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# Fashion Supply Chain Management

Industry and Business Analysis



**Tsan-Ming Choi**

# Fashion Supply Chain Management: Industry and Business Analysis

Tsan-Ming Choi  
*Hong Kong Polytechnic University, Hong Kong*

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## Section 1 Mathematical Modelling Research

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<i>Anna Nagurney, University of Massachusetts Amherst, USA</i>	
<i>Min Yu, University of Massachusetts Amherst, USA</i>	

In order to determine the optimal multiproduct flows associated with the fashion supply chain network activities, Nagurney and Yu consider a multi-criteria decision-making optimization model subject to multimarket demand satisfaction. They provide an equivalent variational inequality formulation and identify the minimal total operational cost and total time consumption. Their model allows decision-maker to achieve the total time minimization objective of the supply chain network for time-sensitive fashion products.

### Chapter 2

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Supply chain coordination is a core topic in fashion supply chain management. Kurata, Yue, and Alwan explore the role played by incentive alignment contracts such as scan-back trade deal and buyback contract in fashion supply chain models. They analytically derive insights into when a fashion retailer has incentive to accept the scan-back trade deal. They also find that the manufacturer and the entire fashion

supply chain can always benefit from the scan-back trade deal but it is not the case for the retailer. In order to achieve win-win situation in the supply chain upon coordination, a revised policy combining both scan-back trade deal and buyback is proposed.

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Competition and coordination are important dimensions in fashion supply chain management. Huang, Leng, and Liang study a two-echelon single-supplier single-retailer multi-period supply chain model. Under a price-discount sharing scheme with the supplier's wholesale price being a linear function of the retail price, they develop a stochastic game and show that a unique Nash equilibrium exists (for each period). They further show that over the infinite horizon the supplier chooses a stationary base stock policy whereas the retailer's equilibrium can be non-stationary. They then derive the condition for achieving supply chain coordination via a wholesale pricing scheme.

### **Chapter 4**

Small Manufacturers vs. Large Retailers on RFID Adoption in the Apparel Supply Chain ..... 74

*May Tajima, The University of Western Ontario, Canada*

Radio frequency identification (RFID) technology is a very useful tool in fashion supply chain management. In fact, a lot of large scale fashion retailers, such as Marks and Spencer, have been driving RFID adoption. In order to study the impact of the relationship between small manufacturers and large retailers on the small manufacturers' RFID adoption decisions, Tajima develops a two-by-two gaming model and conducts outcome stability analysis. Some interesting results and insights are generated. For instance, it is found that the retailer's opportunistic behaviour is unlikely to occur (due to the strong stability associated with the manufacturer's do-nothing option) and the retailer's pressure tactic is not effective in persuading the small manufacturer to adopt RFID.

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*Tsan-Ming Choi, The Hong Kong Polytechnic University, Hong Kong*

Risk analysis is a timely issue in fashion supply chain management. Inspired by the popularity of the Value-at-Risk (VaR) objective in finance, Chiu, Zheng, and Choi examine and review its application in fashion retail pricing and inventory decision making problems. They first review a formal optimization model for the problem, in which the fashion retailer's goal is to optimize a VaR objective function. After that, they explore the detailed solution schemes and demonstrate the applications of the proposed models via numerical examples. Finally, they investigate the performance of buyback contract and wholesale

pricing contract in enhancing the supply chain's efficiency when the fashion retailer takes a VaR objective. They analytically find some counter-intuitive insights, which include the failure of buyback contract in enhancing the supply chain's efficiency with a VaR retailer.

## **Section 2**

### **Quantitative Empirical Research**

*This section includes chapters that employ empirical data for quantitative analysis. The approaches include data-driven research, survey-based statistical analysis (and its review), intelligent systems, and empirical gaming models.*

#### **Chapter 6**

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*Chris K. Y. Lo, Hong Kong Polytechnic University, Hong Kong*

Quality management and environmental challenges are pertinent issues in fashion supply chain management. Lo conducts an empirical study to explore the impacts to fashion and textiles companies (FTCs) brought by quality management systems (QMS) and environmental management systems (EMS). By investigating the adoption of ISO 9000 (a quality management system) and ISO 14000 (an environmental management system) by 284 publicly listed FTCs in the U.S., many important insights are revealed. For example, he shows that the operating cycle time has been shortened by about two weeks (in a five-year period). He also finds that the early adopters of ISO 9000 and high-tech textiles related firms tend to enjoy more supply chain benefits.

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*Lorynn R. Divita, Baylor University, USA*

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*David A. Ludwig, University of Miami, USA*

Focusing on the U.S. Textile and Apparel industry, Divita, Cassill, and Ludwig explore the value and fairness issues in strategic partnerships. Based on the social exchange, transactional cost analysis, and distributive justice theories, a national quantitative questionnaire and case study research was conducted. They prove that there exists a statistically significant relationship between social value and fairness. Implications for industry and future research directions are discussed.

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*Jin Su, Indiana University of Pennsylvania, USA*

*Vidyaranya B. Gargeya, The University of North Carolina at Greensboro, USA*

Strategic sourcing and supplier selection are crucially important in managing fashion supply chains. In the literature, the use of survey-based empirical research is one of the popular research methodologies in

addressing sourcing and supplier selection problems. Motivated by the importance of the topic, Su and Gargeya conduct a review on the current state-of-the art survey-based empirical research on strategic sourcing and supplier selection in fashion. They examine the latest development and trends in the related areas and establish an agenda for future research.

### **Chapter 9**

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*Wei-Shuo Lo, Meiho University, Taiwan*

*Tzung-Pei Hong, National University of Kaohsiung, Taiwan*

The use intelligent systems can enhance the performance of fashion supply chains. Lo and Hong study a three-level e-multi-agent early warning mechanism for preventing loss of customers in fashion supply chains. The system includes three levels, namely data mining, ontology, and decision support. At each level, different agents would execute different tasks in order to achieve integration in the fashion supply chain with less human intervention. The proposed framework also enhances transparent connections among businesses and assists in information sharing, thereby helping to prevent customer loss.

### **Chapter 10**

Time-Constrained Fashion Sales Forecasting by Extended Random Vector Functional Link Model..... 185

*Yong Yu, Hong Kong Polytechnic University, Hong Kong*

*Tsan-Ming Choi, Hong Kong Polytechnic University, Hong Kong*

*Chi-Leung Hui, Hong Kong Polytechnic University, Hong Kong*

Due to the ever-changing features of customer demands, fashion sales forecasting is a challenging problem. Traditionally, in order to yield accurate forecasting result, sophisticated tools, such as artificial neural network (ANN), have been employed. However, the traditional ANN suffers a major drawback because it takes a very long time in order to get the forecasting result. Motivated by this limitation, Yu, Choi, and Hui propose a time-constrained forecasting model (TCFM) for fashion sales forecasting. This TCFM is based on the random vector functional link (RVFL) model. Their real-data driven experiment has shown that the proposed TCFM can produce quality forecasting within the user specified time constraint.

## **Section 3**

### **Exploratory Study and Case Research**

*Most scientific research in FSCM is inspired by real cases and industrial exploratory studies. This section presents a number of different studies, including cases, on many timely and emerging issues related to FSCM. It is expected that more future research, including many probable quantitative analyses, will be motivated by these cases and exploratory studies.*



## Chapter 11

Fast Fashion Business Model: What, Why and How?..... 193

*Byoungho Jin, The University of North Carolina at Greensboro, USA*

*Hyo Jung (Julie) Chang, The University of North Carolina at Greensboro, USA*

*Delisia R. Matthews, The University of North Carolina at Greensboro, USA*

*Megha Gupta, The University of North Carolina at Greensboro, USA*

In fashion supply chain management, fast fashion is one prominent industrial trend, and it is known that fast fashion retailers are facing two important challenges, namely high demand uncertainty and the strategic consumer behaviours. Motivated by the importance of fast fashion, Jin, Chang, Matthews, and Gupta explore what a fast fashion model is, why a fast fashion business model is becoming prominent in fashion business, and how the fast fashion supply chain is managed. They address these questions by examining the strategies of Zara and H&M, two highly successful fast fashion retailers. Suggestions for non-fast fashion retailers and future research directions are discussed.

## Chapter 12

“Network Process Re-Engineering” in a Home Textile Network: The Importance of Business Relationships and Actor Bonds..... 212

*Enrico Baraldi, Uppsala University, Sweden*

*Giancarlo Nadin, Università Cattolica del Sacro Cuore – Milano, Italy*

Network process re-engineering (NPR) is an important issue in many textile and clothing companies. Based on a case study on Stella, an Italian home textile manufacturer, Baraldi and Nadin illustrate the challenges of engaging other firms into NPR projects. They explore the importance of the connection between inter-organizational activities that need to be redesigned and coordinated. They suggest that the highly-complex coordination tasks can only be completed if there are strong integrative relationships between the involved parties. Insights on how the pivotal firms of a network can support NPR projects are also discussed.

## Chapter 13

Matching Manufacturing and Retailing Models in Fashion ..... 235

*Simone Guercini, University of Florence, Italy*

In fashion supply chains, interdependencies have long been established with reference to the manufacturer-retailer interactions. In many cases, since fashion retailers aim at reducing the inventory risk from unsold merchandise, markdown, and stockouts, they interact with and rely on the manufacturing suppliers to adopt effective measures to help fulfil orders flexibly and replenish quickly. Guercini examines the implications of these interactions and discusses further developments. One important insight is the probable shifting of channel relationship from a perspective of supply to one of demand.

## Chapter 14

A Mass Customisation Implementation Model for the Total Design Process of the Fashion System..... 251

*Bernice Pan, Seamsystemic Design Research, UK*

Mass customisation (MC) is an industrial trend in fashion retailing. Pan develops a new conceptual model of MC which aligns the activities and interests of the collective fashion supply chain producers. This model takes a consumer-centric approach, and places designers as the instrument for MC. This model aims to enable the prospect for small-to-medium sized fashion companies to implement MC in a more efficient, coordinated, and responsive way. The probable benefits and insights of this new model are discussed.

### **Chapter 15**

An Exploratory Study on Product Lifecycle Management in the Fashion Chain: Evidences from the Italian Leather Luxury Industry ..... 270

*Romeo Bandinelli, Università degli Studi di Firenze, Italy*

*Sergio Terzi, Università degli Studi di Bergamo, Italy*

Fashion supply chain management is characterized by an increasing global competition and pressure to improve product quality, and respond quickly to changing customer needs with a shortened product lifecycle. These requirements are increasingly fulfilled by applying the product lifecycle management (PLM) approach. As an exploratory study, Bandinelli and Terzi conduct an analysis on PLM in the Italian leather luxury industry (ILLI) by investigating 20 companies. They identify some differences that exist between ILLI and other more PLM-oriented sectors in several dimensions (such as the adopted information and communication technology). Insights are generated.

### **Chapter 16**

Consumer Perceptions of Online Apparel Customization: An Exploratory Study ..... 286

*Hira Cho, California State University-Northridge, USA*

Cho identifies a variety of important consumer perceptions of online apparel customization (OAC). As an exploratory study, Cho conducts a survey and the survey-participants need to visit apparel customization websites and customize a pair of jeans before answering the survey questions. The respondents' inputs are analyzed and categorized into eight dimensions representing the major benefits and costs of OAC. Insights regarding why people are willing or unwilling to customize apparel online are generated. Future research directions are discussed.

### **Chapter 17**

RFID Technology in the Fashion Supply Chain: An Exploratory Analysis ..... 303

*Susana Garrido Azevedo, University of Beira Interior, Portugal*

*Helena Carvalho, Universidade Nova de Lisboa, Portugal*

Azevedo and Carvalho review the benefits, disadvantages, and barriers associated with the radio frequency identification (RFID) technology in fashion supply chain management. The focal point is on RFID's implementation in fast moving fashion supply chains. A cross-case analysis is also conducted to generate additional insights regarding how RFID technology affects fashion supply chain management.

## **Chapter 18**

Fashioning a Socially Responsible Garment Supply Chain: A Qualitative Exploration of Corporate Social Responsibility in Sri Lankan Export Garment Manufacturers ..... 327

*Patsy Perry, Heriot-Watt University, UK*

*Neil Towers, Heriot-Watt University, UK*

Corporate social responsibility (CSR) is a hot topic in fashion supply chain management. Even though there is evidence of a rising consumer demand for low cost fashionable clothing sourced through socially responsible supply chains, the nature of the “high street” fashion industry is not conducive to the implementation of CSR. Motivated by the importance of CSR in fashion supply chain management, Perry and Towers explore obstacles and drivers of CSR implementation in Sri Lankan export garment manufacturers. They propose that in a fashion supply chain, a partnership approach that encourages collaboration on CSR initiatives is more likely to promote supplier engagement with CSR issues than coercive compliance-based mechanisms. Many important insights are generated.

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## Foreword

It is my great pleasure to write a foreword for the book *Fashion Supply Chain Management: Industry and Business Analysis*. I want to congratulate the editor, Tsan-Ming Choi (Jason), for compiling this impressive volume. Undoubtedly, this book will provide a solid reference on fashion supply chain management research and inspire new research in the area.

The fashion and textiles industry is an ever-green global industry. Without controversy, it is always among the top three most important industries in the world. One characteristic of the fashion and textile industry is its long supply chain, including fibers, yarns, fabrics (both woven and knitted), finishes and coloration, and retailing. Management and coordination of the entire fashion supply chain is critical to the success of companies in the fashion industry. This is especially true under the profound changes in the fashion industry over the past few years. In fact, in addition to the reallocation of the manufacturing activities of the industry to low-cost countries and the higher degree of globalization under fewer trade restrictions, a number of pertinent challenges such as environmental sustainability, fast fashion models, use of advanced Information Technologies, social responsibility, and product innovations and development have emerged. These issues all call for deeper explorations and further research. In particular, industrial-practice-driven quantitative research can provide the much needed insights and measures to address these important issues.

It is therefore gratifying to see Jason focusing his volume on fashion supply chain management with an emphasis on quantitative research and exploratory studies on various timely issues in the fashion industry. The featured articles cover nearly all aspects of the fashion supply chains and offer many innovative solutions and significant findings.

I am sure that this handbook will stimulate new research and industrial analysis on fashion supply chain management and readers will find it a valuable text on this important subject.

*Xiao-Ming Tao*

*Hong Kong Polytechnic University, Hong Kong*

**Xiao-Ming Tao** is Chair Professor and Head of Institute of Textiles and Clothing, The Hong Kong Polytechnic University. She gained her PhD in Textile Physics from University of New South Wales, Australia in 1987. She has published more than 600 scientific publications including over 180 SCI journal papers, 5 research monographs and 14 patents. She has been invited to deliver plenary/keynote presentations in over 60 international conferences. Professor Tao's research work has won her scholarships and prizes from USA, Belgium, Australia, New Zealand, UK, Hong Kong, and China. Currently she is leading several research projects in the area of smart textiles and new yarn manufacturing technology. Professor Tao is the immediate past World President of the Textile Institute International. She is an elected Fellow of American Society of Mechanic Engineers, Royal Society of Arts and Design and the Hong Kong Institution of Textiles and Apparel. Professor Tao is Editor-in-Chief of *Textile Progress* and an editorial board member of several international journals.

## Preface

Fashion Supply Chain Management (FSCM) is an important topic in modern fashion business. In addition to the traditional functions of inventory management, transportation management, and facility control, FSCM puts a strong emphasis on the collaboration and partnership among channel members along the fashion supply chain. Obviously, FSCM provides a very strong area for establishing a competitive edge for fashion companies.

Traditionally, most researchers in fashion have been focusing mainly on the “art” side of fashion instead of “science.” There is hence a need to publish a book which comprehensively reports FSCM with more emphasis on scientific research.

This new research handbook focuses on reporting both quantitative research on FSCM and exploratory studies on emerging supply chain management related issues in the fashion industry. Both quantitative and qualitative analyses are included. To be specific, this handbook is organized into several sections outlined as follows:

**Section 1 – Mathematical Modelling Research:** This section consists of chapters that employ traditional mathematical modelling approach in conducting analytical studies. Both theoretical analysis and application-oriented papers are included. This section includes five chapter papers and they are introduced as follows.

In order to determine the optimal multiproduct flows associated with the fashion supply chain network activities, Nagurney and Yu consider in Chapter 1 a multi-criteria decision-making optimization model subject to multimarket demand satisfaction. They develop an equivalent variational inequality formulation and identify the minimal total operational cost and total time consumption. Their modeling analysis provides insight which allows decision-maker to achieve the total time minimization objective of the supply chain network for fashion products.

Supply chain coordination is a core topic in fashion supply chain management. In Chapter 2, Kurata, Yue, and Alwan explore the role played by incentive alignment contracts such as scan-back trade deal and buyback contract in fashion supply chain models. They analytically derive insights into when a fashion retailer has incentive to accept the scan-back trade deal. They also find that the manufacturer and the entire fashion supply chain can always benefit from the scan-back trade deal but it is not the case for the retailer. In order to achieve win-win situation in the supply chain upon coordination, a revised policy combining both scan-back trade deal and buyback is proposed. Managerial insights are developed.

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ists (for each period). They further show that over the infinite horizon, the supplier chooses a stationary base stock policy whereas the retailer's equilibrium can be non-stationary. Afterwards, they derive the condition for achieving supply chain coordination via a wholesale pricing scheme. Analytical insights are derived.

Radio frequency identification (RFID) technology is a very useful tool in fashion supply chain management. In fact, a lot of large scale fashion retailers, such as Marks and Spencer, have been driving RFID adoption. In order to study the impact of the relationship between small manufacturers and large retailers on the small manufacturers' RFID adoption decisions, Tajima develops in Chapter 4 a two-by-two gaming model and conducts outcome stability analysis. Some interesting results and insights are generated. For instance, it is found that the retailer's opportunistic behaviour is unlikely to occur (due to the strong stability associated with the manufacturer's do-nothing option) and the retailer's pressure tactic is not effective in persuading the small manufacturer to adopt RFID.

Risk analysis is timely issue in fashion supply chain management. Inspired by the popularity of the Value-at-Risk (VaR) objective in finance, Chiu, Zheng, and Choi examine and review its application in fashion retail pricing and inventory decision making problems in Chapter 5. They first review a formal optimization model for the problem, in which the fashion retailer's goal is to optimize an VaR objective function. After that, they explore the detailed solution schemes and demonstrate the applications of the proposed models via numerical examples. Finally, they investigate the performance of buyback contract and wholesale pricing contract in enhancing the supply chain's efficiency when the fashion retailer takes an VaR objective. They analytically find some counter-intuitive insights which include the failure of buyback contract in enhancing the supply chain's efficiency with an VaR retailer.

Section 2 – Quantitative Empirical Research: This section includes papers that employ empirical data for quantitative analysis. The approaches include data-driven research and survey-based statistical analysis (and its review). There are five chapter papers in this section, and they are briefly described below.

