collaborative practice was the mean of high performers minus low performers under different operational performance criteria. The t-test of equality of means was used to check the significance of the mean differences of collaborative practices between low and high performers.

As shown in Table 8.1, the high performers practised all types of data sharing compared to low performers in attaining fulfilment performance, except on order status. This indicated that the sample shared data on order status evenly regardless of low or high fulfilment performance. Order status appeared as a common requirement for respondents in order fulfilment. Both suppliers and retailers placed similar importance on data exchanges concerning promotional events, demand forecasts, POS, price changes, inventory costs, inventory levels, inventory policy, supply disruptions, and delivery schedules.

164

In the case of inventory performance, high performers had greater reliance on sharing data about promotional events, demand forecasts, POS, price changes, inventory costs, and inventory levels. Among these practices, high performing suppliers placed more importance on sharing promotional plans, demand forecasts, and POS. This indicated that suppliers needed these data to enable them to deploy inventory. Furthermore, retailers with high inventory performance exchanged more data on inventory costs and inventory policy. These two data are important for determining ordering decisions, which minimised inventory levels. Finally, both suppliers and retailers with high performance exchanged more data on price changes and inventory levels compared to low performers. Both types of respondents appeared to agree on the importance of data on price and inventory levels in managing inventory.

Table 8.1. Differences in means in the use of information sharing practices between high and low performers

Information Sharing Practices	Performance Criteria								
	Fulfilment			Inventory			Responsiveness		
	S	R	A	S	R	A	S	R	A
1. On promotional events.	1.35 ***	1.07 ***	1.13 ***	1.22 ***	.47 -	.91 ***	.87 **	.86 ***	.88 ***
2. On demand forecasts.	1.64 ***	1.39 ***	1.60 ***	.58 *	-.17 -	.55 **	.49 -	.68 **	.65 **
3. On points-of-sale (POS).	1.25 **	1.61 ***	1.46 ***	1.07 **	.05 -	.86 ***	1.32 **	1.04 ***	1.23 ***
4. On price changes.	1.34 **	1.02 ***	.98 ***	1.01 **	1.05 **	.87 ***	1.28 **	.53 -	.88 ***
5. On inventory costs.	.87 ***	.99 **	1.13 ***	.42 -	1.08 **	.91 ***	.84 **	.75 *	.86 ***
6. On inventory levels.	1.56 ***	.67 *	1.26 ***	.86 **	1.03 **	1.06 ***	.69 *	.38 -	.59 **
7. On inventory policy.	1.06 ***	.87 **	.95 ***	-.24 -	.87 *	.27 -	.59 -	.86 **	.76 ***
8. On supply disruptions.	.78 **	.68 **	.76 ***	.51 -	.42 -	.54 -	.72 **	.20 -	.48 **
9. On order status.	.47 -	-.08 -	.38 -	.17 -	-.31 -	.17 -	.50 -	.47 -	.52 *
10. On delivery schedules.	.73 *	.62 *	.79 ***	.64 -	.45 -	-.30 -	.45 -	.46 -	.49 *

Note: S = supplier, R = retailer, A = aggregate, * $p < .10$, two-tailed test; ** $p < .05$, two-tailed test, *** $p < .01$, two-tailed test, - Not statistically significant.

In terms of responsiveness, the sample with high responsiveness significantly carried out all information sharing practices (see the responsiveness column in Table 8.1). Table 8.1 also shows that retailers with high responsiveness emphasised exchanges on demand forecasts and inventory policy to create better responsiveness. Suppliers with high responsiveness relied on data about price changes and supply disruptions. Both

types of respondents with high responsiveness seemed to practise data exchanges on promotional events, POS, and inventory costs in order to enable them to improve responsiveness.

Table 8.2 shows differences in means in the practices of decision synchronisation between high performers and low performers. The respondents with high fulfilment performance conducted all decision synchronisation practices significantly compared to low performers. Suppliers with high fulfilment performance were keen to practise joint decisions on product planning, safety stock requirements, and resolution on order exceptions. This indicated that upstream members were more concerned with cooperating on the supply side to ensure reliable fulfilment. On the other hand, retailers with high fulfilment performance carried out joint decisions on order quantity, which help them to attain better fulfilment. Both types of respondents agreed on the importance of joint decisions on promotional events, demand forecasts, forecast exceptions, pricing policy, and availability targets.

Table 8.2. Differences in means in the use of decision synchronisation practices between high and low performers

Decision Synchronisation Practices	Performance Criteria								
	Fulfilment			Inventory			Responsiveness		
	S	R	A	S	R	A	S	R	A
1. Joint plan on product assortment.	1.44 ***	.31 -	.85 ***	.62 -	-.28 -	.28 -	.43 -	.21 -	.22 -
2. Joint plan on promotional events.	1.04 ***	.68 *	.81 ***	1.14 ***	.59 -	.82 ***	1.00 **	.68 *	.73 ***
3. Joint development of demand forecast.	1.17 ***	.73 **	1.17 ***	.56 *	.98 **	.88 ***	.76 **	.84 ***	.86 ***
4. Joint resolution on forecast exceptions.	.88 ***	.94 ***	1.05 ***	.54 *	.72 *	.75 ***	.81 **	.95 ***	.95 ***
5. Consultation on pricing policy.	.84 *	.68 *	.58 **	1.15 ***	.66 -	.87 ***	.62 -	.26 -	.44 -
6. Joint decision on availability level.	1.01 **	.68 *	.92 ***	.40 -	.89 *	.57 **	1.08 ***	1.00 ***	1.08 ***
7. Joint decision on safety stock requirements.	.91 **	.42 -	.78 ***	.86 ***	1.37 ***	1.13 ***	.91 **	.31 -	.57 **
8. Joint decision on optimal order quantity.	.45 -	.73 *	.58 **	.71 **	1.42 ***	1.03 ***	.49 -	.42 -	.34 -
9. Joint resolution on order exceptions.	.68 *	.42 -	.82 ***	.65 *	.73 *	.82 ***	1.14 ***	.31 -	.65 ***

Note: S denotes supplier, R denotes retailer, A denotes aggregate, * $p < .10$, two-tailed test; ** $p < .05$, two-tailed test, *** $p < .01$, two-tailed test, - Not statistically significant.

In the case of inventory performance, high performers conducted all decision synchronisation practices significantly compared to low performers except for joint

planning on product assortment. Suppliers with high inventory performance placed more emphasis on co-promotional plans and consultation on pricing policy, whereas retailers with high inventory performance significantly made joint decisions on availability target to reduce inventory levels. It appeared that retailers were interested in serving end customers better with respect to availability. Joint development of demand forecasts, joint resolution on forecast exceptions, joint decisions on safety stock requirements, joint decisions on optimal order quantity, and joint resolutions on order exceptions were outlined as most important for both types of respondents.

In terms of responsiveness, there were significant differences between high and low performers on promotional plans, demand forecasts, demand exceptions, availability targets, safety stock requirements, and order exceptions for creating a high level of responsiveness. However, the sample had no preferences on joint decisions on product planning, pricing policy, and optimal order quantity. Suppliers with a high level of responsiveness were seen to be more cooperative with regard to safety stock requirements and resolution on order exceptions. These practices appeared to enable suppliers to improve responsiveness because they knew the target service level and how to handle order exceptions. Both types of respondents appeared to agree on the importance of joint decisions on promotional events, demand forecasts, forecast exceptions, and availability targets.

Table 8.3 shows differences in means in the practices of incentive alignment between high performers and low performers. Overall, respondents emphasised the importance of joint promotional efforts, shared saving on lowered inventory costs, allowance for product defects, subsidies for markdowns, and order flexibility in their efforts to improve fulfilment. Retailers placed more emphasis on subsidies for markdowns. It appeared that retailers need risk sharing due to the decline in retail prices. On the other hand, suppliers were more concerned about shared savings from lowered inventory, delivery guarantee for a peak demand, and allowance for product defects. This indicated that suppliers carefully developed their supply capability for creating better fulfilment.

High performers carried out all incentive alignment practices to attain better inventory performance. As in the case of fulfilment, suppliers emphasise arrangements on

shared saving on reduced inventory costs, delivery guarantee on peak demand, and allowance for product defects to improve inventory performance. However, retailers placed importance on joint promotional efforts, subsidies for markdowns, and order flexibility in their efforts to reduce inventory; these practices were considered to be important by suppliers as well.