Quality management and environmental challenges are pertinent issues in fashion supply chain management. In Chapter 6, Lo conducts an empirical study to explore the impacts to fashion and textiles companies (FTCs) brought by quality management systems and environmental management systems. By investigating the adoption of ISO 9000 (a quality management system) and ISO 14000 (an environmental management system) by 284 publicly listed FTCs in the U.S., many important insights are revealed. For example, he shows that the operating cycle time has been shortened by about two weeks (in a five-year period). He also finds that the early adopters of ISO 9000 and high-tech textiles related firms tend to enjoy more supply chain benefits.

Focusing on the U.S. Textile and Apparel industry, Divita, Cassill, and Ludwig explore the value and fairness issues in strategic partnerships in Chapter 7. Based on the social exchange, transactional cost analysis, and distributive justice theories, a national quantitative questionnaire and case study research was conducted. They prove that there exists a statistically significant relationship between social value and fairness. Implications for industry and future research directions are discussed.

Strategic sourcing and supplier selection are crucially important in managing fashion supply chains. In the literature, the use of survey-based empirical research is one of the popular research methodologies in addressing sourcing and supplier selection problems. Motivated by the importance of the topic, Su and Gargeya conduct a review in Chapter 8 on the current state-of-the art survey-based empirical research on strategic sourcing and supplier selection in fashion. They examine the latest development and trends in the related areas and establish an agenda for future research.

The use intelligent systems can enhance the performance of fashion supply chains. Lo and Hong study in Chapter 9 a three-level e-multi-agent early warning mechanism for preventing loss of customers in fashion supply chains. The system includes three levels, namely data mining, ontology, and decision support. At each level, different agents would execute different tasks in order to achieve integration in the fashion supply chain with less human intervention. The proposed framework also enhances transparent connections among businesses and assists in information sharing, thereby helping to prevent customer loss.

Due to the ever-changing features of customer demands, fashion sales forecasting is a challenging problem. Traditionally, in order to yield accurate forecasting result, sophisticated tools, such as artificial neural net-work (ANN), have been employed. However, the traditional ANN suffers a major drawback because it takes a very long time in order to get the forecasting result. Motivated by this limitation, Yu, Choi, and Hui propose a time-constrained forecasting model (TCFM) for fashion sales forecasting in Chapter 10. This TCFM is based on the random vector functional link (RVFL) model. Their real-data driven experiment has shown that the proposed TCFM can produce quality forecasting within the user specified time constraint.

Section 3 – Exploratory Study and Case Research: Most scientific research in fashion supply chain management is inspired by real cases and industrial exploratory studies. This section presents a number of different studies, including cases, on many timely and emerging issues related to fashion supply chain management. It is expected that more future research, including many probable quantitative analyses, will be motivated by these cases and exploratory studies. To be specific, this section includes eight chapters and they are stated in the following.

In fashion supply chain management, fast fashion is one prominent industrial trend, and it is known that fast fashion retailers are facing two important challenges, namely high demand uncertainty and the strategic consumer behaviours. Motivated by the importance of fast fashion, Jin, Chang, Matthews, and Gupta explore in Chapter 11 what a fast fashion model is, why a fast fashion business model is becoming prominent in fashion business, and how the fast fashion supply chain is managed. They address these questions by examining the strategies of Zara and H&M, two highly successful fast fashion retailers. Suggestions for non-fast fashion retailers and future research directions are discussed.

Network process re-engineering (NPR) is an important issue in many textile and clothing companies. Based on a case study on Stella, an Italian home textile manufacturer, Baraldi and Nadin illustrate the challenges of engaging other firms into NPR projects in Chapter 12. They explore the importance of the connection between inter-organizational activities that need to be redesigned and coordinated. They suggest that the highly-complex coordination tasks can only be completed if there are strong integrative relationships between the involved parties. Insights on how the pivotal firms of a network can support NPR projects are also discussed.

In fashion supply chains, interdependencies have long been established with reference to the manufacturer-retailer interactions. In many cases, since fashion retailers aim at reducing the inventory risk from unsold merchandise, markdown, and stockouts, they interact with and rely on the manufacturing suppliers to adopt effective measures to help fulfil orders flexibly and replenish quickly. In Chapter 13, Guercini examines the implications of these interactions and discusses further developments. One important insight is the probable shifting of channel relationship from a perspective of supply to one of demand.

Mass customisation (MC) is an industrial trend in fashion retailing. In Chapter 14, Pan develops a new conceptual model of MC that aligns the activities and interests of the collective fashion supply chain producers. This model takes a consumer-centric approach, and places designers as the instrument for MC. This model aims to enable the prospect for small-to-medium sized fashion companies to imple-

ment MC in a more efficient, coordinated, and responsive way. The probable benefits and insights of this new model are discussed.

Fashion supply chain management is characterized by an increasing global competition and pressure to improve product quality, and respond quickly to changing customer needs with a shortened product lifecycle. These requirements are increasingly fulfilled by applying the product lifecycle management (PLM) approach. As an exploratory study, Bandinelli and Terzi conduct an analysis in chapter 15 on PLM in the Italian leather luxury industry (ILLI) by investigating 20 companies. They identify some differences that exist between ILLI and other more PLM-oriented sectors in several dimensions (such as the adopted information and communication technology). Insights are generated.

In Chapter 16, Cho identifies a variety of important consumer perceptions of online apparel customization (OAC). As an exploratory study, Cho conducted a survey and the survey-participants needed to visit apparel customization websites and customize a pair of jeans before answering the survey questions. The respondents' inputs were analyzed and categorized into eight dimensions representing the major benefits and costs of OAC. Insights regarding why people are willing or unwilling to customize apparel online are generated. Future research directions are discussed.

Azevedo and Carvalho review in Chapter 17 the benefits, disadvantages, and barriers associated with the radio frequency identification (RFID) technology in fashion supply chain management. The focal point is on RFID's implementation in fast moving fashion supply chains. A cross-case analysis is also conducted to generate additional insights regarding how RFID technology affects fashion supply chain management.

Corporate social responsibility (CSR) is a hot topic in fashion supply chain management. Even though there is evidence of a rising consumer demand for low cost fashionable clothing sourced through socially responsible supply chains, the nature of the "high street" fashion industry is not conducive to the implementation of CSR. Motivated by the importance of CSR in fashion supply chain management, Perry and Towers explore in Chapter 18 obstacles and drivers of CSR implementation in Sri Lankan export garment manufacturers. They propose that in a fashion supply chain, a partnership approach that encourages collaboration on CSR initiatives is more likely to promote supplier engagement with CSR issues than coercive compliance-based mechanisms. Many important insights are generated.

I am pleased to see that this handbook contains new analytical and empirical results with valuable insights, which will help both the academicians and the practitioners to understand more about the latest development and solution schemes in FSCM. In particular, this handbook positions itself as a pioneering text that reports many important research results in quantitative FSCM. As a result, researchers and practitioners who are interested in FSCM should find this book a valuable reference.

I would like to take this opportunity to thank Professor Xiao-Ming Tao for writing the foreword of this handbook and her kind support for this book project. I must thank all editorial advisory board members, Hannah Abelbeck and Christine Buffon from IGI Global, and my editorial assistant Pui-Sze Chow for their help along the course of carrying out this project. I am indebted to all the authors who have contributed their works to this handbook. I am also grateful to all reviewers who reviewed the submitted manuscripts and provided me with constructive comments and recommendations. I also acknowledge the funding support from The Hong Kong Polytechnic University under the Dean's Reserve Funding Scheme.

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*November 30, 2010*



Section 1  
**Mathematical Modelling  
Research**

*This section consists of chapters that employ traditional mathematical modelling approach in conducting analytical studies. Both theoretical analysis and application-oriented papers are included.*

# Chapter 1

## Fashion Supply Chain Management through Cost and Time Minimization from a Network Perspective

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### ABSTRACT

*In this chapter, we consider fashion supply chain management through cost and time minimization, from a network perspective, and in the case of multiple fashion products. We develop a multicriteria decision-making optimization model subject to multimarket demand satisfaction, and provide its equivalent variational inequality formulation. The model allows for the determination of the optimal multiproduct fashion flows associated with the supply chain network activities, in the form of: manufacturing, storage, and distribution, and identifies the minimal total operational cost and total time consumption. The model allows the decision-maker to weigh the total time minimization objective of the supply chain network for the time-sensitive fashion products, as appropriate. Furthermore, we discuss potential applications to fashion supply chain management through a series of numerical examples.*

### INTRODUCTION

In recent decades, fashion retailers, such as Benetton, H&M, Topshop, and Zara have revolutionized the fashion industry by following what has become known as the “fast fashion” strategy, in

which retailers respond to shifts in the market within just a few weeks, versus an industry average of six months (Sull and Turconi (2008)). Specifically, fast fashion is a concept developed in Europe to serve markets for teenage and young adult women who desire trendy, short-cycle, and relatively inexpensive clothing, and who are willing to buy from small retail shops and boutiques

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(Doeringer and Crean (2006)). Fast fashion chains have grown quicker than the industry as a whole and have seized market share from traditional rivals (Sull and Turconi (2008)), since they aim to obtain fabrics, to manufacture samples, and to start shipping products with far shorter lead times than those of the traditional production calendar (Doeringer and Crean (2006)).

Nordas, Pinali, and Geloso Grosso (2006) further argued that time is a critical component in the case of labor-intensive products such as clothing as well as consumer electronics, both examples of classes of products that are increasingly time-sensitive. They presented two case studies of the textile and clothing sector in Bulgaria and the Dominican Republic, respectively, and noted that, despite higher production costs than in China, their closeness to major markets gave these two countries the advantage of a shorter lead time that allowed them to specialize in fast fashion products. Interestingly and importantly, the authors also identified that lengthy, time-consuming administrative procedures for exports and imports reduce the probability that firms will even enter export markets for time-sensitive products.

Clearly, superior time performance must be weighed against the associated costs. Indeed, as noted by So (2000), it can be costly to deliver superior time performance, since delivery time performance generally depends on the available capacity and on the operating efficiency of the system. It is increasingly evident that, in the case of time-sensitive products, with fashion being an example par excellence, an appropriate supply chain management framework for such products must capture both the operational (and other) cost dimension as well as the time dimension.

For example, in the literature, the total order cycle time, which refers to the time elapsed in between the receipt of customer order until the delivery of finished goods to the customer, is considered an important measure as well as a major source of competitive advantage (see Bower and Hout (1988) and Christopher (1992)), directly influencing the customer satisfaction level (cf.

Gunasekaran, Patel, and Tirtiroglu (2001) and Towill (1997)). Moreover, according to the survey of Gunasekaran, Patel, and McGaughey (2004), performance metrics for time issues associated with planning, purchasing, manufacturing, and delivery are consistently rated as important factors in supply chain management.

Conventionally, there have been several methodological approaches utilized for time-dependent supply chain management, including multiperiod dynamic programming and queuing theory (see, e.g., Guide Jr., Muyldermans, and Van Wassenhove (2005), Lederer and Li (1997), Palaka, Erlebacher, and Kropp (1998), So and Song (1998), So (2000), Ray and Jewkes (2004), and Liu, Parlar, and Zhu (2007)). However, according to the review by Goetschalckx, Vidal, and Dogan (2002), the paper by Arntzen et al. (1995) is the only one that has captured the time issue in the modeling and design of a global logistics system, with the expression of time consumption explicitly in the objective function.

In particular, Arntzen et al. (1995) applied the Global Supply Chain Model (GSCM) to the Digital Equipment Corporation so as to evaluate global supply chain alternatives and to determine the worldwide manufacturing and distribution strategies. In their mixed-integer linear programming model to minimize the weighted combination of total cost and activity days, the authors adopted a weighted activity time to measure activity days throughout the supply chain, which is the sum of processing times for each individual segment multiplied by the number of units processed or shipped through the link. However, we believe that the authors oversimplified the weighted activity time in assuming that the unit processing activity days are fixed, regardless of the facility capacities and the product flows. Also, in some other mathematical models dealing with time-sensitive demand, the lead time is used as the only indicator to differentiate the demand groups (see Cheong, Bhatnagar, and Graves (2004)). We note that Ferdows, Lewis, and Machuca (2004) recognized the nonlinear relationship between

capacity and time in the context of the fashion industry and fast response with a focus on Zara and, hence, an appropriate model for fashion supply chain management must be able to handle such nonlinearities.

In this paper, we utilize a network economics approach to develop a mathematical model for fashion supply chain management that allows a firm to determine its cost-minimizing and time-minimizing multiproduct flows, subject to demand satisfaction at the demand markets, with the inclusion of an appropriate weight associated with time minimization. Hence, we utilize a multicriteria decision-making perspective. In addition, we allow the cost on each network link, be it one corresponding to manufacturing (or procurement), to transportation/shipment, and/or to storage, or to any other type of product processing, which may also include administrative processing associated with importing/exporting, to be an increasing function of the flow in order to capture the aspect of capacity and, in effect, congestion, as would result in queuing phenomena. Hence, we take some ideas from the transportation and logistics literature (cf. Nagurney (1999) and the references therein). Similar assumptions we impose on the link time functions since, clearly, the time to process a volume of fashion product should be dependent on the flow. Given the realities of the fashion industry in the US (see, e.g., Sen (2008)), it is imperative to have a methodological framework that can provide decision-makers with both cost and time information associated with the complex network of fashion supply chain activities. As early as Fisher (1997) it has been recognized that different products may require distinct supply chains.

Multicriteria decision-making for supply chain management applications has been applied in both centralized and decentralized decision-making contexts and in the case of general, multitiered networks (see, e.g., Nagurney (2006) and Nagurney and Qiang (2009) and the references therein) with the most popular criteria utilized

being cost, quality, and on-time delivery (Ho, Xu and Dey (2010)). Nagurney et al. (2005), in turn, developed a multitiered competitive supply chain network equilibrium model with supply side and demand side risk (see also Dong et al. (2005) and Nagurney and Matsypura (2005)). Nagurney and Woolley (2010) studied the decision-making problem associated with supply chain network integration, in the context of mergers and acquisitions, so as to minimize the cost and the emissions generated. Nagurney and Nagurney (2010) added environmental concerns into a supply chain network design model. In this paper, we capture the explicit time consumption associated with fashion supply chain activities, along with the associated costs, within a network framework. The model in this paper provides decision-makers with insights associated with trade-offs between the operational costs and the time involved in a multiproduct fashion supply chain subject to multimarket demand satisfaction.

This paper is organized as follows. In “The Fashion Supply Chain Management Model,” we develop the fashion supply chain management model and reveal the generality of the associated network framework. We provide both the multicriteria decision-making optimization model as well as its equivalent variational inequality formulation. The latter is given, for the sake of generality, since it provides us with the foundation to also develop models for multiproduct competition in the fashion industry, with results on supply chain network design under oligopolistic competition and profit maximization obtained in Nagurney (2010). In addition, the variational inequality form allows for the efficient and effective computation of the multiproduct supply chain network flows. We also provide some qualitative properties.

In “Numerical Examples” we illustrate the model and its potential applications to fashion supply chain management through a series of numerical examples. In the concluding section, we summarize the results in this paper and provide suggestions for future research.

## THE FASHION SUPPLY CHAIN MANAGEMENT MODEL

We assume that the fashion firm is involved in the production, storage, and distribution of multiple fashion products and is seeking to determine its optimal multiproduct flows to its demand points (markets) under total cost minimization and total time minimization, with the latter objective function weighted by the fashion firm.

We consider the fashion supply chain network topology depicted in Figure 1 but emphasize that the modeling framework developed here is not limited to such a network. This network is only representative, for definiteness. The origin node in the network in Figure 1 consists of node 1, which represents the beginning of the product processing, and the destination nodes,  $R_1, \dots, R_{n_r}$ , are the demand points (markets) located at the bottom tier of the network. The paths joining the origin node to the destination nodes represent sequences of supply chain network activities corresponding to directed links that ensure that the fashion products are produced and, ultimately, delivered to the demand points. Hence, different supply chain network topologies to that depicted in Figure 1 correspond to distinct fashion supply chain network problems. For example, if the fashion product(s) can be delivered directly to the demand points from a manufacturing plant, then there would be, as depicted, links joining the corresponding nodes.

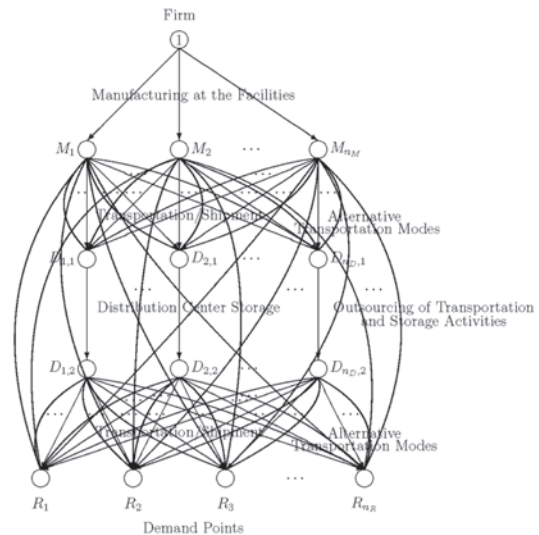
We assume that the fashion producing firm is involved in the production, storage, and transportation / distribution of  $J$  products, with a typical product denoted by  $j$ . In particular, as depicted in Figure 1, we assume that the firm has, at its disposal,  $n_M$  manufacturing facilities/plants;  $n_D$  distribution centers, and must serve the  $n_R$  demand points. The links from the top-tiered node are connected to the manufacturing facility nodes of the firm, which are denoted, respectively, by:  $M_1, \dots, M_{n_M}$ . The links from the manufacturing

facility nodes, in turn, are connected to the distribution/storage center nodes of the firm, which are denoted by  $D_{1,1}, \dots, D_{n_D,1}$ . Here we allow for the possibility of multiple links joining each such pair of nodes to reflect possible alternative modes of transportation/shipment between the manufacturing facilities and the distribution centers, an issue highly relevant to the fashion industry.

The links joining nodes  $D_{1,1}, \dots, D_{n_D,1}$  with nodes  $D_{1,2}, \dots, D_{n_D,2}$  correspond to the possible storage links for the products. Finally, there are multiple transportation/shipment links joining the nodes  $D_{1,2}, \dots, D_{n_D,2}$  with the demand nodes:  $R_1, \dots, R_{n_R}$ . Distinct such links also correspond to different modes of transportation/shipment.

The outermost links in Figure 1 can also depict the option of possible outsourcing of the transportation and storage activities, with appropriate assigned costs and time values, as will be discussed below. Indeed, our supply chain network framework is sufficiently general and flexible to also capture alternatives (such as outsourcing of

Figure 1. The fashion supply chain network topology



some of the supply chain network activities) that may be available to the fashion firm.

We assume that in the supply chain network topology there exists one path (or more) joining node 1 with each destination node. This assumption for the fashion supply chain network model guarantees that the demand at each demand point will be satisfied. We denote the supply chain network consisting of the graph  $G=[N, L]$ , where  $N$  denotes the set of nodes and  $L$  the set of directed links.

The demands for the fashion products are assumed as given and are associated with each product and each demand point. Let  $d_k^j$  denote the demand for the product  $j, j=1, \dots, J$ , at demand point  $R_k$ . A path consists of a sequence of links originating at the top node and denotes supply chain activities comprising manufacturing, storage, and transportation/shipment of the products to the demand nodes. Note that, if need be, one can also add other tiers of nodes and associated links to correspond to import/export administrative activities. Let  $x_p^j$  denote the nonnegative flow of product  $j$  on path  $p$ . Let  $P_k$  denote the set of all paths joining the origin node 1 with destination (demand) node  $R_k$ . The paths are assumed to be acyclic.

The following conservation of flow equations must hold for each product  $j$  and each demand point  $R_k$ :

$$\sum_{p \in P_k} x_p^j = d_k^j, \quad j = 1, \dots, J; \quad k = 1, \dots, n_R, \quad (1)$$

that is, the demand for each product must be satisfied at each demand point.

Links are denoted by  $a, b$ , etc. Let  $f_a^j$  denote the flow of product  $j$  on link  $a$ . We must have the following conservation of flow equations satisfied:

$$f_a^j = \sum_{p \in P} x_p^j \delta_{ap}, \quad j = 1, \dots, J; \quad \forall a \in L, \quad (2)$$

where  $\delta_{ap} = 1$  if link  $a$  is contained in path  $p$  and  $\delta_{ap} = 0$ , otherwise. In other words, the flow of a product on a link is equal to the sum of flows of the product on paths that contain that link. Here  $P$  denotes the set of all the paths in Figure 1. The path flows must be nonnegative, that is,

$$x_p^j \geq 0, \quad j = 1, \dots, J; \quad \forall p \in P. \quad (3)$$

We group the path flows into the vector  $x$  and the link flows into the vector  $f$ , respectively.

Below we present the optimization problems in path flows and in link flows.

There is a unit operational cost associated with each product and each link (cf. Figure 1) of the network. We denote the unit cost on a link  $a$  associated with product  $j$  by  $c_a^j$ . The unit cost of a link associated with each product, be it a manufacturing link, a transportation/shipment link, or a storage link, etc., is assumed, for the sake of generality, to be a function of the flow of all the products on the link. Hence, we have that

$$c_a^j = c_a^j(f_a^1, \dots, f_a^J), \quad j = 1, \dots, J; \quad \forall a \in L. \quad (4)$$

Note that in the case of an outsourcing link for a fashion product the unit cost may be fixed, as per the negotiated contract.

Let  $C_p^j$  denote the unit operational cost associated with product  $j, j=1, \dots, J$ , on a path  $p$ , where

$$C_p^j = \sum_{a \in L} c_a^j \delta_{ap}, \quad j = 1, \dots, J; \quad \forall p \in P. \quad (5)$$

Then, the total operational cost for product  $j, j=1, \dots, J$ , on path  $p, p \in P$ , in view of (2), (4), and (5), can be expressed as:

$$\hat{C}_p^j(x) = C_p^j(x) \times x_p^j, \quad j = 1, \dots, J; \quad \forall p \in P. \quad (6)$$

The total cost minimization problem, hence, is formulated as:

$$\text{Minimize } \sum_{j=1}^J \sum_{p \in P} \hat{C}_p^j(x), \quad (7)$$

subject to constraints (1) and (3).

In addition, the firm also seeks to minimize the time consumption associated with the demand satisfaction for each product at each demand point. Let  $t_a^j$  denote the average unit time consumption for product  $j$ ;  $j=1, \dots, J$ , on link  $a$ ,  $a \in L$ . We assume that

$$t_a^j = t_a^j(f_a^1, \dots, f_a^J), \quad j = 1, \dots, J, \quad \forall a \in L, \quad (8)$$

that is, the link average unit time consumption is, also, for the sake of generality, a function of the flow of all the products on that link.

Therefore, the average unit time consumption for product  $j$  on path  $p$  is:

$$T_p^j = \sum_{a \in L} t_a^j \delta_{ap}, \quad j = 1, \dots, J, \quad \forall p \in P, \quad (9)$$

with the total time consumption for product  $j$  on path  $p$ , in view of (2), (8), and (9), given by:

$$\hat{T}_p^j(x) = T_p^j(x) \times x_p^j, \quad j = 1, \dots, J; \quad \forall p \in P. \quad (10)$$

The objective of time minimization problem is to minimize the total time associated with the supply chain network processing of all the products, which yields the following optimization problem:

$$\text{Minimize } \sum_{j=1}^J \sum_{p \in P} \hat{T}_p^j(x), \quad (11)$$

subject to constraints (1) and (3).

The optimization problems (7) and (11) can be integrated into a single multicriteria objective function (cf. Dong et al. (2005)) using a weighting factor,  $\omega$ , representing the preference of the decision-making authority. Please note that  $\omega$  here can be interpreted as the monetary value of a unit of time. Consequently, the multicriteria decision-making problem, in path flows, can be expressed as:

$$\text{Minimize } \sum_{j=1}^J \sum_{p \in P} \hat{C}_p^j(x) + \omega \sum_{j=1}^J \sum_{p \in P} \hat{T}_p^j(x), \quad (12)$$

subject to constraints (1) and (3).

The optimization problem (12) with the use of (2), (4), (5), (8), and (9), can be equivalently reformulated in link flows, rather than in path flows, as done above, as:

$$\text{Minimize } \sum_{j=1}^J \sum_{a \in L} \hat{c}_a^j + \omega \sum_{j=1}^J \sum_{a \in L} \hat{t}_a^j, \quad (13)$$

subject to constraints (1)-(3) where  $\hat{c}_a^j \equiv c_a^j(f_a^1, \dots, f_a^J) \times f_a^j$  and the  $\hat{t}_a^j \equiv t_a^j(f_a^1, \dots, f_a^J) \times f_a^j$ . We assume that the total link cost functions  $\hat{c}_a^j$  and total time functions  $\hat{t}_a^j$  are convex and continuously differentiable, for all products  $j$  and all links  $a \in L$ .

Let  $K$  denote the feasible set such that

$$K \equiv \{x \mid (1) \text{ and } (3) \text{ are satisfied}\}. \quad (14)$$

We now state the following result in which we derive the variational inequality formulations of the problem in both path flows and link flows, respectively. Having alternative formulations allows for the application of distinct algorithms (see, e.g., Nagurney (2006)).

### THEOREM 1

A path flow vector  $x^* \in K$  is an optimal solution to the optimization problem (12), subject to constraints (1) and (3), if and only if it is a solution to the variational inequality problem in path flows: determine the vector of optimal path flows,  $x^* \in K$ , such that:

$$\sum_{j=1}^J \sum_{p \in P} \left[ \frac{\partial \hat{C}_p^j(x^*)}{\partial x_p^j} + \omega \frac{\partial \hat{T}_p^j(x^*)}{\partial x_p^j} \right] \times (x_p^j - x_p^{j*}) \geq 0, \quad \forall x \in K, \quad (15)$$

where  $\frac{\partial \hat{C}_p^j(x)}{\partial x_p^j} \equiv \sum_{l=1}^J \sum_{a \in L} \frac{\partial \hat{c}_a^l(f_a^1, \dots, f_a^J)}{\partial f_a^j} \delta_{ap}$ , and  $\frac{\partial \hat{T}_p^j(x)}{\partial x_p^j} \equiv \sum_{l=1}^J \sum_{a \in L} \frac{\partial \hat{t}_a^l(f_a^1, \dots, f_a^J)}{\partial f_a^j} \delta_{ap}$ .

A link flow vector  $f^* \in K^1$  is an optimal solution to the optimization problem (13), subject to constraints (1) – (3), in turn, if and only if it is a solution to the variational inequality problem in link flows: determine the vector of optimal link flows,  $f^* \in K^1$ , such that:

$$\sum_{j=1}^J \sum_{l=1}^J \sum_{a \in L} \left[ \frac{\partial \hat{c}_a^l(f_a^{1*}, \dots, f_a^{J*})}{\partial f_a^j} + \omega \frac{\partial \hat{t}_a^l(f_a^{1*}, \dots, f_a^{J*})}{\partial f_a^j} \right] \times (f_a^j - f_a^{j*}) \geq 0, \quad \forall f \in K^1, \quad (16)$$

where  $K^1 \equiv \{f \mid (1) - (3) \text{ are satisfied}\}$ .

**Proof:** The result follows from the standard theory of variational inequalities (see the book by Nagurney (1999) and the references therein) since the functions comprising the objective functions are convex and continuously differentiable under the imposed assumptions and the respective feasible sets consisting of the constraints are nonempty, closed, and convex. Q.E.D.

In addition, the following theoretical results in terms of the existence of solutions as well as the uniqueness of a link flow solution are immediate from the theory of variational inequalities. Indeed, the existence of solutions to (15) and (16) is guaranteed since the underlying feasible sets,  $K$  and  $K^1$ , are compact and the corresponding functions of marginal total costs and marginal total time are continuous, under the above assumptions. If the total link cost functions and the total time functions are strictly convex, then the solution to (16) is guaranteed to be unique.

It is worth noting that the above model contains, as a special case, the multiclass system-optimization transportation network model of Dafermos (1972) if we set  $\omega=0$ . The fashion supply chain management network model developed here is novel since it captures both the reality of multiple products in this application domain as well as the significant relevant criteria of cost minimization as well as time minimization in the production and delivery of the fashion products to the demand markets.

Variational inequality (15) can be put into standard form (see Nagurney (1999)): determine  $X^* \in K$  such that:

$$\langle F(X^*)^T, X - X^* \rangle \geq 0, \quad \forall X \in K, \quad (17)$$

where  $\langle \cdot, \cdot \rangle$  denotes the inner product in  $n$ -dimensional Euclidean space. Indeed, if we define the column vectors:  $X=x$  and

$$F(X) \equiv \left[ \begin{array}{c} \frac{\partial \hat{C}_p^j(x)}{\partial x_p^j} + \omega \frac{\partial \hat{T}_p^j(x)}{\partial x_p^j} \\ j = 1, \dots, J; p \in P \end{array} \right], \quad (18)$$

and  $K=K$  then (15) can be re-expressed as (17).

Similarly, if we define the column vectors:  $X=f$  and



$$F(X) \equiv \left[ \begin{array}{c} \frac{\partial \hat{c}_a^l(f_a^1, \dots, f_a^J)}{\partial f_a^j} + \omega \frac{\partial \hat{t}_a^l(f_a^1, \dots, f_a^J)}{\partial f_a^j} \\ j = 1, \dots, J; l = 1, \dots, J; a \in L \end{array} \right], \quad (19)$$

and  $K=K^1$  then (16) can be re-expressed as (17).

Note that the above model may be transformed into a single product network model by making as many copies of the network in Figure 1 as there are products and by constructing appropriate link total cost and time functions, which would be nonseparable, and by redefining the associated link flows, path flows, and demands accordingly. For details, see Nagurney and Qiang (2009) and the references therein.

## NUMERICAL EXAMPLES

We now, for illustration purposes, present fashion supply chain numerical examples, both single product and multiproduct ones.

### Single Product Fashion Supply Chain Examples

We assume that the fashion firm is involved in the production of a single fashion product and has, at its disposal, two manufacturing plants and two distribution centers. It must supply two different demand points. Hence, the topology is as depicted in Figure 2.

The manufacturing plant  $M_1$  is located in the U.S., while the manufacturing plant  $M_2$  is located off-shore and has lower operating cost. The average manufacturing time consumption of one unit of product is identical at these two plants, while the related costs vary mainly because of the different labor costs. The total cost functions and the total time functions for all the links are given in Table 1.

The demands for this fashion product at the demand points are:

$$d_1=100, d_2=200,$$

that is, the market at demand point  $R_1$  is half that at demand market  $R_2$ .

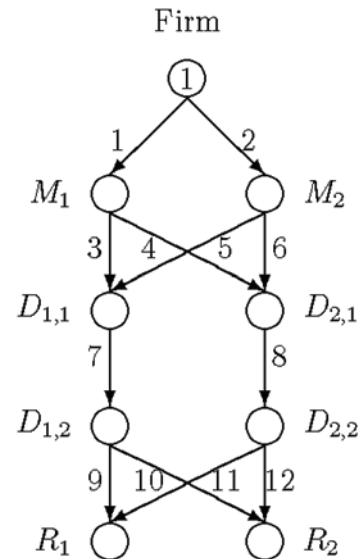
We used the the general equilibration algorithm of Dafermos and Sparrow (1969) (see also, e.g., Nagurney (1999)) for the solution of the numerical examples.

We conducted sensitivity analysis by varying the value of time,  $\omega$ , for  $\omega=0,1,2,3,4,5$ . The computed optimal link flows are reported in Table 2.

We now display the optimal link flows as  $\omega$  varies for the manufacturing links in Figure 3; for the first set of transportation links in Figure 4; for the set of storage links in Figure 5, and for the bottom tier of transportation links in Figure 6.

It is interesting to note from Figure 3 that, with the increase of the value of time, part of the fashion production is shifted from offshore manufacturing plant  $M_2$  to onshore facility  $M_1$ , due to the onshore facility's advantage of shorter transportation time to distribution centers (or demand markets). Consequently, there is an increase in

Figure 2. The supply chain network topology for the numerical examples



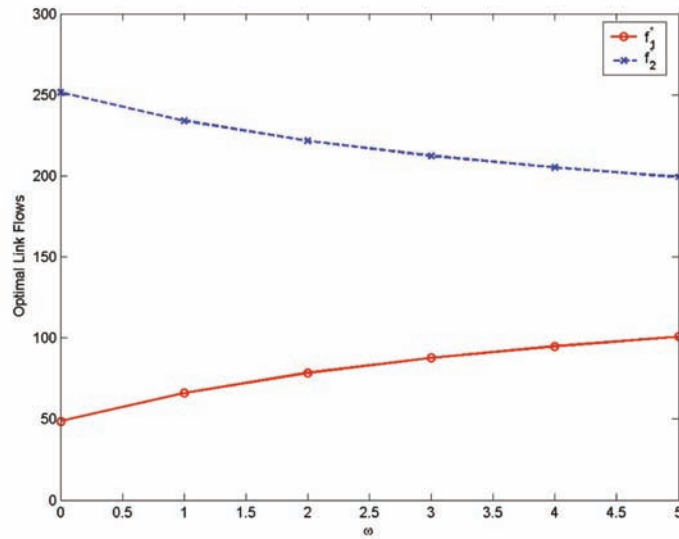
*Table 1. Total link operational cost and total time functions*

Link $a$	$\hat{c}_a(f_a)$	$\hat{t}_a(f_a)$
1	$10f_1^2 + 10f_1$	$f_1^2 + 10f_1$
2	$f_2^2 + 5f_2$	$f_2^2 + 10f_2$
3	$f_3^2 + 3f_3$	$.5f_3^2 + 5f_3$
4	$f_4^2 + 4f_4$	$.5f_4^2 + 7f_4$
5	$2f_5^2 + 30f_5$	$.5f_5^2 + 25f_5$
6	$2f_6^2 + 20f_6$	$.5f_6^2 + 15f_6$
7	$.5f_7^2 + 3f_7$	$f_7^2 + 5f_7$
8	$f_8^2 + 3f_8$	$f_8^2 + 2f_8$
9	$f_9^2 + 2f_9$	$f_9^2 + 5f_9$
10	$2f_{10}^2 + f_{10}$	$f_{10}^2 + 3f_{10}$
11	$f_{11}^2 + 5f_{11}$	$f_{11}^2 + 2f_{11}$
12	$f_{12}^2 + 4f_{12}$	$f_{12}^2 + 4f_{12}$

*Table 2. Computed optimal link flows  $f_a^*$  as  $\omega$  increases*

Link $a$	$\omega=0$	$\omega=1$	$\omega=2$	$\omega=3$	$\omega=4$	$\omega=5$
1	48.66	66.02	78.41	87.71	94.94	100.73
2	251.34	233.98	221.59	212.29	205.06	199.27
3	31.06	36.68	42.13	46.49	49.97	52.80
4	17.60	29.34	36.29	41.22	44.97	47.93
5	127.66	116.89	109.82	104.67	100.72	97.58
6	123.68	117.09	111.76	107.62	104.34	101.69
7	158.72	153.57	151.95	151.16	150.69	150.38
8	141.28	146.43	148.05	148.84	149.31	149.62
9	75.23	62.87	58.43	56.14	54.74	53.80
10	83.49	90.70	93.51	95.02	95.95	96.58
11	24.77	37.13	41.57	43.86	45.26	46.20
12	116.51	109.30	106.49	104.98	104.05	103.42

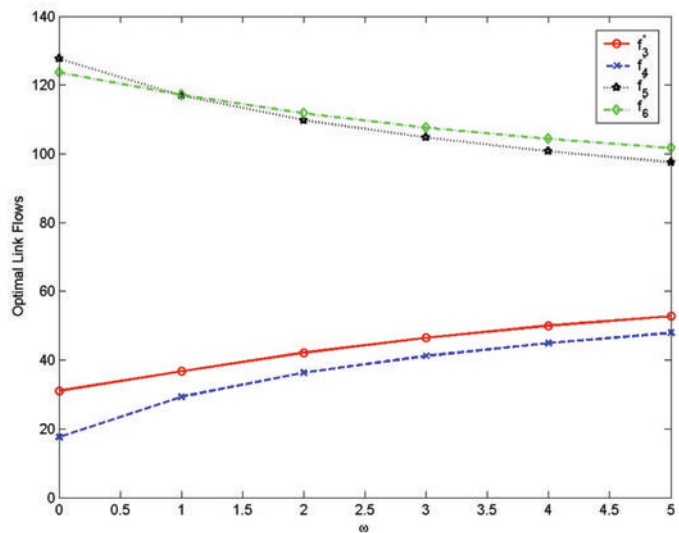
Figure 3. Optimal link flows on manufacturing links 1 and 2 as  $\omega$  increases



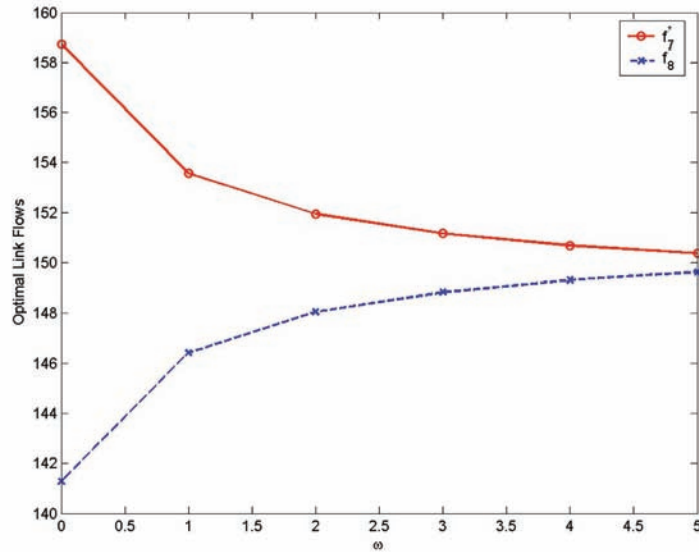
transportation flow from the onshore facility  $M_1$  to the distribution centers, as depicted in Figure 4. Figure 5, in turn, illustrates that distribution center  $D_2$  is getting to be an appealing choice as the time performance concern increases, although the storage cost there is slightly higher than at  $D_1$ .