Table 8.3. Differences in means in the use of incentive alignment practices between high and low performers

| Incentive Alignment Practices | Performance Criteria | | | | | | | | |
| | Fulfilment | | | Inventory | | | Responsiveness | | |
	S	R	A	S	R	A	S	R	A
1. Joint frequent shopper programs (co-promotions).	1.78 ***	1.46 ***	1.45 ***	1.17 ***	1.64 ***	1.24 ***	1.28 **	.92 **	1.10 ***
2. Shared saving on reduced inventory costs.	1.28 ***	.11 -	.83 ***	.89 **	.69 -	.88 ***	1.56 ***	.35 -	.96 ***
3. Delivery guarantee for a peak demand.	.53 *	.28 -	.28 -	1.02 ***	.15 -	.54 **	.75 **	-.09 -	.29 -
4. Substitution for product defects.	.96 **	.36 -	.56 *	1.28 ***	.58 -	.86 **	1.12 **	.66 -	.87 ***
5. Subsidies for retail price markdowns.	.76 -	.71 *	.57 *	1.57 ***	.91 *	1.11 ***	1.19 **	.53 -	.83 **
6. Agreements on order changes.	.88 **	.76 **	.85 ***	.54 **	.56 *	.62 ***	.52 -	1.03 ***	.81 ***

Note: S = supplier, R = retailer, A = aggregate, * $p < .10$, two-tailed test; ** $p < .05$, two-tailed test, *** $p < .01$, two-tailed test, - Not statistically significant.

In terms of responsiveness, high performers significantly carried out all incentive alignment practices to attain high responsiveness - except for delivery guarantee. However, suppliers significantly conducted arrangements on shared savings of lowered inventory costs, delivery guarantee on peak demand, allowance for product defects, and subsidies for retail price markdowns to improve responsiveness. It appeared that suppliers considered markdowns in their efforts to improve responsiveness in reacting to demand changes. Retailers put emphasis on order flexibility for increasing responsiveness. This indicated that they required flexibility to respond to demand changes.

8.5. Managerial Implications

Supply chain collaboration has increasingly gained popularity in recent years as companies have sought new ways to improve operational performance. It appears that suppliers and retailers will continue to actively develop close collaborative efforts to effectively meet customer needs. This research confirmed that supply chain collaboration enables the chain members to attain better performance. It thus has

important managerial implications. First, the concept of supply chain collaboration helps to explain how chain members with strong collaboration are often able to gain better performance than their competitors. These chain members are quite willing to develop collaborative practices in information sharing, decision synchronisation, and incentive alignment to improve fulfilment, inventory, and responsiveness. However, the chain members need to modify and tailor the items of collaborative practice that suit their unique circumstances and to conduct regular surveys to provide up-to-date benchmarking data because of changes in a competitive environment.

Second, the scatter plot (see Figure 8.2) shows that companies differed in their relative position both in the collaboration index and in the performance index. Four collaboration-performance profiles were identified: efficient, underrating, prospective, and synergistic. This finding implies that the use of a scatter plot enables the chain members to recognise their profile and assess the performance of their collaborative efforts. They need to respond to an unfavourable profile by finding ways to reach a favourable position such as identifying which practices need attention for further improvement.

Third, the research highlights the items of collaborative practice that drive operational performance. Suppliers and retailers differed in the degrees of importance they accorded to collaborative practices that differentiate between high and low performance. For example, suppliers were more concerned with the upstream side of the supply chain. This implies that a company needs to understand the differing priorities of the various members of the supply chain. The reality is that collaborative efforts add costs and bring benefits differently to the chain members. Therefore, benchmarking data enables the chain members to understand each other's concerns and find effective solutions that benefit all parties.

Finally, the research emphasises the importance of collaborative efforts in attaining better performance. This benchmarking study showed that there are different expectations of outcomes from collaborative practices amongst the chain members (i.e., suppliers and retailers). To increase the probability of acceptance, suppliers do not create collaborative efforts in isolation but only after intimate discussion with their retailers. They need to share concerns in order to clearly set objectives and

devise plans to achieve those objectives. Management from both parties must put together an integrated strategy in order to initiate improvement in specific collaborative practices. Improving collaborative practices would lead to better performance in fulfilment, lowered inventory, and responsiveness.

8.6. Concluding Remarks

This chapter provided a benchmarking study on supply chain collaboration that incorporated conceptualisation of supply chain collaboration and survey results. Supply chain collaboration was characterised into three dimensions, namely information sharing, decision synchronisation, and incentive alignment. It is argued that the three dimensions contribute to the attainment of better operational performance. Survey instruments were developed based on this concept and sent to a sample of New Zealand companies. There were 76 valid responses, which provided a 21% response rate. The survey results indicated that sales, on-time delivery, and inventory reductions were the top three reasons for establishing collaboration.

A collaboration index was introduced to represent the level of collaborative practices in information sharing, decision synchronisation, and incentive alignment. A correlation analysis confirmed that a higher level of collaboration index means a higher level of operational performance. This suggests that respondents who had a higher collaboration index were able to achieve better operational performance. Furthermore, based on the collaboration index and performance index, this study identified four profiles of collaboration: efficient, underrating, prospective, and synergistic. This profile provides benchmark data for practitioners to identify their collaboration positions on the scatter plot.

The chapter also empirically showed the benchmarking data on the collaborative practices that differentiate between high and low performers. These practices can be seen as enablers for creating better operational performance. Overall, respondents perceived the importance of information sharing with regards to promotions, demand forecasts, POS, price changes, inventory costs, inventory levels, inventory policy, supply disruptions, order status, and delivery schedules to improve responsiveness. When becoming involved in decision synchronisation, suppliers were more concerned

170

with the supply side of the chain such as product assortment, joint plan on promotional events, safety stock requirements, and order exceptions. A similar conclusion also occurred with suppliers who placed emphasis on shared incentives, were more concerned with upstream improvements of the chain such as reduced inventory costs, reduced product defects, and delivery guarantee during peak demand. This finding demonstrates that the best practices of collaboration have different degrees of importance perceived by suppliers and retailers in attaining better operational performance. There is plenty of room for improving opportunities if the chain members share concerns and see the complementary effect of the three dimensions of collaboration. It therefore makes more sense to consider all three dimensions when creating a collaborative relationship.

Chapter 9
Conclusions and Future Research

9.1. Introduction

Previous research testimonies suggest that supply chain collaboration is crucial in determining the performance of a firm (Dyer and Ouchi, 1993; Geary and Zonnenberg, 2000; Spekman *et al.*, 1998). Collaboration between the chain members in the supply chain enables them not only to improve overall performance but also to set new standards of competition. Supply chain collaboration has also shifted the paradigm of cooperation from antagonistic bargaining only over price to synergistic problem solving to improve the overall revenues and reduce the total costs of the supply chain. All participating members benefit from this collaboration.

However, despite its importance, little attention has been given to identifying the significant elements of supply chain collaboration which can used to leverage overall performance. Decisions made about these elements as drivers of improvements influence not only current performance, but also subsequent performance. A study of multiple elements of collaboration is warranted, in order to identify important drivers that could be designed and implemented by the chain members to improve overall performance of their supply chains. Such research would enhance the understanding of supply chain collaboration at both the conceptual and empirical levels.

The main purpose of this thesis was to offer an integrative framework that explicitly recognised the multiple elements of collaboration. The development of this framework would allow a better understanding of the strategic importance of these elements and what needs be done to realise the potential benefits of collaboration. This purpose was achieved by addressing the following objectives: (i) to develop an integrative framework that explains the important characteristics of supply chain collaboration, (ii) to carry out an empirical study that examines the relationship between the practice of supply chain collaboration and operational performance, (iii)

to develop and test the scales used to measure the concept of supply chain collaboration, and (iv) to explain important practices that differentiate between high and low performers of supply chain collaboration.

In this chapter, the main conclusions from the study are summarised and implications from the research for practitioners and the discipline are discussed. Conclusions are organised according to the research questions discussed in the introductory chapter. The generalisation of research findings is reviewed and areas for potential future research are identified.