Also, as the value of time increases, a volume of the fashion product flow switches from transportation link 9 (or link 12) to transportation link 11 (or link 10), to reduce the total time consumption of the distribution activities (as shown in Figure 6).

Figure 4. Optimal link flows on transportation links 3, 4, 5, and 6 as  $\omega$  increases



*Figure 5. Optimal link flows on storage links 7 and 8 as  $\omega$  increases*

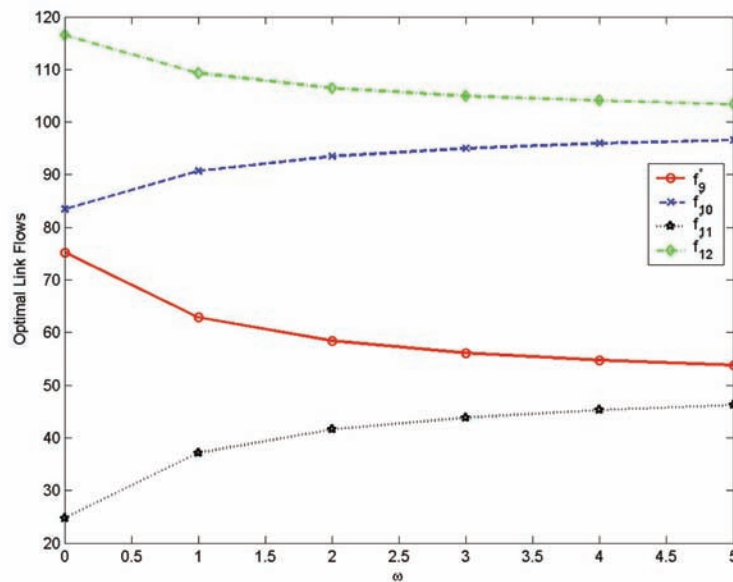


In Table 3, we provide the values of the total costs and the total time at the optimal solutions for the examples as  $\omega$  increases.

The values of the minimal total costs and the minimal total time for varying  $\omega$  are displayed

graphically in Figure 7. As can be seen from Figure 7, as the weight  $\omega$  increases the minimal total time decreases, as expected, since a higher value of  $\omega$  represents an increase in the decision-maker's valuation of time as a criterion.

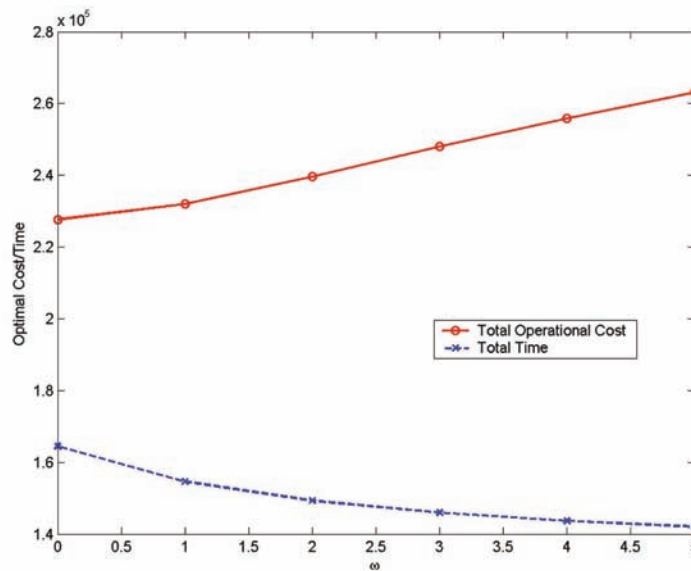
*Figure 6. Optimal link flows on transportation links 9, 10, 11, and 12 as  $\omega$  increases*



*Table 3. Total costs and total times as  $\omega$  increases*

	$\omega=0$	$\omega=1$	$\omega=2$	$\omega=3$	$\omega=4$	$\omega=5$
Total cost	227,590.89	231,893.93	239,656.04	247,949.30	255,864.62	263,121.79
Total time	164,488.11	154,652.53	149,329.07	145,965.20	143,684.11	142,061.79

*Figure 7. Minimal total costs and minimal total times as  $\omega$  increases*



### **Multiproduct Fashion Supply Chain Examples**

We then considered multiproduct fashion supply chain problems. We assumed that the fashion firm provides two different fashion products with the same supply chain network topology as depicted in Figure 2. The total cost functions and the total time functions for all the links associated with product 1 and product 2 are given in Table 4 and 5, respectively.

The demands for the two fashion products at the demand points are:

$$d_1^1 = 100, \quad d_2^1 = 200,$$

$$d_1^2 = 300, \quad d_2^2 = 400.$$

To solve these problems, we used the modified projection method of Korpelevich (1977), embedded with the general equilibration algorithm of Dafermos and Sparrow (1969) (see also, e.g., Nagurney (1999)).

We also conducted sensitivity analysis, as in the section “Single Product Fashion Supply Chain Examples,” by varying the value of time,  $\omega$ , for  $\omega=0,1,2,3,4,5$ . The computed optimal link flows associated with products 1 and 2 are, respectively, reported in Tables 6 and 7.

We display the optimal link flows of products 1 and 2 as  $\omega$  varies for the manufacturing links in Figure 8; for the first set of transportation links in Figure 9; for the set of storage links in Figure 10, and for the bottom tier of transportation links in Figure 11.

*Table 4. Total link operational cost and total time functions for product 1*

Link $a$	$\hat{c}_a^1(f_a^1, f_a^2)$	$\hat{t}_a^1(f_a^1, f_a^2)$
1	$10(f_1^1)^2 + 1f_1^1 f_1^2 + 10f_1^1$	$1(f_1^1)^2 + .3f_1^1 f_1^2 + 10f_1^1$
2	$1(f_2^1)^2 + .4f_2^1 f_2^2 + 5f_2^1$	$1(f_2^1)^2 + .3f_2^1 f_2^2 + 10f_2^1$
3	$1(f_3^1)^2 + .3f_3^1 f_3^2 + 3f_3^1$	$.5(f_3^1)^2 + .2f_3^1 f_3^2 + 5f_3^1$
4	$1(f_4^1)^2 + .2f_4^1 f_4^2 + 4f_4^1$	$.5(f_4^1)^2 + .2f_4^1 f_4^2 + 7f_4^1$
5	$2(f_5^1)^2 + .25f_5^1 f_5^2 + 30f_5^1$	$.5(f_5^1)^2 + .1f_5^1 f_5^2 + 25f_5^1$
6	$2(f_6^1)^2 + .3f_6^1 f_6^2 + 20f_6^1$	$.5(f_6^1)^2 + .1f_6^1 f_6^2 + 15f_6^1$
7	$.5(f_7^1)^2 + .1f_7^1 f_7^2 + 3f_7^1$	$1(f_7^1)^2 + .5f_7^1 f_7^2 + 5f_7^1$
8	$1(f_8^1)^2 + .1f_8^1 f_8^2 + 3f_8^1$	$1(f_8^1)^2 + .5f_8^1 f_8^2 + 2f_8^1$
9	$1(f_9^1)^2 + .5f_9^1 f_9^2 + 2f_9^1$	$1(f_9^1)^2 + .2f_9^1 f_9^2 + 5f_9^1$
10	$2(f_{10}^1)^2 + .3f_{10}^1 f_{10}^2 + 1f_{10}^1$	$1(f_{10}^1)^2 + .4f_{10}^1 f_{10}^2 + 3f_{10}^1$
11	$1(f_{11}^1)^2 + .6f_{11}^1 f_{11}^2 + 5f_{11}^1$	$1(f_{11}^1)^2 + .25f_{11}^1 f_{11}^2 + 2f_{11}^1$
12	$1(f_{12}^1)^2 + .7f_{12}^1 f_{12}^2 + 4f_{12}^1$	$1(f_{12}^1)^2 + .25f_{12}^1 f_{12}^2 + 4f_{12}^1$

With the increase of the value of time, parts of the production of fashion products 1 and 2 are shifted from offshore manufacturing plant  $M_2$  to onshore facility  $M_1$  (as depicted in Figure 8), resulting in an increase in transportation flow from  $M_1$  to the distribution centers for both fashion products (as shown in Figure 9). However, Figure 10 illustrates that the distribution center  $D_2$  is getting to be appealing for product 1 as the value of time increases, while the distribution center  $D_1$  becomes attractive for product 2, since the distribution center  $D_1$  is more time-efficient for product 2. In Figure 11, as the time performance concern increases, a volume of fashion product

1 switches from transportation link 9 to link 11; in contrast, the volume of flow of fashion product 2 on link 9 increases. Also, a volume of fashion product 2 switches from link 12 to link 10, while the flows of fashion product 1 on link 10 and 12 change slightly.

The values of the total costs and the total time at the optimal solutions for the examples as  $\omega$  increases are provided in Table 8, and displayed graphically in Figure 12. As expected, the minimal total time decreases as  $\omega$  increases.

*Table 5. Total link operational cost and total time functions for product 2*

Link $a$	$\hat{c}_a^2(f_a^1, f_a^2)$	$\hat{t}_a^2(f_a^1, f_a^2)$
1	$8(f_1^2)^2 + 1f_1^1 f_1^2 + 10f_1^2$	$1(f_1^2)^2 + .5f_1^1 f_1^2 + 8f_1^2$
2	$1(f_2^2)^2 + .5f_2^1 f_2^2 + 4f_2^2$	$1(f_2^2)^2 + .5f_2^1 f_2^2 + 8f_2^2$
3	$1.5(f_3^2)^2 + .2f_3^1 f_3^2 + 3f_3^2$	$1(f_3^2)^2 + .1f_3^1 f_3^2 + 3f_3^2$
4	$1(f_4^2)^2 + .3f_4^1 f_4^2 + 4f_4^2$	$1(f_4^2)^2 + .2f_4^1 f_4^2 + 3f_4^2$
5	$2(f_5^2)^2 + .3f_5^1 f_5^2 + 25f_5^2$	$.8(f_5^2)^2 + .1f_5^1 f_5^2 + 20f_5^2$
6	$3(f_6^2)^2 + .4f_6^1 f_6^2 + 20f_6^2$	$.8(f_6^2)^2 + .2f_6^1 f_6^2 + 12f_6^2$
7	$1(f_7^2)^2 + .1f_7^1 f_7^2 + 3f_7^2$	$1(f_7^2)^2 + .4f_7^1 f_7^2 + 4f_7^2$
8	$.5(f_8^2)^2 + .2f_8^1 f_8^2 + 3f_8^2$	$1(f_8^2)^2 + .6f_8^1 f_8^2 + 4f_8^2$
9	$2(f_9^2)^2 + .3f_9^1 f_9^2 + 2f_9^2$	$1(f_9^2)^2 + .1f_9^1 f_9^2 + 7f_9^2$
10	$1(f_{10}^2)^2 + .5f_{10}^1 f_{10}^2 + 1f_{10}^2$	$1(f_{10}^2)^2 + .3f_{10}^1 f_{10}^2 + 6f_{10}^2$
11	$2(f_{11}^2)^2 + .5f_{11}^1 f_{11}^2 + 8f_{11}^2$	$1(f_{11}^2)^2 + .3f_{11}^1 f_{11}^2 + 3f_{11}^2$
12	$1(f_{12}^2)^2 + .4f_{12}^1 f_{12}^2 + 7f_{12}^2$	$1(f_{12}^2)^2 + .5f_{12}^1 f_{12}^2 + 4f_{12}^2$

*Table 6. Computed optimal link flows  $f_a^{1*}$  as  $\omega$  increases for product 1*

Link $a$	$\omega=0$	$\omega=1$	$\omega=2$	$\omega=3$	$\omega=4$	$\omega=5$
1	53.81	71.31	83.38	92.24	99.02	104.39
2	246.19	228.69	216.62	207.76	200.98	195.61
3	41.58	43.44	47.03	50.23	52.90	55.10
4	12.23	27.87	36.35	42.01	46.13	49.29
5	125.73	114.20	106.97	101.86	98.02	95.01
6	120.45	114.49	109.64	105.90	102.96	100.60
7	167.32	157.64	154.00	152.09	150.91	150.11
8	132.68	142.36	146.00	147.91	149.09	149.89
9	73.27	63.60	60.07	58.25	57.14	56.39
10	94.05	94.04	93.93	93.84	93.78	93.73
11	26.73	36.40	39.93	41.75	42.86	43.61
12	105.95	105.96	106.07	106.16	106.22	106.27

*Table 7. Computed optimal link flows  $f_a^{2*}$  as  $\omega$  increases for product 2*

Link $a$	$\omega=0$	$\omega=1$	$\omega=2$	$\omega=3$	$\omega=4$	$\omega=5$
1	150.04	192.14	219.13	237.85	251.58	262.07
2	549.96	507.86	480.87	462.15	448.42	437.93
3	17.38	63.50	87.28	102.35	112.87	120.65
4	132.66	128.64	131.85	135.50	138.71	141.42
5	309.57	278.09	259.11	246.45	237.40	230.61
6	240.39	229.77	221.75	215.70	211.02	207.32
7	326.95	341.59	346.39	348.80	350.27	351.26
8	373.05	358.41	353.61	351.20	349.73	348.74
9	141.99	145.71	147.19	148.00	148.52	148.88
10	184.96	195.88	199.20	200.80	201.75	202.38
11	158.01	154.29	152.81	152.00	151.48	151.12
12	215.04	204.12	200.80	199.20	198.25	197.62

**SUMMARY AND CONCLUSION AND SUGGESTIONS FOR FUTURE RESEARCH**

In this paper, we developed a fashion supply chain management model, using a network econom-

ics perspective, that allows for multiple fashion products. The model consists of two objective functions: total cost minimization, associated with supply chain network activities, in the form of: manufacturing, storage, and distribution, and total time consumption minimization. A weighted

*Figure 8. Optimal link flows on manufacturing links 1 and 2 as  $\omega$  increases*

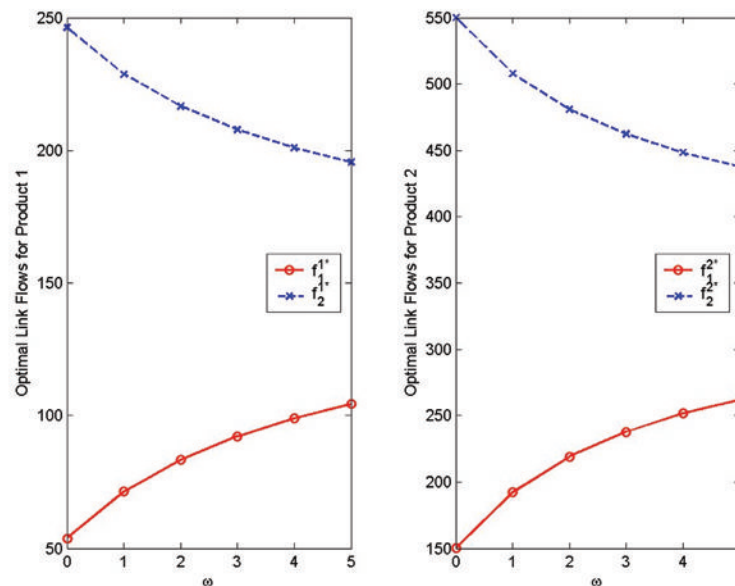




Figure 9. Optimal link flows on transportation links 3, 4, 5, and 6 as  $\omega$  increases

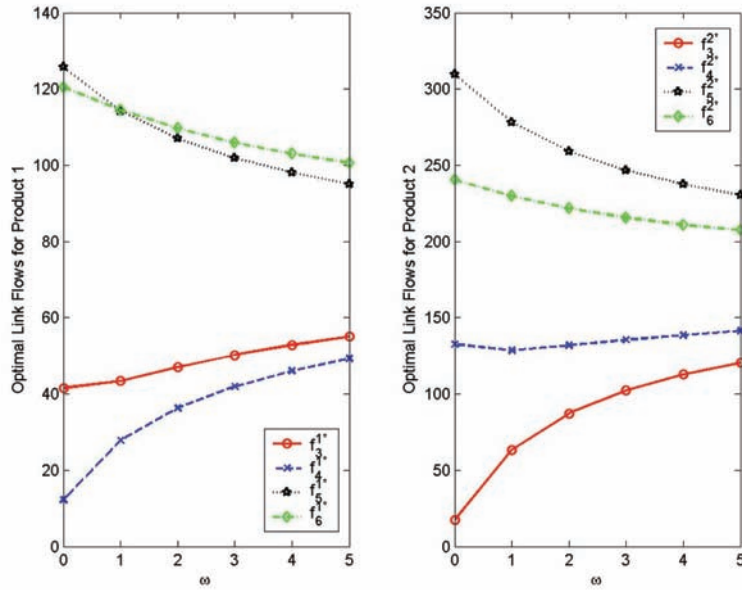


Figure 10. Optimal link flows on storage links 7 and 8 as  $\omega$  increases

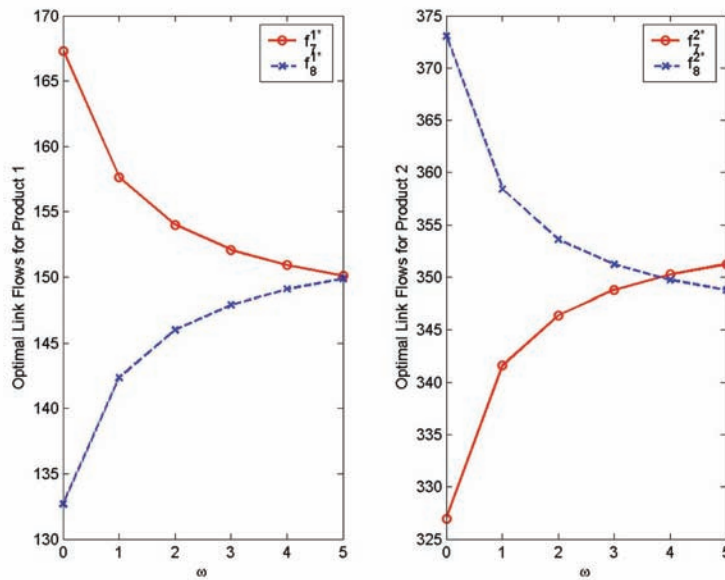


Figure 11. Optimal link flows on transportation links 9, 10, 11, and 12 as  $\omega$  increases

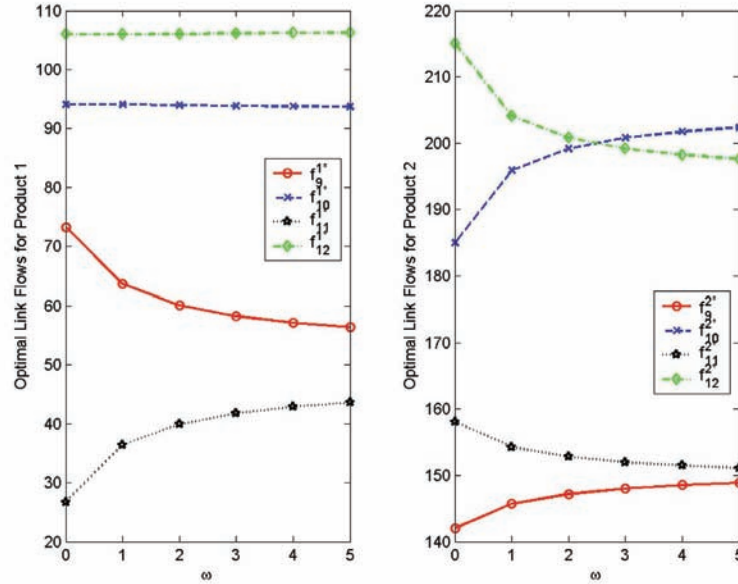
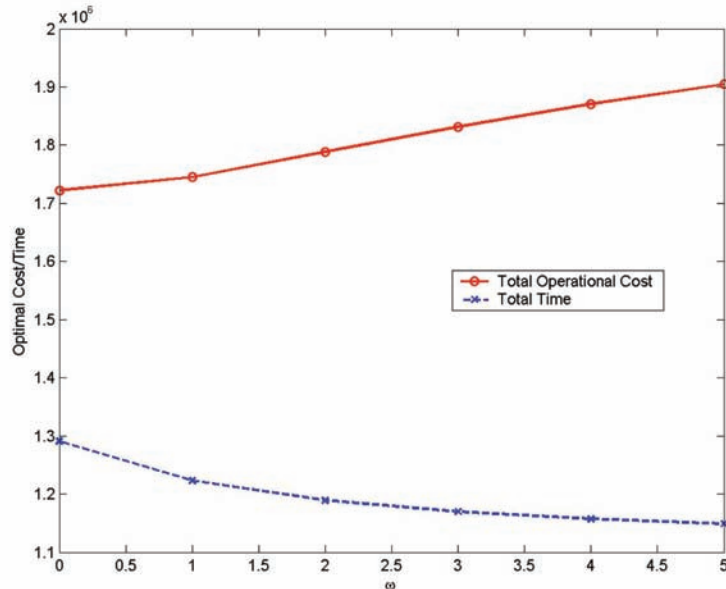


Table 8. Total costs and total times as  $\omega$  increases

	$\omega=0$	$\omega=1$	$\omega=2$	$\omega=3$	$\omega=4$	$\omega=5$
Total cost	1,722,082.05	1,745,201.77	1,788,457.21	1,831,689.80	1,870,523.21	1,904,398.75
Total time	1,291,094.62	1,222,959.73	1,189,192.37	1,169,656.19	1,157,297.60	1,148,975.34

Figure 12. Minimal total costs and minimal total times as  $\omega$  increases



objective function was then constructed with the weighting factor, representing the monetary value of a unit of time, decided by the firm.