9.2. Research Conclusions

The results of the study support the idea that the investigation of interorganisational settings across the boundaries of the chain members is best suited to explain supply chain collaboration. This is because overall performance is determined not only by an individual company's actions, but also by those of other supply chain members. In addition, an integrative framework as proposed in this study accounts well for important key elements of collaboration. As such, supply chain collaboration can be thought of as an evolving process involving different instruments to improve overall performance. The following paragraphs present the main findings of this research.

The first research question was stated as: "What are the important key elements of supply chain collaboration that represent the governance of interorganisational boundaries between the chain members?" This question was examined using the three steps of research: a literature review, the discontent model, and a conceptualisation. The literature review constructed a taxonomy of research on supply chain collaboration and confirmed the paucity of research in considering the interaction between different focuses of supply chain collaboration. The discontent model described multiple sources of discontent that prevent the chain members from attaining better performance. Lastly, the conceptualisation was conducted to build an integrative framework that consists of five key elements of supply chain collaboration: (1) the structure of a collaborative performance system to evaluate the performance of individuals and the overall supply chain, (2) the structure of decision synchronisation to assign joint decision making, (3) the structure of information

sharing to facilitate planning and execution of supply chain operations, (4) the schemes of incentive alignment to structure rewards and penalties, and (5) streamlined intercompany business processes to effectively meet customer needs at minimal cost.

It is argued that successful collaborations synchronise decision making in such a way that members' decision-making rights are linked with the necessary information sharing for making productive decisions. The chain members also need to ensure that the collaborative performance system enables the chain members to make and implement value-increasing decisions and to provide decision makers with appropriate incentives to motivate them to support the improvement of the supply chain performance as a whole.

The second research question was stated as: "Is there a relationship between the practice of supply chain collaboration and operational performance?" This question was examined using a hypothesis-testing approach between the practice of supply chain collaboration and operational performance. Results showed that information sharing, decision synchronisation, and incentive alignment significantly contributed to fulfilment performance. Information sharing and decision synchronisation consistently affected fulfilment, inventory, and responsiveness performance. This research also confirmed that performance monitoring moderated incentive alignment to have a positive effect on inventory and responsiveness performance.

The third research question was stated as: "How should the extent of supply chain collaboration be measured?" It was necessary to develop an instrument to assess the extent of supply chain collaboration. The concept of supply chain collaboration was characterised into three dimensions that act as enabling factors, namely information sharing, decision synchronisation, and incentive alignment. The instruments were developed and the questionnaire was sent out to a sample of New Zealand companies. The survey results showed that the instruments achieve adequate levels of reliability and validity. Furthermore, analysis of variance showed that each of the three dimensions had an influence on operational performance. This confirmed the concurrent validity of the instrument.

The fourth research question was stated as: "How could one benchmark supply chain practice?" This question was examined using a benchmarking study approach to assess what collaborative practices account for performance differences. In order to examine the difference in the performance index scores, the respondents were divided into high- and low- performing collaborators based upon the performance data. The mean of the performance scores was used to separate high-performing collaborators from low-performing collaborators, the high-performing collaborators scored 3 or higher, while the low-performing collaborators scored lower than 3. A t-test was used to see if the collaborative practice scores were different between the high-performing collaborators and low-performing collaborators. Findings showed differences in the best practices between of high- and low-performing collaborators that lead to better performance. The t-test results also indicated various collaborative practices that led to better performance.

9.3. Implications of the Findings

This study has a number of implications. First, a taxonomy offered in this study provides insight into the relationship between different research streams that have previously appeared in the literature of supply chain collaboration and thereby suggests a more holistic approach to the review of the study of supply chain collaboration. Researchers have tended to recognise different types of collaborative instruments, but largely in isolation. The taxonomy chapter provides a better understanding of the range of research streams that focus on specific instruments in supply chain collaboration and a set of research opportunities. This new perspective helps the practitioners and academics to consider multiple instruments - including information systems, business processes, performance systems, and incentive schemes - in supply chain collaboration while studying and implementing collaboration.

Second, the study makes the important contribution that there are discontent factors which can arise amongst the chain members when their collaborative efforts do not achieve their expected potential benefits. The discontent model argues that the chain members have a responsibility to identify and eliminate multiple sources of supply chain discontent that prevent them from achieving better performance. Being highly involved in collaboration does not automatically lead to better performance because

176

there is always a need for resolution of interorganisational settings when two or more companies develop collaboration. It is clear from the discontent model that multiple sources of discontent exist across the interorganisational boundaries of the chain members. They include incongruent strategic objectives, disintegrated performance systems, information asymmetry, misaligned incentives, and fragmented intercompany business processes. The chain members should engage in identifying these sources of discontent in order to be able to pursue mutual solutions that benefit all members. This has important implications for supply chain managers and consultants i.e.: if they collaborate to gain better performance, then they also need to share responsibility in identifying and mitigating sources of supply chain discontent.

Third, an integrative framework offered in this research also challenges the conventional wisdom that relies on the unilateral approach that focuses on a single element of collaboration such as information sharing or process improvements. The framework, in contrast, suggests the reciprocal approach to explain interactions between the five elements of collaboration. These five elements are related to each other and can be used to leverage supply chain performance. This finding implies that practitioners do need to consider not only the five elements of collaboration but also the interactions amongst them because changes in one element will affect how other elements contribute to overall performance.

Fourth, the study provides insight into the relationship between the practice of supply chain collaboration and operational performance. The findings suggest that information sharing, decision synchronisation, and incentive alignment are important determinants of operational performance and indicate that practitioners need to consider these three dimensions of collaboration in an attempt to improve operational performance. They also need to establish performance monitoring to ensure the functionality of incentive alignment.

Fifth, the study also has important implications for scale development in that it provides a reliable and valid instrument to measure the extent of collaboration that incorporates information sharing, decision synchronisation, and incentive alignment. Practitioners can adopt and modify the scale to gauge their collaborative efforts.

Sixth, the benchmarking study in this research showed that there are different expectations from collaborative practices amongst the chain members. To increase the probability of acceptance, suppliers should not create collaborative efforts in isolation but only after discussion with their retailers. They need to share concerns in order to clearly set objectives and devise plans to achieve those objectives. This finding suggests that the chain members should put together an integrated strategy in order to initiate improvement in specific collaborative practices. Improving collaborative practices in an integrated way would lead to better operational performance in order fulfilment, lowered inventory, and responsiveness.

9.4. Future Research

Several directions for future research are identified as follows. First, the current research focuses on the five elements of supply chain collaboration. Future research is necessary to investigate antecedent variables (Mentzer *et al.*, 2000a) including contingency variables such as uncertainty, power, collaborative readiness, and the top management commitment.

Second, in collaboration settings someone needs to give direction to the transformation process. Basically the question is, "who will provide the leadership that is needed?" (Andraski, 1998; Sherman, 1998). It cannot be expected that there is a natural tendency of the chain members to align their actions in such a way that they will cooperate smoothly to realise collaborative advantage. Collaborative leaders initiate collaboration by bringing the right partners together and ensuring that the process is sustained. Without forcing their perspective on the collaborative process they keep it going and progressing toward common shared goals. Collaborative leaders such as Wal-Mart, HP, and Dell indicate the importance of leadership posture in managing supply chain collaboration (Lee *et al.*, 1997). Future research is required to examine the role of collaborative leaders in initiating and implementing the process of supply chain collaboration especially to understand changes required by the participating members to realise the benefits of collaboration.

Third, future research is required to develop an implementation support model for supply chain collaboration. Supply chain collaboration becomes necessary for

capturing the value of supply chain management. The process of implementation of supply chain collaboration has received little attention in the literature. Christopher (1998) identified the fact that supply chain collaboration requires different levels of commitment from top management and managers. It is a collaborative effort of data gathering, data discussion, action planning and action between the chain members and those who have to enact it. Collaborative teams who represent the participating members have to learn to view change as an ongoing process necessary to remain at the cutting edge in meeting customer needs (Christopher, 1998). Ancona *et al.* (2002) argue that externally oriented teams were associated with positive results across a wide variety of industries. Therefore, it is recommended to develop an implementation support model to help collaborative teams to understand relevant factors that reinforce the success of implementation. They could use this model to help them to plan and monitor the progress of collaboration over time.

The fourth opportunity for future research is designing incentive alignment models for supply chain collaboration. Supply chain collaboration often brings benefits for all participating parties. However, differences in cost and revenue structures make it difficult to fairly share the costs and benefits of collaboration (Lee *et al.*, 1997). This research should aim to design different schemes for incentive alignment for collaborative relationships between retailers and suppliers. Specifically, the focus is on finding incentive schemes for different collaborative scenarios that motivate all members to improve overall performance of the chain whilst benefiting all members.

Fifth, although multiple items were used in the benchmarking study, the operationalisation of the three dimensions and performance criteria can be expanded based on focus groups or case studies. For example, information sharing in this study was limited to operational data. New items can be generated to include exchanges of financial data, market data, and other costs related data. Performance criteria can also be extended to incorporate the financial impacts of collaboration. Some of these issues could be addressed in future research on supply chain collaboration.

A sixth direction for future research relates to quantifying the value of supply chain collaboration. Supply chain collaboration is necessary in the age of globalisation and the constant pressure for cost effectiveness. The benefits of collaboration should

exceed the costs of implementing the collaboration plan. However, the chain members often do not know whether or not their collaborative efforts pay off (Grey *et al.*, 2003; Kaplan and Norton, 2002). The question is thus how the chain members can quantify and monitor the benefits and costs of supply chain collaboration over time. This research aim would be to develop practical models for quantifying the value of supply chain collaboration.

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Appendix A

Statistical Analysis for An Empirical Study of Supply Chain Collaboration

NONRESPONSE BIAS TEST

As recommended by Armstrong and Overton (1977), the author assesses potential non-response bias through an extrapolation method by comparing early (first two third) versus late (last third) respondents. These tests showed no significant differences between these groups (i.e., information sharing: $F_{(1,74)} = 1.212$, n.s.; decision synchronisation: $F_{(1,74)} = 1.278$, n.s.; incentive alignment: $F_{(1,74)} = 0.068$, n.s.; fulfilment: $F_{(1,74)} = 1.276$, n.s.; inventory: $F_{(1,74)} = 2.265$, n.s.; and responsiveness: $F_{(1,74)} = 1.833$, n.s.). This suggests that the data is unlikely to be tainted by non-response bias.

Between IS early and IS late

Descriptives

IS

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	45	3.1333	.89918	.13404	2.8632	3.4035	1.25	4.75
2	31	3.3629	.88468	.15889	3.0384	3.6874	1.25	5.00
Total	76	3.2270	.89459	.10262	3.0226	3.4314	1.25	5.00

ANOVA

IS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.967	1	.967	1.212	.274
Within Groups	59.055	74	.798		
Total	60.022	75			

Between DS early and DS late

Descriptives

DS

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	45	2.0389	.80120	.11944	1.7982	2.2796	1.00	4.50
2	31	2.2661	.94193	.16918	1.9206	2.6116	1.00	4.75
Total	76	2.1316	.86263	.09895	1.9345	2.3287	1.00	4.75

ANOVA
DS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.948	1	.948	1.278	.262
Within Groups	54.861	74	.741		
Total	55.809	75			

Between IA early and IA late

Descriptives
IA

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	45	3.3778	.71633	.10678	3.1626	3.5930	1.50	5.00
2	31	3.3306	.85729	.15397	3.0162	3.6451	1.50	4.75
Total	76	3.3586	.77172	.08852	3.1822	3.5349	1.50	5.00

ANOVA
IA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.041	1	.041	.068	.796
Within Groups	44.626	74	.603		
Total	44.667	75			

Between FULFILMENT early and FULFILMENT late

Descriptives
FULFIL

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	45	2.9716	.66213	.09871	2.7726	3.1705	1.67	5.00
2	31	3.1506	.70383	.12641	2.8925	3.4088	1.67	4.67
Total	76	3.0446	.68059	.07807	2.8891	3.2001	1.67	5.00

ANOVA
FULFIL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.589	1	.589	1.276	.262
Within Groups	34.152	74	.462		
Total	34.740	75			

Between INVENTORY early and INVENTORY late

Descriptives
INVENT

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	45	2.4889	.69486	.10358	2.2801	2.6976	1.50	4.50
2	31	2.7903	.88293	.15858	2.4665	3.1142	1.50	4.50
Total	76	2.6118	.78570	.09013	2.4323	2.7914	1.50	4.50

ANOVA
INVENT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.668	1	1.668	2.765	.101
Within Groups	44.632	74	.603		
Total	46.299	75			

Between RESPONSIVENESS early and RESPONSIVENESS late

Descriptives
RESPONSE

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	45	2.5111	.80120	.11944	2.2704	2.7518	1.50	4.50
2	31	2.7581	.75134	.13495	2.4825	3.0337	1.50	4.50
Total	76	2.6118	.78570	.09013	2.4323	2.7914	1.50	4.50

ANOVA
RESPONSE

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.119	1	1.119	1.833	.180
Within Groups	45.180	74	.611		
Total	46.299	75			

FACTOR ANALYSIS

Factor analysis is a body of techniques concerned with the study of interrelationships among a set of variables, none of which is given the special status of a criterion variable. In this study the purpose of factor analysis is to confirm the factors or constructs that underlie the observed variables (Hair *et al.*, 1998). There are three factors based on the concept of collaboration: information sharing, decision synchronisation, and incentive alignment. Besides confirming these dimensions (convergent validity), factor analysis also indicates discriminant validity (Guinan *et al.*, 1998). Factor loading indicates the correlation between a variable and a factor. Low level of factor loading between a factor and its non-associated variables indicates discriminant validity.

Total Variance Explained

Component	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.377	42.510	42.510	6.377	42.510	42.510	3.759	25.058	25.058
2	1.689	11.261	53.771	1.689	11.261	53.771	3.073	20.485	45.543
3	1.308	8.718	62.488	1.308	8.718	62.488	2.542	16.945	62.488
4	.992	6.616	69.105						
5	.778	5.190	74.294						
6	.706	4.709	79.003						
7	.540	3.598	82.601						
8	.448	2.989	85.590						
9	.431	2.871	88.460						
10	.411	2.740	91.200						
11	.362	2.414	93.614						
12	.292	1.950	95.563						
13	.281	1.877	97.440						
14	.199	1.329	98.769						
15	.185	1.231	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix

	Component		
	1	2	3
DS3	.830	-.162	-5.692E-02
DS2	.799	9.353E-02	.120
IA3	.771	-.165	-.160
DS4	.755	-7.294E-02	-.294
IS3	.729	-.131	-.218
IS5	.695	-.394	.265
DS5	.666	5.749E-02	-.387
IS2	.649	-8.781E-03	.327
DS1	.619	6.501E-02	-.474
IS4	.605	-.337	.509
IA5	.582	.392	.448
IA2	.544	.520	1.763E-02
IS1	.535	-.452	-4.730E-02
IA1	.325	.600	-.212
IA4	.479	.583	.268

Extraction Method: Principal Component Analysis.
a 3 components extracted.

Rotated Component Matrix

	Component		
	1	2	3
DS1	.757	1.369E-02	.197
DS4	.742	.278	.186
DS5	.729	.101	.234
IS3	.678	.341	.145
IA3	.670	.419	.149
DS3	.638	.520	.205
IS4	.103	.846	.108
IS5	.347	.767	3.311E-02
IS2	.220	.590	.361
IS1	.463	.499	-.170
DS2	.458	.492	.459
IA4	6.758E-02	.163	.781
IA5	3.684E-02	.434	.709
IA2	.298	6.752E-02	.688
IA1	.299	-.247	.600

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 8 iterations.

RELIABILITY TEST

Reliability is the degree to which measures are free from error and therefore yield consistent rules (Peter, 1979). The following test concerns the homogeneity of the measure. An attempt to measure an attitude may require asking several similar (but not identical) questions or presenting a battery of scale items. To measure the internal consistency of a multiple-item measure, scores on subsets of the items within the scale

are correlated. Coefficient alpha provides a measure of intercorrelations that exist among a set of items. Alpha is calculated as:

$$\alpha = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum_{i=1}^{k}\sigma_i^2}{\sigma_t^2}\right)$$

where

k = number of items in the scale,

σ_i^2 = variance of scores on item i across subjects, and

σ_t^2 = variance of total scores across subjects where the total score for each respondent represents the sum of the individual item scores.