We also provided the optimization model's equivalent variational inequality formulation, with nice features for computational purposes. The solution of the model yields the optimal multiproduct fashion flows of supply chain network activities, with the demands being satisfied at the minimal total cost and the minimal total time consumption. The model is illustrated with a spectrum of numerical examples with potential application to fashion supply chain management.

The fashion supply chain network model allows the cognizant decision-maker to evaluate the effects of changes in the demand for its products on the total operations costs and time. It allows for the evaluation of changes in the cost functions and the time functions on total supply chain network costs and time. In addition, the flexibility of the network framework allows for the evaluation of the addition of various links (or their removal) on the values of the objective function(s). Finally, the model, since it is network-based, is visually graphic.

The research in this paper can be extended in several directions. One can construct a fashion supply chain management model with price-sensitive and time-sensitive demands under oligopolistic competition. One can also incorporate environmental concerns and associated trade-offs. In addition, one can explore computationally as well as empirically large-scale fashion supply chain networks within our modeling framework. We leave such research for the future.

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## Chapter 2

# Trade Promotion Mode Choice and Information Sharing in Fashion Retail Supply Chains

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### ABSTRACT

*Trade promotion has a significant impact on the fashion retail business. Manufacturers have traditionally been concerned with the inefficient trade promotion due to the low pass-through rate of the trade deals from retailers to customers. The scan-back (SB) trade deal, which monitors a retailer's sales via an IT system, benefits the manufacturer, but may or may not benefit the retailer. We provide insight into when a retailer has incentive to accept the SB trade deal. We show that (1) the manufacturer and the entire supply chain can always benefit from the SB trade deal while the retailer benefits only under some conditions, and that (2) both the retailer and the manufacturer can benefit from the SB trade deal if the SB deal is accompanied by a buyback contract. We examine the effect of a retailer's confidential pass-through rate on a firm's incentive to use the SB trade deal.*

### INTRODUCTION

Consider a two-stage supply chain consisting of a manufacturer and a retailer. This chapter explores the incentives for these two firms in the two-stage fashion supply chain to shift from a traditional

trade promotion mode to a new mode enabled by information sharing. There are generally two modes of trade promotion: the *off-invoice (OI)* trade deal and the *scan-back (SB)* trade deal (Drèze & Bell, 2003). A traditional supply chain uses OI trade promotion in which a manufacturer gives trade promotion money to a retailer to encourage the latter to sell more of the manufacturer's

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product. However, the manufacturer usually cannot monitor whether the retailer fully passes the trade promotion money to the customers. Recent developments in information technology applied to supply chain management can create a new type of trade promotion called a scan-back (SB) trade deal. In the SB trade deal, the manufacturer reimburses the retailer based on the exact number of sales the retailer makes.

Trade promotion has a significant impact on the fashion businesses, particularly in the apparel industry. Kincaide, Woodard, and Park (2002) find that retailers' benefits in the apparel sector are significantly related to financial promotional support from manufacturers. Generally, promotion is an important instrument in cases of intense competition with high demand uncertainty, with the manufacturer producing fashion items and often giving the retailer a large trade promotion budget. However, retailers may take advantage of the trade promotion budget to maximize their profits at the expense of the manufacturer.

In the traditional OI trade deal, a manufacturer usually cannot directly ascertain how much the retailer spends on its sales promotion. The manufacturer can only observe the actual order from the retailer. Hence, the OI trade deal leads to the principal-agent problem, which is defined in game theory as the problem of motivating one decision-maker to act on behalf of the other. Therefore, an essential question for the manufacturer is how much of the trade promotion benefit is being passed to customers. In fact, many discussions about the OI trade deal refer to the *pass-through rate*, which is defined as the retailer's actual promotion spending divided by the total trade promotion amount offered to the retailer; often, this figure is not high enough for the manufacturer. Consequently, a critical challenge for manufacturers is to determine how to resolve this principal-agent problem, and more directly, how to monitor the retailer's promotion process.

The SB trade deal is one method of monitoring the retailer's pass-through rate. Whether the

retailer is willing to accept the SB trade deal, however, is another issue. The SB trade deal is implicitly linked to information technology, which frees the manufacturer from the principal-agent problem by allowing it to monitor end-sales to customers. For example, Cachon and Terwiesch (2005, Section 14.2) mention that Vendor Managed Inventory (VMI), a common information sharing system, can eliminate traditional methods of trade promotion. Generating a wholesale price reduction under a VMI system is offered as a scan-back deal. Obviously, since the SB trade deal gives the manufacturer access to end sales information, an SB trade deal eliminates the retailer's opportunity to pocket some portion of the trade promotion money. A retailer has no apparent reason to welcome a SB trade promotion since it forces the retailer to indirectly share its sales information with the manufacturer.

Supply chain management is critical for success in the fashion business. Over the last several years, a considerable number of studies on fashion supply chain and the apparel industry have been conducted. The importance of responsiveness in a fashion supply chain is among the most intensively researched themes of fashion supply chains. For example, Choi (2006) shows how a quick response policy, accompanied by a buyback contract, can benefit the firms belonging to a particular fashion supply chain. Choi and Chow (2008) explore the risk of quick response program to supply chain members using a mean-variance analysis. Bhardwaj and Fairhurst (2010) examine existing articles on fast fashion and responsiveness and then propose directions for future research in the fashion industry. Another important avenue in the study of fashion industry is to discuss design and item variety in apparel and textile industries. For example, developing a numerical decision support model, Vaagen and Wallace (2008) show a hedging portfolio of products benefits apparel firms when uncertainty of demand and fashion trend exist. Aspers (2010) uses the concept of "conceptual knowledge" to examine how design and marketing

sections of apparel firms get knowledge across global members of the fashion supply chain. Other themes that literature on fashion industry covers include capacity management (e.g., Sridharan, 1998), multiple product ordering (e.g., Lau & Lau, 1998), product planning (e.g., De Toni & Meneghetti, 2000), delivery scheduling (e.g., Chou, Chang, & Yang, 2001), postponement of garment dyeing (e.g., Yeh & Yang, 2003), and information updating (e.g., Choi, 2007). We, however, examine a fashion supply chain from quite a unique viewpoint. Our main concern is to consider the incentives of information sharing from the perspective of a retailer and of a supplier.

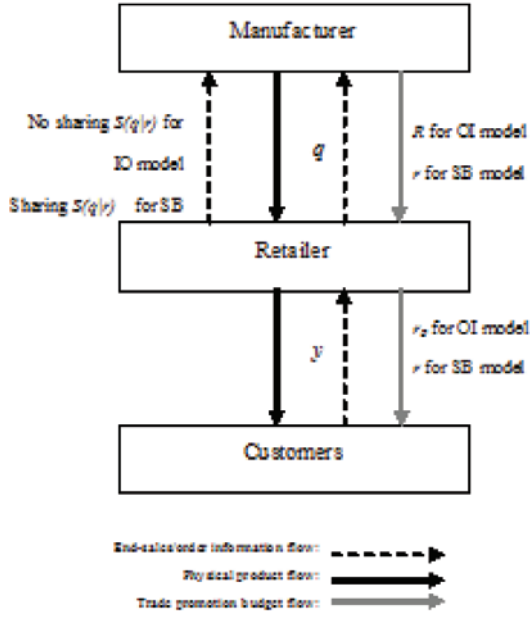
In fact, many information-sharing studies in recent supply chain literature discuss how a manufacturer can elicit information from retailers through inventory, lead time, and shortage allocation policies (e.g., Gavirneni, Kapuscinski, & Tayur, 1999; Cachon & Fisher, 2000; Chen, Drezner, Ryan, & Simchi-Levi, 2000; Lee, So, & Tang, 2000; Gavirneni 2002; Li & Zhang, 2008; Ha & Tong, 2008; Leng & Parlar, 2009; Chen & Lee, 2009). The primary focus of the information sharing literature is the benefit to the manufacturer. Relatively less research explicitly addressed the impact of information sharing on the retailer. The research suggests that information sharing is not necessarily favorable for all involved supply chain parties. For example, Gal-Or (1985) proves that in an oligopoly with symmetric  $n$  firms, the Nash equilibrium dictates that there is no incentive for a firm to share its information. Anand and Mendelson (1997) further show that if local knowledge can sufficiently compensate for a lack of centralized knowledge, a system without information sharing can be more effective than one with information sharing. Zhang (2002) states that, in the case of a supply chain with vertical information sharing and horizontal competition, a retailer is always worse off when sharing its demand information with a manufacturer, while the manufacturer is always better off.

Our goal is to compare the traditional OI trade deal with the SB trade deal and determine when a retailer in a two-stage supply chain has an incentive to switch from the OI trade deal to the SB trade deal. While there is research on trade promotions in the literature, little prior research compares the OI trade deal with the SB trade deal under a supply chain framework while analyzing the incentive for the SB deal and a supply chain contract. One existing study that is similar to ours is Taylor (2002), who investigated the supply chain coordination between a manufacturer and a retailer by comparing two types of channel rebates, a linear rebate and a target rebate. Our work makes three important contributions. First, we prove that the SB trade deal enhances the entire supply chain's profitability by identifying the conditions under which the SB trade deal is welcomed by all the supply chain members. Second, we demonstrate that the convexity of the promotion return on sales determines whether the retailer tends to keep its pass-through rate confidential. Third, we find that the SB trade deal accompanied by the buyback (BB) contract can serve as a win-win solution to maximize profits for the retailer and the manufacturer.

The rest of this chapter is organized as follows: In "Modeling Background," we explain the model framework. In "Model Analysis," we determine optimal order sizes and expected profits for four different scenarios. In "Comparison of the OI and SB Trade Deals," we investigate the retailer's incentive for accepting an SB trade deal. In "Supply Chain Coordination and Incentive," we examine supply chain coordination through a BB contract. In "Payment as Incentive," we discuss how payment from one firm to the other plays an incentive role for acceptance of the SB trade deal. In "Effect of the Retailer's Confidential Pass-Through Rate on the Manufacturer," we analyze the case in which the retailer's pass-through rate is unknown to the manufacturer. Finally, we present our conclusions.



Figure 1. Supply chain structure



## MODELING BACKGROUND

Our supply chain model includes a manufacturer and a retailer. Figure 1 illustrates our supply chain structure regarding the trade promotion and supply chain contract.

**Objective functions and assumptions.** We formulate an expected profit maximization model for a manufacturer and a retailer. The decision variable is the retailer's order quantity  $q$  for the given trade promotion mode. All the notations and symbols are summarized in Table 1.

We set the following assumptions in our model formulation:

- A1. Retail price  $p$  and wholesale price  $w$  are exogenously given and fixed.
- A2. The retailer's promotion effort is proportional to the retailer's unit promotion budget  $r$ .
- A3. The expected sales and demand function increase in the promotion budget per unit  $r$ :  $\partial S(q, r)/\partial r > 0$  and  $\partial F(y)/\partial r < 0$ .

- A4. The promotion cost increases in proportion to  $q$  and  $r$ :  $g(r) = krq$ , where  $0 < k < 1$ .
- A5. For simplicity, there is no overage cost for unsold items and no shortage cost for lost sales.
- A6. We apply a newsvendor approach to determine the optimal order quantity for the retailer.
- A7. We assume that for the OI trade deal the total amount of trade promotion that reaches the customers is  $\theta R$  ( $0 \leq \theta \leq 1$ ) and that this actual amount of trade promotion can be equally divided into all the units that the retailer orders. That is, the following relationship exists between  $R$ ,  $\theta$  and  $r_\theta$ :  $r_\theta q = \theta R$ . (1)

Note that the retailer pockets the remaining  $(1-\theta)R$ . In the SB model, (1) is rewritten as  $rq \leq R$ .

**Model formulation.** For the fashion business, on-time promotion has a significant impact on the customer's purchasing decision. Hence, we apply a newsvendor approach to determine the optimal order size and expected profit. The literature commonly assumes that the retail price is fixed so as to clarify the effects of the promotional factor on sales (Baiman, Fischer, & Rajan, 2000; Corbett & DeCroix, 2001; Wang & Gerchak, 2001). Hence, the retail price in our model is exogenous. We formulate the following two models.

**Off-invoice (OI) trade deal model:** In the OI trade deal, the manufacturer offers an off-invoice trade promotion  $R$  to the retailer, but only a portion of the total budget (i.e.,  $\theta R$ ) eventually reaches the customers. In the OI model, the manufacturer can monitor neither an actual end-sales  $y$  nor the pass-through rate  $\theta$ . What the manufacturer knows from the retailer is only the order size  $q$ . Consequently, the manufacturer faces the principal-agent problem. We first gain insight in the case of  $\theta$  being known for the manufacturer, and then in "Effect of the Retailer's Confidential Pass-Through Rate on the Manufacturer," we consider the case of  $\theta$  being unknown to the manufacturer.

*Table 1. Notations and symbols*

symbols	
$q_k$	Order from a retailer to a manufacturer in Scenario $k$ : $k = 1, 2, 3$ , and 4
$p$	Retail price
$y$	Customers' demand (i.e., end-sales)
$\pi_{ij}$	Expected profit for a retailer ( $j=r$ ) or a supplier ( $j=m$ ) in Scenario $k$
$\Pi_k$	Expected profit for the system in Scenario $k$
$S(q r)$	Expected sales when order size is $q$ and promotion level is $r$
$r$	Amount of the scan-back trade deal per unit sold
$F(y r)$	c.d.f. for the end sales for the given promotion level $r$
$f(y r)$	p.d.f. for the end sales for the given promotion level $r$
$R$	Amount of the off-invoice trade deal decided by a manufacturer
$\theta$	Retailer's pass-through rate ( $0 \leq \theta \leq 1$ )
$r_\theta$	Actual per-unit amount of the off-invoice passed onto customers, $r_\theta \equiv \theta R/q$
$g(r)$	Promotion cost: $g(r) = krq$ , where $0 < k < 1$
$w$	Manufacturer's wholesale price
$c$	Manufacturer's unit production cost
$b$	Buyback amount from the manufacturer for each unsold item at a retailer
$r_3, \bar{b}, r_3$	Threshold values in Proposition 2, Proposition 3, and Lemma 1, respectively
$\bar{r}_\theta$	Average pass-through rate when assuming $r_\theta \sim U(\bar{r}_\theta - \varepsilon, \bar{r}_\theta + \varepsilon)$ , where $\varepsilon > 0$
$L_j$	Premium, incentive payment from the manufacturer ( $j=m$ ) or the retailer ( $j=r$ )
$L_{m, private}$	Premium from the manufacturer when $\theta$ is private information
$\mu, \sigma$	Mean and Standard deviation of the end-sales demand, respectively, at Table 2
$x$	A factor determining the convexity/concavity in the numerical example
$^0$	Superscripts representing the optimum for the centralized system
$*$	Superscripts representing the optimum for the decentralized system

**Scan-back (SB) trade deal model:** The SB trade deal model implicitly assumes that all of the firms in the chain can share end-sales information using an installed IT system. Hence, in the SB model, a manufacturer knows both the retailer's order  $q$  and the sales amount  $y$ . The total amount of trade promotion that the manufacturer gives to the retailer as reimbursement is exactly determined by the manufacturer's knowledge of  $y$ .

We compare the two models to measure the difference between the two trade promotion modes.

*Scenario 1 (OI model):* The system uses the OI trade deal.

*Scenario 2 (SB model):* The system uses the SB trade deal.

In "Supply Chain Coordination and Incentive" and after, we formulate two more scenarios to evaluate the performance of a buyback (BB) contract (a return policy contract).

*Scenario 3 (OI-BB model):* The system uses the OI trade deal and the BB contract.

*Scenario 4 (SB-BB model):* The system uses the SB trade deal and the BB contract.

## MODEL ANALYSIS

We formulate the profit functions for the retailer and the manufacturer to determine the optimal order quantities for each trade promotion mode. Here we consider both the *decentralized system*, in which the retailer makes a decision so as to maximize its profit, and the *centralized system*, in which the optimal decision is made for the entire system. Note that our model formulation is similar to that of Cachon's (2003). In this setting, we assume that  $\theta$ ,  $R$  and  $r_\theta q$  are exogenous and they have the relationship of  $r_\theta q = \theta R$ . We also assume that  $\theta$  in the OI model is common knowledge.