DECISION SYNCHRONIZATION

R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

Reliability Coefficients

N of Cases =   76.0   N of Items = 4

Alpha =   .8163

INFORMATION SHARING

R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

Reliability Coefficients

N of Cases =   76.0   N of Items = 4

Alpha =   .7676

INCENTIVE ALIGNMENT

R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

Reliability Coefficients

N of Cases =   76.0   N of Items = 4

Alpha =   .7105

PERFORMANCE MEASURES

FULFILMENT PERFORMANCE

```
R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

Reliability Coefficients

N of Cases =      76.0                  N of Items =  3

Alpha =    .7655
```

INVENTORY PERFORMANCE

```
R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

Reliability Coefficients

N of Cases =      76.0                  N of Items =  3

Alpha =    .8315
```

RESPONSIVENESS PERFORMANCE

```
R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

Reliability Coefficients

N of Cases =      76.0                  N of Items =  2

Alpha =    .7065
```

REGRESSION ANALYSIS

Regression analysis is used to describe the extent, direction, and strength of the relationship between several independent variables and a continuous dependent variable. In this study, regression analysis is to characterise between operational performance (i.e., fulfilment, inventory, and responsiveness) and the variables information sharing (IS), decision synchronisation (DS), and incentive alignment (IA)

by determining the extent, direction, and strength of the association. The regression equation with these three predictor variables is $Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$, where Y is the criterion variable (i.e., operational performance) and X_1 (i.e., information sharing), X_2 (i.e., decision synchronisation), X_3 (i.e., incentive alignment) are the predictor variables, β_i is the partial regression coefficient, and ε is the error associated with the prediction of Y when X_1, X_2, and X_3 are the predictor variables.

Three simplifying assumptions are made about the error term: the mean or average value of the disturbance term is zero, the variance of the disturbance term is constant and is independent of the values of the predictor variable, and the values of the error term are independent of one another. The multiple regression also requires the additional assumption that the predictor variables are not correlated among themselves. Multicollinearity is said to be present in a multiple-regression problem when the predictor variables are correlated among themselves. Factor analysis was used to eliminate the effect of multicollinearity. The residual plot that involves the residuals versus the predicted dependent values was used to test the normality of the error term distribution. Furthermore, three tests were conducted for the individual independent variables to confirm the three assumptions of linearity, constant variance, and normality. First, scatter plots of the individual independent variables did not indicate nonlinear relationships between information sharing (IS), decision synchronisation (DS), incentive alignment (IA), and performance monitoring (PM) and operational performance. Second, tests for heteroscedacity did not find any variable violating the assumption of constant variance. Finally, the tests of normality using the Kolmogorov D statistics, skewness, and kurtosis did not find any variable violating the assumption of normality.

Fulfilment Performance

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	IA, IS, DS	.	Enter

a All requested variables entered.
b Dependent Variable: FULFILMENT

Correlations

		FULFILMENT	IS	DS	IA
Pearson Correlation	FULFILMENT	1.000	.589	.736	.532
	IS	.589	1.000	.588	.319
	DS	.736	.588	1.000	.473
	IA	.532	.319	.473	1.000
Sig. (1-tailed)	FULFILMENT	.	.000	.000	.000
	IS	.000	.	.000	.003
	DS	.000	.000	.	.000
	IA	.000	.003	.000	.
N	FULFILMENT	76	76	76	76
	IS	76	76	76	76
	DS	76	76	76	76
	IA	76	76	76	76

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.786	.618	.602	.42922

a Predictors: (Constant), IA, IS, DS

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21.478	3	7.159	38.862	.000
	Residual	13.264	72	.184		
	Total	34.743	75			

a Predictors: (Constant), IA, IS, DS
b Dependent Variable: FULFILMENT

Coefficients

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	.987	.254		3.889	.000
	IS	.171	.069	.225	2.499	.015
	DS	.392	.077	.496	5.116	.000
	IA	.199	.073	.226	2.729	.008

a Dependent Variable: FULFILMENT

Inventory Performance

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	IA, IS, DS	.	Enter

a All requested variables entered.
b Dependent Variable: INVENT

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.746	.556	.537	.58895

a Predictors: (Constant), IA, IS, DS

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	31.252	3	10.417	30.033	.000
	Residual	24.974	72	.347		
	Total	56.227	75			

a Predictors: (Constant), IA, IS, DS
b Dependent Variable: INVENT

Coefficients

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	1.016	.348		2.918	.005
	IS	.473	.094	.489	5.025	.000
	DS	.381	.105	.380	3.629	.001
	IA	-8.607E-02	.100	-.077	-.859	.393

a Dependent Variable: INVENT

Responsiveness Performance

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	IA, IS, DS	.	Enter

a All requested variables entered.
b Dependent Variable: RESPONSE

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.597	.356	.329	.64356

a Predictors: (Constant), IA, IS, DS

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.479	3	5.493	13.263	.000
	Residual	29.820	72	.414		
	Total	46.299	75			

a Predictors: (Constant), IA, IS, DS
b Dependent Variable: RESPONSE

Coefficients

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	1.003	.380		2.637	.010
	IS	.175	.103	.199	1.699	.094
	DS	.385	.115	.423	3.354	.001
	IA	6.681E-02	.109	.066	.610	.544

a Dependent Variable: RESPONSE

MODERATED REGRESSION ANALYSIS

Moderated regression analysis was used in the study for the purpose of determining whether the hypothesised moderator variable, performance monitoring, did in fact moderate the relationship between information sharing, decision synchronisation, and incentive alignment and operational performance.

Sharma *et al.* (1981) describe moderated regression analysis (MRA) as an "analytic approach which maintains the integrity of a sample yet provides a basis for controlling the effects of a moderator variable". They discuss the application of MRA in terms of one predictor variable, as follows. Three regression equations should be examined for equality of regression coefficients:

(1) $y = a + b_1x$

(2) $y = a + b_1x + b_2z$

(3) $y = a + b_1x + b_2z + b_3xz$

where y is the criterion variable, x is the predictor variable, and z is the possible moderator variable.

If equations (2) and (3) are not significantly different (i.e., $b_3 = 0$, $b_2 \neq 0$), z is not a moderator, but simply an independent predictor variable. For z to be a pure moderator variable, equations (1) and (2) should not be different from equation (3) (i.e., $b_2 = 0$, $b_3 \neq 0$). For z to be classified as a quasi moderator, equations (1), (2), and (3) should be different from each other (i.e., $b_2 \neq b_3 \neq 0$).

Fulfillment Performance

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	IAM, DS, IA, IS, DSM, ISM	.	Enter

a All requested variables entered.
b Dependent Variable: FULFIL

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21.491	6	3.582	18.651	.000
	Residual	13.251	69	.192		
	Total	34.743	75			

a Predictors: (Constant), IAM, DS, IA, IS, DSM, ISM
b Dependent Variable: FULFIL

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.973	.312		3.122	.003
	IS	.148	.265	.195	.559	.578
	DS	.470	.316	.596	1.489	.141
	IA	.183	.254	.207	.720	.474
	ISM	8.946E-03	.094	.069	.095	.924
	DSM	-2.355E-02	.092	-.141	-.256	.799
	IAM	4.289E-03	.086	.026	.050	.960

a Dependent Variable: FULFIL

Inventory Performance

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	IAM, DS, IA, IS, DSM, ISM	.	Enter

a All requested variables entered.
b Dependent Variable: INVENT

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	34.023	6	5.670	17.621	.000
	Residual	22.204	69	.322		
	Total	56.227	75			

a Predictors: (Constant), IAM, DS, IA, IS, DSM, ISM
b Dependent Variable: INVENT

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.527	.403		3.785	.000
	IS	.573	.342	.592	1.672	.099
	DS	.769	.409	.766	1.880	.064
	IA	-.772	.329	-.688	-2.350	.022
	ISM	-9.991E-02	.121	-.606	-.824	.413
	DSM	-.119	.119	-.563	-1.003	.319
	IAM	.241	.111	1.157	2.175	.033

a Dependent Variable: INVENT

Responsiveness Performance

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	IAM, DS, IA, IS, DSM, ISM	.	Enter

a All requested variables entered.
b Dependent Variable: RESPONSE

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.628	.394	.342	.63746

a Predictors: (Constant), IAM, DS, IA, IS, DSM, ISM

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.261	6	3.043	7.490	.000
	Residual	28.039	69	.406		
	Total	46.299	75			

a Predictors: (Constant), IAM, DS, IA, IS, DSM, ISM
b Dependent Variable: RESPONSE

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.429	.453		3.152	.002
	IS	.408	.385	.464	1.060	.293
	DS	.583	.459	.640	1.268	.209
	IA	-.560	.369	-.550	-1.517	.134
	ISM	-.133	.136	-.891	-.978	.331
	DSM	-6.024E-02	.134	-.313	-.450	.654
	IAM	.222	.125	1.175	1.783	.079

a Dependent Variable: RESPONSE

Appendix B

**Statistical Analysis for the Collaboration Index:
Measuring Supply Chain Collaboration**

NONRESPONSE BIAS TEST

As recommended by Armstrong and Overton (1977), the author assesses potential non-response bias through an extrapolation method by comparing early (first two third) versus late (last third) respondents. These tests showed no significant differences between these groups (i.e., information sharing: $F_{(1,74)} = 1.165$, n.s.; decision synchronisation: $F_{(1,74)} = 1.598$, n.s.; incentive alignment: $F_{(1,74)} = 0.204$, n.s.; fulfilment: $F_{(1,74)} = 1.276$, n.s.; inventory: $F_{(1,74)} = 2.265$, n.s.; and responsiveness: $F_{(1,74)} = 1.833$, n.s.). This suggests that the data is unlikely to be tainted by non-response bias.