### 1. Scenario 1 (OI Trade Deal)

The profit functions are formulated for the given  $0 \leq \theta \leq 1$ ,  $R$  and  $r_\theta$  as follows.

The retailer's expected profit ( $\pi_{1r}$ ):

$$\pi_{1r} = pS(q, r\theta) - wq - g(r\theta) + R = pS(q, r\theta) - wq - kr\theta q + R,$$

where  $S(q, r_\theta)$  is the expected sales defined as

$$S(q, r_\theta) = q(1 - F(q | r_\theta)) + \int_0^q yf(y | r_\theta) dy = q - \int_0^q F(y | r_\theta) dy.$$

Note that if  $\theta = 0$ ,  $kr_\theta q$  disappears from the profit function.

Also, the manufacturer's expected profit ( $\pi_{1m}$ ):

$$\pi_{1m} = (w - c)q - R.$$

The supply chain's expected profit ( $\Pi_1$ ):

$$\Pi_1 = pS(q, r_\theta) - cq - kr_\theta q. \quad (2)$$

Note that in Scenario 1  $\theta R$  out of  $R$  actually reaches the customers, while the remaining  $(1 - \theta)R$  is absorbed by the retailer. Therefore, only  $kr_\theta q$  appears in (2) as the trade promotion cost for the entire system.

### 2. Scenario 2 (SB Trade Deal)

We assume that in the SB model the manufacturer gives the retailer trade promotion money  $r$  for each unit sold by the retailer. Thus, throughout the SB model, the manufacturer can implicitly monitor the actual sales using an IT system.

The profit functions for the SB model are formulated for the given  $r$  as follows.

The retailer's expected profit ( $\pi_{2r}$ ):

$$\pi_{2r} = (p + r)S(q, r) - wq - g(r) = (p + r)S(q, r) - wq - krq.$$

The manufacturer's expected profit ( $\pi_{2m}$ ):

$$\pi_{2m} = (w - c)q - rS(q, r).$$

The supply chain's expected profit ( $\Pi_2$ ):

$$\Pi_2 = pS(q, r) - cq - krq. \quad (3)$$

**Centralized system solution for Scenarios 1 and 2.** We assume that the profit functions, such as  $\Pi_1$  and  $\Pi_2$ , are unimodal with respect to  $q$  for any given trade promotion level  $r_\theta$  and  $r$ . Cachon (2003) refers to this assumption, which this chapter generally uses, as the profit function that "behaves well." In addition to its mathematical convenience, this "well-behaved-function" assumption is realistic. The optimal order level in the centralized system is determined by the first order condition (FOC) of the profit functions.

$$\text{For Scenario 1: } \frac{\partial \Pi_1}{\partial q} \Big|_{r_\theta} = p(1 - F(q, r_\theta)) - c - kr_\theta = 0.$$

Then,  $q_1^0$  is defined by  $F(q_1^0) = \frac{p - kr_0 - c}{p}$ . (4)

For Scenario 2:  $\frac{\partial \Pi_2}{q} \Big|_r = p(1 - F(q, r)) - c - kr_{set} = 0$ .

Then,  $q_2^0$  is defined by  $F(q_2^0) = \frac{p - kr - c}{p}$ . (5)

Note that superscript of “0” represents the optimum for the centralized system. It is obvious from (4) and (5) that  $q_1^0 = q_2^0$  if  $r_0 = r$ .

**Decentralized system solution for Scenarios 1 and 2.** Assume that the “well-behaved-function” assumption is also used for the decentralized system.

For Scenario 1:  $\frac{\partial \pi_{1r}}{q} \Big|_{r_0} = p(1 - F(q)) - w - kr_0_{set} = 0$ .

Then,  $q_1^*$  is defined by  $F(q_1^*) = \frac{p - kr_0 - w}{p}$ . (6)

For Scenario 2:  $\frac{\partial \pi_{2r}}{q} \Big|_r = (p + r)(1 - F(q)) - w - kr_{set} = 0$ .

Then,  $q_2^*$  is defined by  $F(q_2^*) = \frac{p + (1 - k)r - w}{p + r}$ . (7)

Note that superscript of “\*” represents the optimum for the decentralized system. Proposition 1 states the answer to our first question.

### Proposition 1. (Coordination by Trade Promotion for Scenarios 1 and 2)

- For Scenario 1,  $q_1^0 > q_1^*$  for any  $r_0 > 0$ . That is, the OI trade deal never coordinates the supply chain and the decentralized system is always understocked.
- For Scenario 2,  $q_2^0 > q_2^*$  for any  $r > 0$ . That is, the SB trade deal never coordinates the supply chain and the decentralized system is always understocked.

**Proof.** See the Appendix.

Proposition 1 indicates that the supply chain cannot be coordinated by trade promotion.

### COMPARISON OF THE OI AND SB TRADE DEALS

In this section, we address the question of whether or not the retailer and the manufacturer have any incentive to switch from the OI to the SB trade deal when promotion effort per unit is set as equivalent in both the OI and SB trade deals (i.e.,  $r = r_0$ ) for the given total trade promotion budget of the manufacturer,  $R$ . Note that the same promotion effort per unit will result in the same amount of sales for the two scenarios. Therefore, our discussion compares the two promotion deals assuming an equivalent promotion effect on customers, in other words, equivalent sales. Proposition 2 summarizes whether or not the retailer or the manufacturer can increase expected profits by switching from the OI to the SB trade deal.

### Proposition 2. (Incentive for the Retailer and the Manufacturer)

When promotion effort per unit is set as equivalent for both trade deal modes for a given  $R$ , we have:

- $q_2^* > q_1^*$  and  $\pi_{2r}^* < \pi_{1r}^*$  for the retailer,
- $\pi_{2m}^* > \pi_{1m}^*$  for the manufacturer,
- $\Pi_2^* > \Pi_1^*$  if  $\theta < 1$ , and  $\Pi_2^* = \Pi_1^*$  if  $\theta = 1$ .

**Proof.** See the Appendix.

Proposition 2 leads to the following conclusions: (a) The manufacturer is always better off by accepting the SB trade deal, (b) The retailer cannot be better off by accepting the SB trade deal; and (c) The SB trade deal can benefit the entire system unless the retailer passes the entire OI trade promotion benefit to the customer.

Proposition 2 has some important implications. We see that both the manufacturer and the whole system always benefit from the SB mode because the SB mode not only prompts more demand relative to the OI mode but also enables the manufacturer to learn about demand information. However, the retailer will not benefit from the SB mode. In other words, the retailer must have an incentive to switch to the SB mode to create a “win-win” situation for both parties. Moreover, based on Proposition 2-(c), the manufacturer gains enough to compensate the retailer for its loss if the SB mode is adopted. Therefore, we can conclude that the SB mode is better than the OI mode in terms of supply chain profitability.

## SUPPLY CHAIN COORDINATION AND INCENTIVE

“Model Analysis” demonstrated that neither the OI nor the SB trade deal can coordinate the supply chain. However, an essential question remains unanswered. Can the incentives to the manufacturer and the supplier for SB trade promotion be aligned in a contract such that both firms are motivated to set the stocking levels equal to the centralized levels that maximize system profits? In answering this question, we herein discuss a buyback (BB) contract (a.k.a., return policy contract).<sup>1</sup> Note that the BB has been frequently analyzed

in recent supply chain literature (e.g., Choi, Li, & Yan 2004). The BB contract is a method by which the manufacturer shares the oversupply risk by giving the retailer buyback money  $b$  for each unsold item. We reasonably assume  $0 < b < w$  and  $r < b$ . Note that in this section, promotion effort per unit is again set as equivalent in both the OI and SB trade deals (i.e.,  $r = r_\theta$ ).

**For Scenario 3 (OI-BB model).** For the OI model, the retailer’s expected profit under the BB contract ( $\pi_{3r}$ ) is defined as:

$$\pi_{3r} = (p-b)S(q, r\theta) - (w-b)q - g(r\theta) + R = (p-b)S(q, r\theta) - (w-b)q - kr\theta q + R.$$

The manufacturer’s expected profit is defined as:

$$\pi_{3m} = (w-c-b)q + bS(q, r\theta) - R.$$

The optimal order quantity under the BB contract can be determined by FOC.

$$\frac{\partial \pi_{3r}}{\partial q} \Big|_{r_\theta} = (p-b)(1-F(q)) - (w-b) - kr_{\theta \text{ set}} = 0.$$

$$\text{Then, } q_3^* \text{ is defined by } F(q_3^*) = \frac{p - kr_{\theta \text{ set}} - w}{p - b}.$$

The optimal order quantity for the centralized system under the BB contract is obtained below.

$$\Pi_3 = pS(q, r\theta) - cq - kr\theta q.$$

$$\text{Then, } \frac{\partial \Pi_3}{\partial q} \Big|_{r_\theta} = p(1-F(q, r_\theta)) - c - kr_{\theta \text{ set}} = 0.$$

$$\text{Therefore, } q_3^0 \text{ is determined by } F(q_3^0) = \frac{p - kr_{\theta \text{ set}} - c}{p}.$$

Note that, for a coordinated system, we would have  $\Pi_3 = \pi_{3r} + \pi_{3m}$  and  $q_3^0 = q_3^*$ . Thus, if  $\frac{p - kr_0 - c}{p} = \frac{p - kr_0 - w}{p - b}$ , we conclude that the BB contract can coordinate the system of the OI trade deal based on the concavity of the profit function.

**For Scenario 4 (SB-BB model).** Next, we consider the retailer's expected profit from the SB trade deal under the BB contract ( $\pi_{4r}$ ):

$$\pi_{4r} = (p+r-b)S(q,r) - (w-b)q - krq.$$

The manufacturer's expected profit is defined as:

$$\pi_{4m} = (w-c-b)q - (r-b)S(q,r).$$

The optimal order quantity under the BB contract is derived as follows:

$$\frac{\partial \pi_{4r}}{\partial q} \Big|_r = (p+r-b)(1-F(q)) - (w-b) - kr = 0.$$

Then,  $q_4^*$  such that satisfies  $F(q_4^*) = \frac{p + (1-k)r - w}{p + r - b}$ .

For the centralized system under the BB contract:

$$\Pi_4 = pS(q,r) - cq - krq.$$

$$\text{Then, } \frac{\partial \Pi_4}{\partial q} \Big|_r = p(1-F(q,r)) - c - kr = 0.$$

Finally,  $q_4^0$  is determined by  $F(q_4^0) = \frac{p - kr - c}{p}$ .

To coordinate the supply chain, we have  $\Pi_4 = \pi_{4r} + \pi_{4m}$  and  $q_4^0 = q_4^*$ . Hence, if  $\frac{p + (1-k)r - w}{p + r - b} = \frac{p - kr - c}{p}$ , we conclude that the BB contract can coordinate the supply chain under the SB trade deal. The performance of the BB contract is recapitulated as follows.

### Proposition 3. (Performance of the BB Contract)

- The OI model can coordinate the system through the buyback rate  $\bar{b} = p \frac{w-c}{p-c-kr} \in [0, w]$  if  $krw + c(w-p) \leq 0$ ; and the SB model can coordinate the system through the buyback rate  $\bar{b} = \frac{pc + rc + kr^2}{kr + c} \in [0, w]$ .
- The retailer tends to overstock (or understock) if the value of  $b$  is more than (or less than) the buyback value  $\bar{b}$  that can coordinate the chain.
- The retailer always benefits from the BB contract:  $\pi_{1r}^* < \pi_{3r}^*$  and  $\pi_{2r}^* < \pi_{4r}^*$ .

There is a case in which the manufacturer benefits from the BB contract in the OI model (i.e.,  $\pi_{1m}^* < \pi_{3m}^*$ ) if  $b > \bar{b}$ , where  $\bar{b}$  satisfies Condition (8):

$$\bar{b} = \left\{ (w-c)q_3^* - R - \pi_{1m}^* \right\} / \int_0^{q_3^*} F(y,r) dy. \quad (8)$$

Otherwise,  $\pi_{1m}^* \geq \pi_{3m}^*$ .

Also, there is a case in which the manufacturer benefits from by the BB contract in the SB model (i.e.,  $\pi_{2m}^* < \pi_{4m}^*$ ) if  $b > \bar{b}$ , where  $\bar{b}$  satisfies Condition (9):

$$\bar{b} = \left\{ (w - c)q_4^* - rS(q_4^*, r) - \pi_{2m}^* \right\} / \int_0^{q_4^*} F(y, r) dy. \quad (9)$$

Otherwise,  $\pi_{2m}^* \geq \pi_{4m}^*$ .

- e. The supply chain always benefits from the BB contract:  $\Pi_1(q_1^*) < \Pi_1(q_1^0) = \Pi_3^*$  and  $\Pi_2(q_2^*) < \Pi_2(q_2^0) = \Pi_4^*$ .

**Proof.** See the Appendix.

Proposition 3 shows that the manufacturer benefits from the BB contract only if the buyback amount is above a certain threshold level given by Conditions (8) and (9) while the retailer is always better off by accepting the BB contract. Interestingly, the manufacturer needs incentives to accept the BB contract while the retailer needs incentives to adopt the SB trade deal.

Table 2 numerically shows the profits of the retailer, the manufacturer, and the entire system with respect to  $b$ . Simulation 1 in Table 2, with parameter settings of  $p=100, w=80, c=40$ , shows

Table 2. Effect of the BB contract,  $b$ , on the expected profits of the retailer, the manufacturer, and the entire system

$b$	Simulation 1 ( $p=100; w=80; c=40$ )			Simulation 2 ( $p=100; w=60; c=30$ )		
	$\pi_{4m}^*$	$\pi_{4m}^*$	$\Pi_4^*$	$\pi_{4m}^*$	$\pi_{4m}^*$	$\Pi_4^*$
0.0	1824.5	3204.1	5028.6	3573.6	2385.7	5959.3
1.4	1825.6	3205.8	5031.4	3576.6	2385.6	5962.2
2.7	1827.9	3207.5	5035.4	3579.3	2385.5	5964.8
4.1	1829.0	3209.3	5038.3	3581.8	2385.2	5967.0
5.4	1830.9	3211.1	5042.1	3584.5	2384.8	5969.3
6.8	1832.1	3212.8	5044.9	3587.2	2384.2	5971.4
8.1	1834.7	3214.8	5049.6	3590.7	2383.6	5974.2
9.5	1836.7	3216.7	5053.4	3593.8	2382.6	5976.5
10.8	1838.3	3218.3	5056.6	3598.0	2381.6	5979.7
12.2	1840.5	3220.0	5060.5	3601.3	2380.1	5981.4
13.5	1843.1	3221.8	5064.9	3605.1	2378.3	5983.4
14.9	1845.8	3223.3	5069.1	3609.6	2376.1	5985.7
16.2	1848.5	3224.4	5073.0	3614.1	2373.4	5987.5
17.6	1851.9	3225.5	5077.4	3618.0	2369.5	5987.5
18.9	1855.7	3226.2	5081.9	3623.4	2365.3	5988.8
20.3	1859.5	3225.6	5085.0	3628.9	2359.8	5988.7
21.6	1864.1	3224.1	5088.2	<b>3635.6</b>	<b>2353.3</b>	<b>5988.9</b>
23.0	<b>1869.3</b>	<b>3220.2</b>	<b>5089.5</b>	3642.2	2344.1	5986.3
24.3	1875.5	3212.6	5088.0	3650.7	2332.9	5983.6
25.7	1883.2	3198.0	5081.2	3658.8	2315.6	5974.4
27.0	1893.6	3168.0	5061.6	3669.5	2290.5	5960.0
<b>Supply chain optimum values are bold.</b> The cases without BB are italic. Parameter setting: $k=0.5; r=3$ ; Demand is normally distributed with mean $\mu=8+3r$ and standard deviation $\sigma=3$ .						

that, comparing the case without BB at  $b=0.0$  with the supply chain optimum under BB at  $b=23.0$ , we know both the retailer and manufacturer can benefit from the BB contract (i.e.,  $1824.5 < 1869.3$  for the retailer and  $3204.1 < 3220.2$  for the manufacturer). In contrast, Simulation 2 with parameter settings of  $p=100$ ,  $w=60$ ,  $c=30$ , shows that, comparing the case without BB at  $b=0.0$  with the supply chain optimum under BB at  $b=21.6$ , we know that the manufacturer does not benefit from the BB contract even if the retailer is benefiting at that point (i.e.,  $3573.6 < 3635.6$  for the retailer and  $2385.7 > 2353.3$  for the manufacturer). Table 2 present a case where the retailer and the entire supply chain benefit from the BB contract but the manufacturer does not.

Finally, we study the effect of the BB contract on the retailer's incentive to switch from the OI mode to the SB mode. Lemma 1 is an extension of Proposition 2 to the supply chain under the BB contract.

**Lemma 1**

When a manufacturer uses the trade promotion budget,  $R$ , for both trade deal modes,

- a.  $q_4^* > q_3^*$  and  $\pi_{4r}^* < \pi_{3r}^*$  for the retailer,
- b.  $\pi_{4m}^* > \pi_{3m}^*$  for the manufacturer,
- c.  $\Pi_4 > \Pi_3$  if  $\theta < 1$ , and  $\Pi_4 = \Pi_3$  if  $\theta = 1$ .

**Proof.** The proof is similar to that of Proposition 2 and is omitted.

Generally, Lemma 1 shows that Proposition 2 regarding the non-BB contract case holds for the BB contract situation: the SB trade deal under the BB contract always increases the profits of both the manufacturer and the entire system, but the retailer will not benefit from the SB trade deal. Lemma 1 implies that a retailer with a BB contract faces the same incentive problem as one without a BB contract.

**PAYMENT AS INCENTIVE**

To see how the trade deal choice (i.e., OI or SB) and the buyback contract decision (i.e., non-BB or BB) can be selected by a firm, we develop three  $2 \times 2$  payoff matrices. Figure 2 illustrates the payoff matrices of this joint selection of a trade deal and a buyback contract.

Figure 2-(c) demonstrates that Scenario 4 (i.e., the SB with the BB contract scenarios) could maximize the profit of the entire system. However, Figure 2-(b) (or Figure 2-(a)) shows that the retailer (or the manufacturer) may reject the SB

Figure 2. Payoff matrices

(a) Payoff for the manufacturer

		Supply chain contract	
		Scenario 1	Scenario 3
Trade deal mode	Non-BB	$\pi_{1m}^*$ OI	$\pi_{3m}^*$
	SB	$\pi_{2m}^*$ OI	$\pi_{4m}^*$

(b) Payoff for the retailer

		Supply chain contract	
		Scenario 1	Scenario 3
Trade deal mode	Non-BB	$\pi_{1r}^*$	$\pi_{3r}^*$
	SB	$\pi_{2r}^*$	$\pi_{4r}^*$

(c) Payoff for the entire system

		Supply chain contract	
		Scenario 1	Scenario 3
Trade deal mode	Non-BB	$\Pi(q_1^*)$	$\Pi(q_3^*)$
	SB	$\Pi(q_2^*)$	$\Pi(q_4^*)$



trade deal (or the BB contract). When  $\pi_{1r}^* > \pi_{2r}^*$  and  $\pi_{1m}^* < \pi_{2m}^*$ , the manufacturer could provide the retailer with some payment as an incentive to switch. We call this incentive payment a *premium from the manufacturer*,  $L_m$ , which has the following constraints when a pass-through rate  $\theta$  is public:

$$\pi_{1r}^* - \pi_{2r}^* < L_m < \pi_{2m}^* - \pi_{1m}^*. \quad (10)$$

At the same time, if  $\pi_{2r}^* < \pi_{4r}^*$  and  $\pi_{2m}^* > \pi_{4m}^*$ , the retailer offers the manufacturer some payment to accept the BB contract. We call the incentive payment in this case a *premium from the retailer*,  $L_r$ , which has the following constraints for the perfect information case:

$$\pi_{2m}^* - \pi_{4m}^* < L_r < \pi_{4r}^* - \pi_{2r}^*. \quad (11)$$

Note that if there exists  $L_m$  and  $L_r$  that simultaneously satisfy (10) and (11), respectively, then the system can move from any scenario, including Scenario 1, to Scenario 4, the highest profit scenario for the system.