Between IS early and IS late

Descriptives

ISB

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	45	2.8800	.70762	.10549	2.6674	3.0926	1.50	5.00
2	31	3.0645	.76748	.13784	2.7830	3.3460	1.40	4.70
Total	76	2.9553	.73328	.08411	2.7877	3.1228	1.40	5.00

ANOVA

ISB

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.625	1	.625	1.165	.284
Within Groups	39.703	74	.537		
Total	40.328	75			

Between DS early and DS late

Descriptives

DSB

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	46	2.4855	.81021	.11946	2.2449	2.7261	1.11	4.44
2	30	2.7222	.77846	.14213	2.4315	3.0129	1.11	4.78
Total	76	2.5789	.80109	.09189	2.3959	2.7620	1.11	4.78

ANOVA

DSB

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.017	1	1.017	1.598	.210
Within Groups	47.114	74	.637		
Total	48.131	75			

Between IA early and IA late

Descriptives
IAB

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	46	2.5326	.79940	.11786	2.2952	2.7700	1.33	4.33
2	30	2.6167	.78069	.14253	2.3252	2.9082	1.17	4.67
Total	76	2.5658	.78791	.09038	2.3857	2.7458	1.17	4.67

ANOVA
IAB

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.128	1	.128	.204	.652
Within Groups	46.432	74	.627		
Total	46.560	75			

Between FULFILMENT early and FULFILMENT late

Descriptives
FULFIL

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	45	2.9716	.66213	.09871	2.7726	3.1705	1.67	5.00
2	31	3.1506	.70383	.12641	2.8925	3.4088	1.67	4.67
Total	76	3.0446	.68059	.07807	2.8891	3.2001	1.67	5.00

ANOVA
FULFIL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.589	1	.589	1.276	.262
Within Groups	34.152	74	.462		
Total	34.740	75			

Between INVENTORY early and INVENTORY late

Descriptives
INVENT

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	45	2.4889	.69486	.10358	2.2801	2.6976	1.50	4.50
2	31	2.7903	.88293	.15858	2.4665	3.1142	1.50	4.50
Total	76	2.6118	.78570	.09013	2.4323	2.7914	1.50	4.50

ANOVA
INVENT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.668	1	1.668	2.765	.101
Within Groups	44.632	74	.603		
Total	46.299	75			

Between RESPONSIVENESS early and RESPONSIVENESS late

Descriptives
RESPONSE

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	45	2.5111	.80120	.11944	2.2704	2.7518	1.50	4.50
2	31	2.7581	.75134	.13495	2.4825	3.0337	1.50	4.50
Total	76	2.6118	.78570	.09013	2.4323	2.7914	1.50	4.50

ANOVA
RESPONSE

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.119	1	1.119	1.833	.180
Within Groups	45.180	74	.611		
Total	46.299	75			

RELIABILITY TEST

Reliability is the degree to which measures are free from error and therefore yield consistent rules (Peter, 1979). The following test concerns the homogeneity of the measure. An attempt to measure an attitude may require asking several similar (but not identical) questions or presenting a battery of scale items. To measure the internal consistency of a multiple-item measure, scores on subsets of the items within the scale are correlated. Coefficient alpha provides a measure of intercorrelations that exist among a set of items. Alpha is calculated as:

$$\alpha = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum_{i=1}^{k}\sigma_i^2}{\sigma_t^2}\right)$$

214

where

k = number of items in the scale,

σ_i^2 = variance of scores on item i across subjects, and

σ_t^2 = variance of total scores across subjects where the total score for each respondent represents the sum of the individual item scores.

DECISION SYNCHRONIZATION

R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item- Total Correlation	Alpha if Item Deleted
Q12	20.2105	44.4884	.4514	.8848
Q13	19.8684	41.9291	.5789	.8753
Q14	20.6053	40.8021	.7326	.8623
Q15	20.7632	41.6765	.6586	.8684
Q16	21.2763	40.7626	.6593	.8682
Q17	20.8421	41.1747	.6664	.8676
Q18	21.2237	40.1493	.7507	.8603
Q20	20.6974	41.4405	.5927	.8743
Q21	20.1974	42.6139	.6016	.8731

Reliability Coefficients
N of Cases =   76.0   N of Items =   9
Alpha =   .8834

INFORMATION SHARING

R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)
Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item- Total Correlation	Alpha if Item Deleted
Q28	25.2105	47.0484	.5790	.8410
Q29	26.0000	44.6933	.6828	.8315
Q30	26.3553	44.8188	.5745	.8412
Q31	26.8684	46.8091	.4998	.8475
Q32	27.0263	44.9060	.6873	.8314
Q33	26.4079	43.2047	.7277	.8265
Q34	26.0658	45.4756	.6527	.8345
Q35	25.4474	48.9439	.4810	.8486
Q36	25.5395	49.1851	.3223	.8636
Q37	25.2500	47.3633	.4499	.8521

Reliability Coefficients
N of Cases =   76.0   N of Items = 10
Alpha =   .8557

INCENTIVE ALIGNMENT

```
R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)
```

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item- Total Correlation	Alpha if Item Deleted
Q39	13.1447	14.9254	.5585	.6481
Q42	13.1974	16.9072	.4119	.6948
Q46	11.7500	18.5633	.3075	.7204
Q49	12.3158	15.1789	.4542	.6859
Q41	13.0132	14.2798	.6221	.6252
Q45	13.5526	18.4639	.3814	.7037

```
Reliability Coefficients
N of Cases =     76.0                    N of Items =  6
Alpha =     .7209
```

PERFORMANCE MEASURES

FULFILMENT PERFORMANCE

```
R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)
```

```
Reliability Coefficients
N of Cases =     76.0                    N of Items =  3
Alpha =     .7655
```

INVENTORY PERFORMANCE

```
R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)
```

```
Reliability Coefficients
N of Cases =     76.0                    N of Items =  3
Alpha =     .8315
```

RESPONSIVENESS PERFORMANCE

```
R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)
```

```
Reliability Coefficients
N of Cases =     76.0                    N of Items =  2
Alpha =     .7065
```

Weight of Collaboration Practice

Equal weight: $w_{is} = w_{ds} = w_{ia} = 1/3$

Unequal weight: $w_{is} = .45$; $w_{ds} = .34$; $w_{ia} = .21$
Score multiplier = $m_{is} = 1.35$; $m_{ds} = 1.02$; $m_{ia} = .63$

Correlation Analysis (equal weight)

Correlation analysis is statistical technique used to measure the closeness of the linear relationship between two or more intervally scaled variables. It considers the joint variation of two measures. The correlation coefficient is concerned with the strength of the linear relationship between Y and X. The measure of this strength can be calculated using the Pearson product-moment correlation coefficient or r. The product moment coefficient of correlation may vary from -1 to $+1$. Perfect positive correlation, where an increase in X determines exactly an increase in Y, yields a coefficient of $+1$. Perfect negative correlation, where an increase in X determines exactly a decrease in Y, yields a coefficient of -1. The square of the correlation coefficient is the coefficient of determination or r^2, which refers to the relative proportion of the total variation in the criterion variable (Y) that can be explained or accounted for by the variation in the predictor variable (X).

Descriptive Statistics

	Mean	Std. Deviation	N
COLINDEX	2.6785	.68014	76
PERFORM	2.9074	.66040	76

Correlations

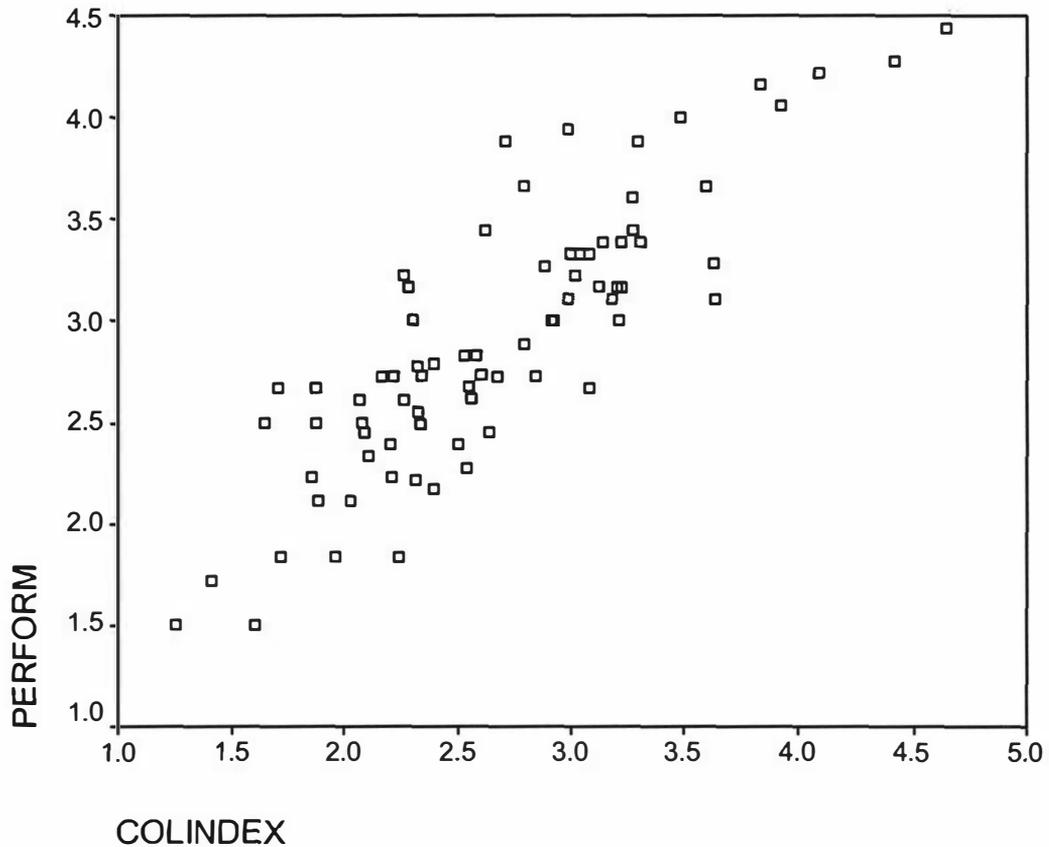|		COLINDEX	PERFORM
COLINDEX	Pearson Correlation	1	.858
	Sig. (2-tailed)	.	.000
	N	76	76
PERFORM	Pearson Correlation	.858	1
	Sig. (2-tailed)	.000	.
	N	76	76

** Correlation is significant at the 0.01 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.858	.736	.733	.34155

a Predictors: (Constant), COLINDEX

Scatter Plot (equal weight)

Analysis of variance (ANOVA)

ANOVA is a statistical test employed with internal data to determine if k $(k \geq 2)$ samples come from populations with equal means. There are three factors in this study: information sharing, decision synchronisation, and incentive alignment. There would be two different levels of each factor (high and low levels of collaborative practice), six different treatments in all since they can be used in combination, and a factorial design would be used. A factorial design is one in which the effects of two or more independent treatment variables are considered simultaneously. Prior to analysis of variance, the Kolmogorov D statistics, skewness, and kurtosis were used to test the normality assumption. Bartlett's test was used to test the hypothesis of equal variances for the factors (Walpole and Myers, 1978).

There are several reasons to use a factorial design. First, it allows the interaction of the factors to be studied. One collaboration might result in better performance in high level of decision synchronisation, whereas other collaboration might be performing better in high level of information sharing. For example, by combining the information sharing and decision synchronisation factors in one experiment, all observations can be examined on both factors. Second, a factorial design allows a saving of time and effort, because all the observations are employed to study the effects of each factor. Third, the conclusions reached have broader application, since each factor is studied with varying combinations of the other factors. Fourth, a factorial design can be used to indicate the concurrent validity of collaborative practice and operational performance. The desire to examine this relationship is based upon the commonly held belief that higher level of collaborative practice is associated with higher operational performance. Results of a factorial design confirmed the concurrent validity of the proposed measure of supply chain collaboration.

Operational Performance

Between-Subjects Factors

		N
IS	1	41
	2	35
DS	1	51
	2	25
IA	1	54
	2	22

Tests of Between-Subjects Effects
Dependent Variable: PERFORM

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	19.850	7	2.836	14.995	.000
Intercept	301.656	1	301.656	1595.145	.000
IS	1.508	1	1.508	7.973	.006
DS	1.882	1	1.882	9.952	.002
IA	1.864	1	1.864	9.856	.003
IS * DS	.138	1	.138	.730	.396
IS * IA	.205	1	.205	1.085	.301
DS * IA	.355	1	.355	1.876	.175
IS * DS * IA	.145	1	.145	.768	.384
Error	12.859	68	.189		
Total	675.141	76			
Corrected Total	32.709	75			

a R Squared = .607 (Adjusted R Squared = .566)

Fulfilment

Between-Subjects Factors

		N
IS	1	41
	2	35
DS	1	51
	2	25
IA	1	54
	2	22

Tests of Between-Subjects Effects
Dependent Variable: FULFIL

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	20.356	7	2.908	13.747	.000
Intercept	314.445	1	314.445	1486.486	.000
IS	2.393	1	2.393	11.312	.001
DS	1.698	1	1.698	8.025	.006
IA	.646	1	.646	3.055	.085
IS * DS	6.051E-02	1	6.051E-02	.286	.595
IS * IA	.534	1	.534	2.526	.117
DS * IA	1.416	1	1.416	6.693	.012
IS * DS * IA	3.679E-03	1	3.679E-03	.017	.895
Error	14.384	68	.212		
Total	739.232	76			
Corrected Total	34.740	75			

a R Squared = .586 (Adjusted R Squared = .543)

Inventory

Between-Subjects Factors

		N
IS	1	41
	2	35
DS	1	51
	2	25
IA	1	54
	2	22

Tests of Between-Subjects Effects
Dependent Variable: INVENT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	25.657	7	3.665	8.149	.000
Intercept	345.991	1	345.991	769.236	.000
IS	1.749	1	1.749	3.889	.053
DS	2.492	1	2.492	5.540	.021
IA	2.857	1	2.857	6.351	.014
IS * DS	6.942E-02	1	6.942E-02	.154	.696
IS * IA	1.187	1	1.187	2.640	.109
DS * IA	.172	1	.172	.383	.538
IS * DS * IA	1.008	1	1.008	2.242	.139
Error	30.585	68	.450		
Total	770.572	76			
Corrected Total	56.243	75			

a R Squared = .456 (Adjusted R Squared = .400)

Responsiveness

Between-Subjects Factors

		N
IS	1	41
	2	35
DS	1	51
	2	25
IA	1	54
	2	22

Tests of Between-Subjects Effects
Dependent Variable: RESPONSE

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	18.507	7	2.644	6.469	.000
Intercept	248.733	1	248.733	608.579	.000
IS	.663	1	.663	1.622	.207
DS	1.523	1	1.523	3.726	.058
IA	2.565	1	2.565	6.275	.015
IS * DS	.367	1	.367	.897	.347
IS * IA	.213	1	.213	.522	.473
DS * IA	3.305E-02	1	3.305E-02	.081	.777
IS * DS * IA	6.109E-03	1	6.109E-03	.015	.903
Error	27.792	68	.409		
Total	564.750	76			
Corrected Total	46.299	75			

a R Squared = .400 (Adjusted R Squared = .338)