#### Proposition 4. (Existence of a Win-Win Scenario)

When  $\theta < 1$  and both the retailer and the manufacturer adopt the SB trade deal and BB contract simultaneously, both firms are always better off and the profit of the entire system is maximized. However, adopting only the SB trade deal may degrade the performance of the retailer (i.e.,  $\pi_{1r}^* > \pi_{2r}^*$  might occur) and adopting only the BB contract may undermine the benefit to the manufacturer (i.e.,  $\pi_{2m}^* > \pi_{4m}^*$  might happen).

**Proof.** See the Appendix.

Proposition 4 claims that if the SB trade deal is used with the BB contract, both the retailer and manufacturer are better off and the supply chain coordination is achieved. The managerial

implication of Proposition 4 is that both parties in the supply chain should consider simultaneously adopting the SB trade deal and the BB contract to achieve maximum profit.

### EFFECT OF THE RETAILER'S CONFIDENTIAL PASS-THROUGH RATE ON THE MANUFACTURER

Our analysis has so far assumed that the manufacturer knows the retailer's pass-through rate  $\theta$ . However, in some situations, the manufacturer cannot observe  $\theta$  in the OI mode. This section explores the player's incentive to switch from the OI mode to the SB mode when  $\theta$  is unknown to the manufacturer. In our OI trade deal setting, the retailer's actual promotion effort per unit  $r_\theta$ , which is a function of  $\theta$ , is unknown to the manufacturer.

For simplicity, this section assumes a uniform distribution for unknown promotion effort  $r_\theta$ :  $r_\theta \sim U(\bar{r}_\theta - \varepsilon, \bar{r}_\theta + \varepsilon)$ , where  $0 \leq \bar{r}_\theta - \varepsilon < \bar{r}_\theta < \bar{r}_\theta + \varepsilon$  and  $\varepsilon \geq 0$ . Note that, in the perfect information case,  $\varepsilon = 0$  and the manufacturer knows the exact value of  $r_\theta = \bar{r}_\theta$ . Within this setting, we have the following results.

#### Lemma 2

For both the non-BB and BB contract cases, when  $r_\theta$  is the retailer's private information:

- If  $F(y|r)$  is concave in  $r$ , then the retailer's and the system's expected profits are more than those in the perfect information case: i.e.,  $\pi_{1r}^* < E_\theta(\pi_{1r}^*)$  or  $\pi_{3r}^* < E_\theta(\pi_{3r}^*)$ , and  $\Pi_1^* < E_\theta(\Pi_1^*)$  or  $\Pi_3^* < E_\theta(\Pi_3^*)$ .
- If  $F(y|r)$  is convex in  $r$ , then the retailer's and the system's expected profits are less than those in the perfect information case: i.e.,  $\pi_{1r}^* > E_\theta(\pi_{1r}^*)$  or  $\pi_{3r}^* > E_\theta(\pi_{3r}^*)$ , and  $\Pi_1^* > E_\theta(\Pi_1^*)$  or  $\Pi_3^* > E_\theta(\Pi_3^*)$ .

- c. Uncertainty does not affect the manufacturer's profits  $\pi_{1m}^* = E_\theta(\pi_{1m}^*)$  but  $\pi_{3m}^* >$  (or  $<$ )  $E_\theta(\pi_{3m}^*)$  if  $F(y|r)$  is concave (or convex) in  $r$ .
- d. The difference in the retailer's profits increase as  $\varepsilon$  increases.

**Proof.** See the Appendix.

We can see from Lemma 2 that the premium payment from the manufacturer to the retailer is influenced by the erroneous profit estimation due to the hidden information  $r_\theta$ . For example, the lower bound in (10) is modified for the private information case as follows.

$$\text{If } F(y|r) \text{ is concave in } r, \pi_{1r}^* - \pi_{2r}^* < E_\theta(\pi_{1r}^*) - \pi_{2r}^* < L_{m,imperfect} \quad (12)$$

$$\text{If } F(y|r) \text{ is convex in } r, E_\theta(\pi_{1r}^*) - \pi_{2r}^* < \pi_{1r}^* - \pi_{2r}^* < L_{m,imperfect} \quad (13)$$

We know from (12) that there exists a high likelihood of  $L_m \leq L_{m,imperfect}$  if  $F(y|r)$  is concave in  $r$  in the uncertainty case. That is, the retailer would receive a larger premium from the manufacturer in the uncertainty case than in the certainty case. Also, (13) shows the possibility that  $L_{m,imperfect} \leq L_m$ . Proposition 5 summarizes the effect of the uncertainty of  $r_\theta$  on the incentive decision made by the manufacturer.

**Proposition 5**

- a. If  $F(y|r)$  is concave in  $r$ , the retailer benefits from keeping the pass-through rate secret. This is because the minimum premium that the retailer may receive from the manufacturer in the private information case is greater than that in the perfect information case.
- b. If  $F(y|r)$  is convex in  $r$ , the retailer benefits from publicizing the pass-through rate. This is because the minimum premium that the retailer may receive from the manufacturer

in the private information case is smaller than that in the perfect information case.

**Proof.** Obvious from (12) and (13).

Note that Proposition 5 holds even for the BB contract case. Proposition 5 shows under what conditions the retailer is willing to share its information with the manufacturer depends on the behavior of the promotion effect on sales. If there are increasing returns on a promotion (i.e.,  $F(y|r)$  is convex in  $r$ ), the retailer tends to share its pass-through information. By contrast, if the promotion effect on the sales increase is diminishing (i.e.,  $F(y|r)$  is concave in  $r$ ), the retailer is likely to hide its information from the manufacturer. This result is intuitive. If the retailer informs the manufacturer that the promotion is less effective, the manufacturer will cut its trade promotion budget to the retailer. To avoid this result, the retailer tends to keep the promotion information secret. On the other hand, if the retailer informs the manufacturer that the promotion is more effective, the manufacturer may increase its trade promotion budget.

A promotion strategy over a product life cycle demonstrates another rationale for deciding when to keep the trade promotion information secret or not: in the introduction stage (i.e.,  $F(y|r)$  is convex), a large initial investment is required to successfully increase the customer's awareness of a new product. Hence, firms usually have a large promotion budget. However, for a mature product (i.e.,  $F(y|r)$  is concave), a promotion usually has less of an effect. This is consistent with the marketing fact that a product at a mature or declining stage is usually promoted less (Kotler & Armstrong, 2004, Chapter 10).

**CONCLUDING REMARKS**

The trade deal is an important strategic tool for successful retail management. This chapter presents a model of a supply chain's incentive

to switch from the traditional off-invoice (OI) trade deal to the information sharing-based scan-back (SB) trade deal. In the OI trade deal form, a manufacturer cannot know the retailer's actual pass-through rate to the customers. However, in the scan-back (SB) trade deal, the manufacturer can monitor the retailer's sales via an IT system. First, we show that the whole system and the manufacturer always benefit from the policy of switching from the OI to the SB trade deal while the retailer only benefits if it accepts the SB trade deal when the pass-through rate is high. Second, we prove that neither the OI nor the SB trade deal can coordinate the system, but if they are accompanied by the buyback (BB) supply chain contract, supply chain coordination can be achieved, thus producing a win-win solution for the supply chain. If the SB trade deal and the BB contract are jointly implemented, both the retailer and manufacturer can achieve the highest profits.

The OI trade deal encapsulates a principal-agent problem: the manufacturer cannot monitor the retailer's actual promotion effort. We have shown that whether or not the retailer is likely to share its private promotion information with the manufacturer depends on the promotion effect on sales. If the returns of a promotion offer to end sales are diminishing, private promotion information may create an opportunity for the retailer to receive a higher incentive from the manufacturer. On the other hand, if the promotion effect produces increasing returns, the retailer is better off from sharing its information with the manufacturer. This finding implies that shifting from the OI trade deal to the SB trade deal is more likely welcomed by the supply chain of a product for which promotion is highly effectively, e.g., one with an expanding marketing share. Finally, there are several extensions to our research. While we assumed one retailer and one manufacturer in our system, a natural extension of this work would have been to consider horizontal competition. Our study took the common assumption found in the promotion research that retail and wholesale

prices are exogenous. It would be interesting to extend our work when this assumption is relaxed. Finally, we see the analysis of the effects of the costs of information exchange on our findings as a relevant question.

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## **KEY TERMS AND DEFINITIONS**

**Buyback (BB) Contract:** A method by which the manufacturer shares the oversupply risk by giving the retailer buyback money for each unsold item.

**Incentive:** A firm’s motivation to accept the offered proposal.

**Information Sharing:** Exchanging business information, especially demand information, between the members of the supply chain.

**Off-Invoice (OI) Trade Promotion:** Trade promotion in which a manufacturer gives trade promotion money to a retailer to encourage the retailer to sell more of the manufacturer’s product.

**Pass through Rate:** The rate calculated by the retailer’s actual promotion spending divided by the total trade promotion amount offered to the retailer.

**Scan-Back (SB) Trade Promotion:** Trade promotion in which a manufacturer reimburses a retailer based on the exact number of sales the retailer makes.

**Trade Promotion:** Promotion directed to the member of the supply chain.

**Win-Win Solution:** A business solution from which both a manufacturer and a retailer can benefit.

## **ENDNOTE**

- <sup>1</sup> In addition to a buyback contract, we also studied a flexible quantity contract, a revenue sharing contract, and a quantity discount contract. However, we proved that only the buyback contract could coordinate the supply chain.

## APPENDIX

**Proof of Proposition 1.** (a) First, for given  $r_\theta$  and  $\theta > 0$ ,  $q_1^* < q_1^0$  for Scenario 1 from (4) with (6). (b) Reasonably assume  $w - c > r$ . That is,  $-c > r - w$ . Thus, when  $r > 0$ , we always have  $\frac{p - kr - c}{p} > \frac{p + (1 - k)r - w}{p + r}$ . From (5) and (7), we know  $q_2^0 > q_2^*$  for Scenario 2.  $\square$

**Proof of Proposition 2.** (a) Here we set  $r = r_\theta$ .  $\frac{p + (1 - k)r - w}{p + r} - \frac{p - kr_\theta - w}{p} = \frac{kr^2 + wr}{p(p + r)} > 0$ . Hence,  $q_2^* > q_1^*$  for any  $r$ . Note that  $r q_2^* \leq R$ .  $\pi_{2m}^* - \pi_{1m}^* = \{(w - c)q_2^* - rS(q_2^*, r)\} - \{(w - c)q_1^* - R\} = (w - c)(q_2^* - q_1^*) - r(q_2^* - \int_0^{q_2^*} F(y | r) dy) + R > (w - c)(q_2^* - q_1^*) + r \int_0^{q_2^*} F(y | r) dy > 0$ . Thus, always,  $\pi_{2m}^* > \pi_{1m}^*$ .

(b) Set  $r = r_\theta$ . Then,  $\pi_{2r}(q_2^*) - \pi_{1r}(q_1 = q_2^*) = \{(p + r)S(q_2^*, r) - wq_2^* - krq_2^*\} - \{pS(q_2^*, r) - (w + kr)q_2^* + R\} = rS(q_2^*, r) - R < 0$ , because  $rS(q_2^*, r) < r q_2^* \leq R$ . Hence, from  $q_2^* > q_1^*$  and the ‘‘well-behaved-function’’ assumption of unimodality for the profit function,  $\pi_{1r}$  is decreasing but more than  $\pi_{2r}^*$  at the point of  $q_2^*$ . Consequently, one can conclude  $\pi_{2r}^* < \pi_{1r}^*$ .

(c) From (2) and (3),  $\Pi_1^*$  and  $\Pi_2^*$  are maximized by  $q_2^0 = F^{-1}\left(\frac{p - kr - c}{p}\right)$ . It is clear that when  $\theta < 1$ , Scenario 2 can use more promotion budget to the customers than Scenario 1 for the given  $R$ : it is possible  $\max(r) > \max(r_\theta)$ . Thus, from Assumption A3,  $\Pi_2^* > \Pi_1^*$ .  $\square$

**Proof of Proposition 3.** (a). For the OI mode, if  $b = 0$ ,  $\frac{p - kr_0 - w}{p} < \frac{p - kr_0 - c}{p}$ . Consequently, understocking occurs in the decentralized system if  $b = 0$ . At  $b = w$ ,  $(p - w)\{p - kr_0 - c\} - p\{p - kr_0 - w\} = w(kr_0 + c) - pc$ . If  $krw + c(w - p) \leq 0$ , then  $\frac{p - kr_0 - w}{p - w} > \frac{p - kr_0 - c}{p}$  at  $b = w$ : that is, the retailer in the decentralized system overstocks at  $b = w$ .  $q_3^*$  is increasing in  $b$ . From the middle point theorem, there exists such  $\bar{b} = p \frac{w - c}{p - c - kr} \in [0, w]$  that satisfies  $\frac{p - kr_0 - w}{p - \bar{b}} = \frac{p - kr_0 - c}{p}$ .

For the SB mode,  $p + r > p$  and  $(p + r - kr - w) - (p - kr - c) = -(w - c) + r < 0$  since it is reasonable to assume  $r + c < w$  to guarantee the manufacturer’s participation. Thus, if  $b = 0$ , then  $\frac{p + (1 - k)r - w}{p + r}$

$< \frac{p - kr - c}{p}$ . Assume  $b = w$  and set  $h(k) \equiv p(p + (1 - k)r - w) - (p + r - w)(p - kr - c) = kr^2 + (c - kw)r + pc - wc$ .

$h(k=0) = c(p + r - w) > 0$ , and  $h(k)$  is decreasing in  $k$  since  $\partial h(k) / \partial k = r(r - w) < 0$ .

$h(k=1) = r^2 + (c - w)r + pc - wc$ . (A-1)



(A-1) is a quadratic function with respect to  $r$  with  $c-w < 0$  and  $(p-w)c > 0$ . Hence, the two roots of  $h(k=1)=0$  are negative. Thus,  $h(k=1) > 0$  for  $r > 0$ . Hence,  $\frac{p + (1-k)r - w}{p + r - w} > \frac{p - kr - c}{p}$ . Consequently, from the middle point theorem, there is such  $\bar{b} = \frac{pc + rc + kr^2}{kr + c} \in [0, w]$  that satisfies

$$\frac{p + (1-k)r - \bar{b}}{p + r - \bar{b}} = \frac{p - kr - c}{p}.$$

(b) From the unimodality assumption for the profit functions, the decentralized system is coordinated only when  $q_3^* = q_3^0$  or  $q_4^* = q_4^0$ . If  $b \neq \bar{b}$ , then  $q_3^* \neq q_3^0$  or  $q_4^* \neq q_4^0$ . That is, the retailer will overstock (or understock) if the value of  $b$  is over (or under) the buyback value  $\bar{b}$ .

(c) Set  $r=r_\theta$ ,  $p\{p-kr-w\} - (p-b)\{p-kr-w\} = b\{p-kr-w\} > 0$ . Then,  $\frac{p - kr - w}{p - b} > \frac{p - kr - w}{p}$ . Consequently,  $q_3^* > q_1^*$ . Also, using the same logic for Scenarios 1 and 3,  $\frac{p + (1-k)r - w}{p + r - b} > \frac{p + (1-k)r - w}{p + r}$ . Consequently,  $q_4^* > q_2^*$ .

Next,  $\pi_{3r}(q_3 = q_1^*) - \pi_{1r}(q_1^*) = \{(p-b)S(q_1^*, r) - (w-b)q_1^* - krq_1^* + R\} - \{pS(q_1^*, r) - wq_1^* - krq_1^* + R\} = b\{q_1^* - S(q_1^*, r)\} > 0$ . From  $q_3^* > q_1^*$  and the “good-behaved” assumption for unimodality,  $\pi_{3r}$  is increasing and more than  $\pi_{1r}(q_1^*)$  at the point of  $q_1^*$ . Therefore,  $\pi_{3r} = \pi_{3r}(q_3^*) > \pi_{1r}$ . Also,  $\pi_{4r}(q_4 = q_2^*) - \pi_{2r}(q_2^*) = \{(p+r-b)S(q_2^*, r) - (w-b)q_2^* - krq_2^*\} - \{(p+r)S(q_2^*, r) - wq_2^* - krq_2^*\} = b\{q_2^* - S(q_2^*, r)\} > 0$ . From  $q_4^* > q_2^*$  and the “well-behaved-function” assumption for unimodality,  $\pi_{4r}$  is increasing and more than  $\pi_{2r}(q_2^*)$  at the point of  $q_2^*$ . Therefore,  $\pi_{4r}^* > \pi_{2r}^*$ .

(d) From definition,  $\partial q / \partial b > 0$ . Also,  $0 < \partial S(q | r) / \partial b = \partial q / \partial b - \frac{\partial}{\partial b} \int_0^q F(y | r) dy < \partial q / \partial b - \frac{\partial q}{\partial b} F(b | r) < \partial q / \partial b$ . Thus,  $S(q|r)$  increases in  $b$  but its increase rate is less than that of  $b$ . Also, it is natural to assume  $(w-c-b) - (r-b) = w-c-r > 0$ , because the manufacturer quits business if  $w-c-r \leq 0$  (i.e., no revenue). Hence, it is easily shown that both  $\pi_{4m}(q_4) = (w-c-b)q_4 - (r-b)S(q_4, r_\theta)$  and  $\pi_{2m}(q_2) = (w-c)q_4 - rS(q_4, r)$  are increasing in  $q_4$  and  $q_2$ , respectively. Next,  $\pi_{4m}(q_4 = q_2^*) - \pi_{2m}^* = \{(w-c-b)q_2^* - (r-b)S(q_2^*, r_\theta)\} - \{(w-c)q_2^* - rS(q_2^*, r)\} = b\{-q_2^* + S(q_2^*, r_\theta)\} < 0$ . Hence,  $\pi_{4m}$  is less than  $\pi_{2m}^*$  at the point of  $q_2^*$ . As  $b$  and  $q_4$  increase,  $\pi_{4m}$  also increases, but whether  $\pi_{4m}^*$  is greater than  $\pi_{2m}^*$  depends. In particular, Condition (8) for the value of  $b$  and the budget constraint are satisfied if there exists the case that  $\pi_{4m}^* \geq \pi_{2m}^*$ . Otherwise,  $\pi_{4m}^* < \pi_{2m}^*$ .