Summary

Source of variance	Dependent Variables			
	Fulfilment	Inventory	Responsiveness	Operational Performance
Information Sharing (IS)	.001	.053	.207	.006
Decision synchronisation (DS)	.006	.021	.058	.002
Incentive alignment (IA)	.085	.014	.015	.003
IS*DS	.595	.696	.347	.396
IS*IA	.117	.109	.473	.301
DS*IA	.012	.538	.777	.175
IS*DS*IA	.895	.139	.903	.384
Adjusted R squared	.543	.400	.338	.566

Appendix C

Statistical Analysis for the Benchmarking Study

Correlation between Collaboration Index and Operational Performance

Correlation analysis is statistical technique used to measure the closeness of the linear relationship between two or more intervally scaled variables. It considers the joint variation of two measures. The correlation coefficient is concerned with the strength of the linear relationship between Y and X. The measure of this strength can be calculated using the Pearson product-moment correlation coefficient or r. The product moment coefficient of correlation may vary from -1 to $+1$. Perfect positive correlation, where an increase in X determines exactly an increase in Y, yields a coefficient of $+1$. Perfect negative correlation, where an increase in X determines exactly a decrease in Y, yields a coefficient of -1. The square of the correlation coefficient is the coefficient of determination or r^2, which refers to the relative proportion of the total variation in the criterion variable (Y) that can be explained or accounted for by the variation in the predictor variable (X).

Descriptive Statistics

	Mean	Std. Deviation	N
COLINDEX	2.6785	.68014	76
PERFORM	2.9074	.66040	76

Correlations

		COLINDEX	PERFORM
COLINDEX	Pearson Correlation	1	.858
	Sig. (2-tailed)	.	.000
	N	76	76
PERFORM	Pearson Correlation	.858	1
	Sig. (2-tailed)	.000	.
	N	76	76

** Correlation is significant at the 0.01 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.858	.736	.733	.34155

a Predictors: (Constant), COLINDEX

Correlation Collaborative Practice versus Performance Criteria

Descriptive Statistics

	Mean	Std. Deviation	N
DSB	2.5789	.80109	76
ISB	2.8908	.74961	76
IAB	2.5658	.78791	76
FULFIL	3.0446	.68059	76
RESPONSE	2.6118	.78570	76
INVENT	3.0658	.86597	76

Correlations

		DSB	ISB	IAB	FULFIL	RESPONSE	INVENT
DSB	Pearson Correlation	1	.701	.665	.658	.525	.657
	Sig. (2-tailed)	.	.000	.000	.000	.000	.000
	N	76	76	76	76	76	76
ISB	Pearson Correlation	.701	1	.557	.832	.561	.594
	Sig. (2-tailed)	.000	.	.000	.000	.000	.000
	N	76	76	76	76	76	76
IAB	Pearson Correlation	.665	.557	1	.566	.638	.710
	Sig. (2-tailed)	.000	.000	.	.000	.000	.000
	N	76	76	76	76	76	76
FULFIL	Pearson Correlation	.658	.832	.566	1	.556	.573
	Sig. (2-tailed)	.000	.000	.000	.	.000	.000
	N	76	76	76	76	76	76
RESPONSE	Pearson Correlation	.525	.561	.638	.556	1	.607
	Sig. (2-tailed)	.000	.000	.000	.000	.	.000
	N	76	76	76	76	76	76
INVENT	Pearson Correlation	.657	.594	.710	.573	.607	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.
	N	76	76	76	76	76	76

** Correlation is significant at the 0.01 level (2-tailed).

The cutoff value for high and low performance

This test aims to examine that the cutoff value of three is adequate to differentiate between low and high performers.

Fulfillment = 3.0
T-Test

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
FULFIL	1	33	2.4258	.32684	.05690
	2	43	3.5195	.46252	.07053

Independent Samples Test

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
FULFIL	Equal variances assumed	-11.544	74	.000	-1.0938	.09475	-1.28257	-.90499
	Equal variances not assumed	-12.070	73.562	.000	-1.0938	.09062	-1.27436	-.91319

Responsiveness = 3.0

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
RESPONSE	1	47	2.1064	.38920	.05677
	2	29	3.4310	.52989	.09840

Independent Samples Test

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
RESPONSE	Equal variances assumed	-12.531	74	.000	-1.3247	.10571	-1.53528	-1.11402
	Equal variances not assumed	-11.660	46.600	.000	-1.3247	.11360	-1.55324	-1.09606

Inventory = 3.0

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
INVENT	1	27	2.0989	.40120	.07721
	2	49	3.5986	.51854	.07408

Independent Samples Test

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
INVENT	Equal variances assumed	-13.020	74	.000	-1.4997	.11519	-1.72920	-1.27017
	Equal variances not assumed	-14.016	65.728	.000	-1.4997	.10700	-1.71333	-1.28603

226

DS to Fulfillment Performance

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
Q12	1	33	2.5152	1.03444	.18007
	2	43	3.3721	.92642	.14128
Q14	1	33	1.9394	.86384	.15037
	2	43	3.1163	.93119	.14200
Q13	1	33	2.8788	1.21854	.21212
	2	43	3.6977	.98886	.15080
Q15	1	33	1.8485	.83371	.14513
	2	43	2.9070	1.01920	.15543
Q16	1	33	1.6061	.89928	.15655
	2	43	2.1860	1.29570	.19759
Q17	1	33	1.8485	.87039	.15152
	2	43	2.7674	1.13047	.17240
Q18	1	33	1.5455	.75378	.13122
	2	43	2.3256	1.22903	.18743
Q20	1	33	2.1818	1.07397	.18695
	2	43	2.7674	1.23128	.18777
Q21	1	33	2.5455	.83258	.14493
	2	43	3.3721	1.06956	.16311

Independent Samples Test

		t-test for Equality of Means					95% Confidence Interval of the Difference	
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Q12	Equal variances assumed	-3.799	74	.000	-.8569	.22555	-1.30636	-.40752
	Equal variances not assumed	-3.744	64.809	.000	-.8569	.22888	-1.31407	-.39981
Q14	Equal variances assumed	-5.634	74	.000	-1.1769	.20891	-1.59314	-.76063
	Equal variances not assumed	-5.690	71.313	.000	-1.1769	.20683	-1.58926	-.76451
Q13	Equal variances assumed	-3.234	74	.002	-.8189	.25321	-1.32342	-.31436
	Equal variances not assumed	-3.146	60.705	.003	-.8189	.26026	-1.33936	-.29841
Q15	Equal variances assumed	-4.848	74	.000	-1.0585	.21835	-1.49356	-.62343
	Equal variances not assumed	-4.978	73.666	.000	-1.0585	.21265	-1.48224	-.63475
Q16	Equal variances assumed	-2.196	74	.031	-.5800	.26413	-1.10628	-.05370
	Equal variances not assumed	-2.301	73.345	.024	-.5800	.25209	-1.08236	-.07761
Q17	Equal variances assumed	-3.870	74	.000	-.9190	.23747	-1.39213	-.44578
	Equal variances not assumed	-4.004	73.997	.000	-.9190	.22951	-1.37627	-.46164
Q18	Equal variances assumed	-3.210	74	.002	-.7801	.24306	-1.26443	-.29583
	Equal variances not assumed	-3.410	70.905	.001	-.7801	.22879	-1.23634	-.32392
Q20	Equal variances assumed	-2.170	74	.033	-.5856	.26981	-1.12324	-.04801
	Equal variances not assumed	-2.210	72.733	.030	-.5856	.26497	-1.11374	-.05751
Q21	Equal variances assumed	-3.667	74	.000	-.8266	.22545	-1.27586	-.37741
	Equal variances not assumed	-3.789	73.977	.000	-.8266	.21820	-1.26141	-.39187

Vita

Togar M. Simatupang holds a Master in Technology degree from Massey University, New Zealand. His current research has focused on supply chain collaboration, theory of constraints, quality management, business process management, and logistics postponement. He has published a number of research papers in *Management Decision*, *Total Quality Management*, *Business Process Management Journal*, *Supply Chain Management: An International Journal*, *Benchmarking: An International Journal*, and *The International Journal of Logistics Management*. He has served as a referee of *Supply Chain Management: An International Journal*. He is also a student member of the Operational Research Society of New Zealand (ORSNZ).