Also,  $\pi_{3m}(q_3 = q_1^*) - \pi_{1m}^* = \{(w-c-b)q_1^* + bS(q_1^*, r_\theta) - R\} - \{(w-c)q_1^* - R\} = b\{-q_1^* + S(q_1^*, r_\theta)\} < 0$ . Using the same logic as Scenarios 4 and 2, we know that Condition (9) for the value of  $b$  and the budget constraint are satisfied if there exists the case that  $\pi_{3m}^* \geq \pi_{1m}^*$ . Otherwise,  $\pi_{3m}^* < \pi_{1m}^*$ .

(e) The OI case: since  $\Pi_1$  and  $\Pi_3$  have the same structure,  $\Pi_1(q_1^0) = \Pi_3(q_3^0)$ . Also,  $q_1^* \neq q_1^0$ . Thus, the decentralized system performs worse than the centralized system from the unimodality assumption for the profit function,  $\pi_{1r}^* + \pi_{1m}^* = \Pi_1(q_1^*) < \Pi_1(q_1^0) = \Pi_3(q_3^0)$ . One can apply the same logic for proving the SB case.  $\square$

**Proof of Proposition 4.** From Proposition 2-(a),  $\Pi_2 > \Pi_1$  if  $\theta < 1$ . Also, it is obvious that  $\Pi_4 > \Pi_2$ . Thus,  $\pi_{4r}^* + \pi_{4m}^* - \pi_{1r}^* - \pi_{1m}^* > 0$ . Rewrite as  $\pi_{4r}^* + \pi_{4m}^* - \pi_{1r}^* - \pi_{1m}^*$

$$\begin{aligned} &= \pi_{4r}^* + \pi_{4m}^* - \pi_{2r}^* - \pi_{2m}^* + \pi_{2r}^* + \pi_{2m}^* - \pi_{1r}^* - \pi_{1m}^* \\ &= \{(\pi_{4r}^* - \pi_{2r}^*) - (\pi_{2m}^* - \pi_{4m}^*)\} + \{(\pi_{2m}^* - \pi_{1mr}^*) - (\pi_{1r}^* - \pi_{2r}^*)\} > 0. \end{aligned} \quad (\text{A-2})$$

From (A-2), it is possible to determine  $L_r$  and  $L_m$  that satisfy

$$\pi_{4r}^* - \pi_{2r}^* > L_m > \pi_{2m}^* - \pi_{4m}^* \quad \text{and} \quad \pi_{2m}^* - \pi_{1mr}^* > L_r > \pi_{1r}^* - \pi_{2r}^*. \quad \square$$

**Proof of Lemma 2.** (a and b) The non-BB contract case: the private information affects the two terms

$S(q, r_\theta)$ , and  $kr_\theta q$  in (2). Obviously,  $kr_\theta q = k\bar{r}_\theta q$ . Also,  $E_\theta(S(q, r_\theta)) = \int_{\bar{r}_\theta - \varepsilon}^{\bar{r}_\theta + \varepsilon} S(q, r_\theta) \frac{1}{2\varepsilon} dr_\theta =$

$$\int_{\bar{r}_\theta - \varepsilon}^{\bar{r}_\theta + \varepsilon} \left( q - \int_0^q F(y | r_\theta) dy \right) \frac{1}{2\varepsilon} dr_\theta = q - \int_{\bar{r}_\theta - \varepsilon}^{\bar{r}_\theta + \varepsilon} \left( \int_0^q F(y | r_\theta) dy \right) \frac{1}{2\varepsilon} dr_\theta = q - \int_0^q \left( \int_{\bar{r}_\theta - \varepsilon}^{\bar{r}_\theta + \varepsilon} F(y | r_\theta) \frac{1}{2\varepsilon} dr_\theta \right) dy.$$

We know that if  $F(y|r)$  is concave in  $r$ , then,  $\int_0^q \left( \int_{\bar{r}_\theta - \varepsilon}^{\bar{r}_\theta + \varepsilon} F(y | r_\theta) \frac{1}{2\varepsilon} dr_\theta \right) dy < \int_0^q F(y | \bar{r}_\theta) dy$ . Hence,  $\pi_{1r}^*(q)$

$< E_\theta(\pi_{1r}^*(q))$  if  $F(y|r)$  is concave in  $r$ . Also, if  $F(y|r)$  is convex in  $r$ ,  $\pi_{1r}^*(q^*) > E_\theta(\pi_{1r}^*)$  is proved by the same logic as the concave case. (c)  $q$  is observable for the manufacturer so that private information has no impact on  $\pi_{1m}^*$ . However,  $\pi_{3m}^*$  contains  $S(q, r_\theta)$  so that  $E_\theta(\pi_{3m}^*)$  depends on which  $F(y|r)$  is concave or

convex as shown above. (d). It is easy to prove that  $\int_{\bar{r}_\theta - \varepsilon}^{\bar{r}_\theta + \varepsilon} \left( \int_0^q F(y | r_\theta) dy \right) \frac{1}{2\varepsilon} dr_\theta$  is an increase function of  $\varepsilon$ . For Scenarios 3 and 4, we use the same logic as Scenarios 1 and 2.  $\square$

## Chapter 3

# Competition and Coordination in a Fashion Supply Chain with Wholesale Pricing Schemes

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### ABSTRACT

*This chapter considers a two-echelon supply chain where a supplier determines his production quantity and a retailer chooses her order size and retail price for each period in an infinite horizon. Under a price-discount sharing (PDS) scheme, the supplier's wholesale price linearly depends on the retail price. We develop a stochastic game in which these two supply chain members maximize their discounted profits. We show that a unique Nash equilibrium solution exists for each period, and over the infinite horizon the supplier chooses a stationary base stock policy whereas the retailer's equilibrium solution could be non-stationary. Next, we investigate the problem of whether or not a wholesale pricing scheme can coordinate the supplier and the retailer, and derive the conditions for supply chain coordination. Moreover, we use Nash arbitration scheme to allocate the system-wide profit between the supplier and the retailer.*

### INTRODUCTION

During the past decade, many academics and practitioners have paid much attention to supply chain coordination, which is achieved when decisions made by members of a supply chain are

identical to globally optimal solutions maximizing total profits or minimizing total costs in the supply chain; see Chopra and Meindl (2004, Ch. 10). Two natural questions regarding the issue arise as follows: What mechanism could be applied to coordinate a supply chain? And how could we implement the mechanism? As Cachon (2003) discussed, a common approach is to design an

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appropriate contract, and in recent years a number of publications are concerned with supply chain coordination with contracts (e.g., side-payment, buy-back, revenue sharing, profit-discount sharing schemes, etc.).

In practice, many academics and practitioners have identified the importance of improving the performance of an entire supply chain, and focused on the question of how to effectively gain supply chain coordination and integration for the improvement. Next, we briefly review several papers concerning the coordination of fashion supply chains. Kincade et al. (2002) conducted a survey and revealed that the benefits of retailers in the apparel industry are greatly related to the financial promotional support from manufacturers. Motivated by a real case in the apparel industry, Eppen and Iyer (1997) developed a stochastic dynamic programming model to investigate a backup agreement for a fashion supply chain involving a catalog company and a manufacturer. Under the agreement, the catalog company commits to a number of units for a certain fashion season, and the manufacturer holds back a percentage of the committed units and delivers the remaining units before the start of the season. It was shown that the backup agreement can increase both the catalog firm's and the manufacturer's expected profits. Indu and Govind (2008) discussed the practices of three European apparel companies (Zara, H&M, and Benetton) that have successfully integrated their fashion supply chains and increased their profits. Kurata and Yue (2008) examined the scan-back (SB) trade deal—a special type of trade promotion used in fashion supply chains—that monitors a retailer's sales via an IT system. They showed that both the retailer and the manufacturer can benefit from the SB trade deal if the SB deal is accompanied by a buyback contract. In addition, it has been widely recognized that the bullwhip effect that increases the variability of production and order quantity negatively impacts supply chain performance. Cachon and Terwiesch (2006, Ch. 14) concluded that such an effect has

been one of two major challenges to supply chain coordination, and discussed several major causes resulting in the undesirable phenomenon: order synchronization, order batch, trade promotion and forward buying, reactive and overreactive ordering and shortage gaming.

Restricting our attention to trade promotion and forward buying, we find a number of evidences about the widespread use of trade promotion and discussions from both academic and practical perspectives. As a survey conducted by MEI Computer Technology Group Inc. in 2010 indicates, trade promotion (e.g., wholesale price reduction) is extensively applied in the consumer packaged goods (CPG) industry, and there is an increased emphasis on improving its effectiveness. According to Investopedia and TechTarget, the CPG industry is one of the largest in North America, valued at approximately US\$2 trillion; some examples of CPGs are food and beverages, footwear and apparel, tobacco, and household products. Ailawadi, Farris, and Shames (1999) stated that trade-promotion expenditures in this industry increased from less than 35 percent in 1983 to nearly 49 percent in 1994, and its budget was more than twice the media advertising budget. The experiences in real business world testify to the conclusions presented in Cachon and Terwiesch (2006, Ch. 14) and Chopra and Meindl (2004, Ch. 10): Trade promotion could result in retail opportunism. When a manufacturer temporarily cuts his wholesale price in order to attract and keep customers, some retailers may use the offer to increase their own margins by purchasing more for future periods rather than sharing the promotion with consumers. This is known as forward buying. Such a response is troubling the manufacturer since he cannot pass the low price to end customers through the retailers and the retailers' opportunistic order behavior leads to the bullwhip effect. On the other hand, without trade promotion, the manufacturer may suffer a significant decline in market share if the competitors continue with trade promotion. More

examples and discussions about trade promotion and forward buying can be found in Kumar, Rajiv, and Jeuland (2001).

To encourage the use of trade promotion but avoid forward buying, Ailawadi, Farris, and Shames (1999) suggested that the manufacturers could coordinate their supply chains by using *price-up deal-down* strategies that link the wholesale price to the retail price. Using the strategies, Bernstein and Federgruen (2005) introduced a linear price-discount sharing (PDS) scheme to a game model, and investigated the equilibrium behavior of decentralized supply chains involving  $N$  competing retailers in the newsvendor setting. They showed that, when a PDS scheme is reduced to a constant wholesale pricing scheme (where the wholesale price is equal to the supplier's purchase cost), supply chain coordination could be achieved with the constant wholesale pricing scheme and a buy-back rate. Cachon and Lariviere (2005) found that, in the price-setting newsvendor model, a PDS scheme is equivalent to the revenue-sharing contract for supply chain coordination. Based on our above survey, we believe that supply chain coordination has been becoming a prevailing issue in the supply chain management field, and it could be induced through a PDS scheme in the newsvendor setting. However, in reality most supply chain members would like to have a long-term business relationship rather than only for a single period, so it should be more interesting to relax the newsvendor assumption and consider a more general case—supply chain competition and coordination with a pricing scheme in a multi-period context. The major purposes of our paper are to seek an equilibrium decision for each period in a multi-period problem, examine whether the decision is stationary over the periods and investigate whether a wholesale pricing scheme (a PDS scheme or a constant wholesale pricing scheme) can be found to achieve supply chain coordination for each period. Moreover, for each period we utilize a game-theoretic solution concept (e.g., Nash arbitration scheme) to split the chainwide

profit generated under supply chain coordination, and compute the side payment transferred between supply chain members to implement the allocation scheme.

In this paper we consider a two-echelon supply chain where a supplier determines his production quantity and a retailer chooses her order size and retail price for each period in an infinite horizon. Using a linear PDS scheme for each period, we base the supplier's wholesale price on the retail price. At the beginning of each period the retailer determines her order quantity for the current period and places an order with the supplier. If customer demand in the period is greater than the retailer's order quantity, the demand is partially filled and the unsatisfied part is lost with a penalty cost charged to the retailer. Otherwise, for the case of overstock, the leftover is carried over to the later period and the retailer incurs a holding cost. The supplier chooses a production quantity and attempts to fill the retailer's order placed at the beginning of each period. In order to immediately fill the order of the retailer, the supplier should make his decision earlier than the arrival of the retailer's order. For simplicity, we assume that the supplier's order can be fully satisfied by his upstream member, and that the lead-time for the supplier to deal with the retailer's order is so short that no more than one order is outstanding at any point in time.

The demand faced by the retailer is an identically-distributed random variable over the infinite horizon, and the demands for different periods are independent of one another. Assuming that the distribution of the demand in a period depends on the retail price in the period, we write the demand function for period  $t$  ( $t = 1, 2, \dots, \infty$ ) in a multiplicative form, i.e.,

$$D_t(p_t, \varepsilon) = D(p_t)\varepsilon, \quad (1)$$

where  $D(p_t)$  is a non-negative constant demand term dependent on the retail price  $p_t$  (chosen by the retailer for period  $t$ ). The term  $\varepsilon$  denotes a

non-negative r.v. which is *stationary* over the infinite time horizon with c.d.f.  $F(\cdot)$  and p.d.f.  $f(\cdot)$ . We denote the mean value and variance of  $\varepsilon$  by  $\mu$  and  $\sigma^2$ , i.e.,  $E(\varepsilon) = \mu$  and  $\text{Var}(\varepsilon) = \sigma^2$ . Using Bertrand's model (1883), we write the deterministic demand  $D(p_t)$  as a linear, continuous, and strictly decreasing function of the retail price  $p_t$ , i.e.,  $\zeta_t$  and  $\eta_t$ . For some applications of Bertrand's model, see Palaka, Erlebacher, and Kropp (1998) and Corbett and Karmarkar (2001).

The multiplicative demand function (1) has been extensively used in the management science and operations management field. For example, Petruzzi and Dada (1999) specified the price-sensitive demand function in the multiplicative form in the newsboy context. Chen and Simchi-levi (2004) assumed the demand function is  $X_t$ , where  $\zeta_t \leq X_t$  is random perturbations identically distributed and independent across times. Equating  $\eta_t \leq X_t$  to zero reduces the demand function in Chen and Simchi-levi (2004) to (1).

In this paper we will develop an inventory-related stochastic game (a.k.a. Markov game) to find the equilibrium decisions of supply chain members, and discuss if a PDS scheme can achieve supply chain coordination for each period in an infinite horizon. The theory of stochastic games—that was introduced by Shapley (1953)—describes the time-dependent multi-period game models. For a particular discussion on such games, see Fudenberg and Tirole (1992). As Cachon and Netessine (2004) reviewed, stochastic games have been used to investigate some supply chain-related problems. Cachon and Zipkin (1999) examined a two-echelon supply chain involving a wholesaler and a retailer who determine their inventory decisions. Assuming stationary stochastic demand and fixed transportation times, they considered two stochastic games and designed simple linear side-payment schemes to coordinate the supply chain. Netessine, Rudi, and Wang (2005) analyzed a stochastic multi-period game for a horizontal supply chain where two retailers compete for customers by determining their ordering quantities of

a single product with an exogenously given price. Different from Netessine, Rudi, and Wang (2005) where the price is given, the retailer's price in our model is a decision variable and the supplier's wholesale price is determined by a PDS scheme. Moreover, our paper considers a vertical supply chain involving a supplier and a retailer, and also examines supply chain coordination.

Our game analysis is conducted under complete information. To reflect dynamic features in our game model, we consider non-stationary costs. Specifically, the supplier's unit purchase cost and both members' unit holding and shortage penalty costs are non-stationary over the time horizon. (Note that the retailer's unit purchase cost is equal to the supplier's wholesale price that is computed by using a PDS scheme.) The expected profits of the supplier and the retailer are computed as the sum of the discounted expected profits incurred for all periods. We assume that the discount factor  $\beta$  is stationary and the same for both members. Moreover, it is assumed that the unit holding cost of the retailer ( $h_t$ ,  $t = 1, 2, \dots$ ) is greater than or equal to that of the supplier ( $H_t$ ,  $t = 1, 2, \dots$ ), i.e.,  $H_t \leq h_t$ . The assumption does actually make sense due to the following fact: The unit holding cost is commonly computed as a fraction of the unit purchase cost, and the retailer's unit purchase cost is the supplier's wholesale price ( $w_t$ ,  $t = 1, 2, \dots$ ) which is no less than the supplier's unit purchase cost ( $c_t$ ,  $t = 1, 2, \dots$ ). Using this fact we make two other assumptions that  $H_t \leq w_t$  and  $h_t \leq c_t$ .

The paper is organized as follows: In "Stochastic Game Model" we develop the discounted profit functions for the supplier and the retailer, and construct a stochastic game model. The "Equilibrium Analysis" section analyzes the game model with a given wholesale pricing (PDS) scheme and obtains the equilibrium decisions for both members. Particularly, in this section we first perform the best-response analysis for each member (player), and then find whether or not a Nash equilibrium exists in each period and the equilibrium solution is unique. If a Nash equilibrium solution exists

for any subgame (game for some periods), we use the concept of Markov perfect equilibrium (see, for example, Fudenberg and Tirole 1992) to characterize equilibrium behaviors of the supplier and the retailer. In “Supply Chain Coordination” we investigate whether or not supply chain coordination can be achieved by a well-designed PDS scheme or a constant wholesale pricing scheme. Under such a scheme, the supplier and the retailer choose their equilibrium decisions that maximize the supply chain-wide profit and make both members better off than in the non-cooperative situation. As Bernstein and Federgruen (2005) showed, the supplier’s wholesale price  $w_t$  for supply chain coordination could be equal to his unit purchase cost  $c_p$ , which resulting in zero profit at the supplier echelon for period  $t$ . For this case, we find that the wholesale price does not depend on the retail price, which implies that the PDS scheme is reduced to a constant wholesale pricing scheme. In order to entice both members to cooperate, we use Nash arbitration scheme to allocate the system-wide profit between the retailer and the supplier, and compute a side payment transferred between them. Under supply chain coordination, both members are better off than in the non-cooperative situation. In the concluding section we summarize our model and major results, and provide some opportunities for the applications of stochastic games.

## STOCHASTIC GAME MODEL

We now construct a stochastic game by developing the objective (discounted profit) functions for both supply chain members. In the model the supplier determines his production quantity  $Q_t$  and the retailer chooses her order quantity  $q_t$  and retail price  $p_t$ ,  $t = 1, 2, \dots, \infty$ . The supplier’s wholesale price  $w_t$  for period  $t$  is computed by using the following linear price-discount sharing (PDS) scheme:

$$w_t = w_t^0 - \alpha_t(p_t^0 - p_t), \quad (2)$$

where  $w_t^0$  and  $p_t^0$  denote a *base* wholesale price and a *base* retail price in period  $t$ , respectively. (For an application of this linear PDS model, see Bernstein and Federgruen, 2005.) We assume that  $c_t \leq w_t^0 \leq p_t^0$ , in which  $c_t$  is the supplier’s unit purchase cost. The parameter  $\alpha_t$  represents a non-stationary ratio of price changes of the two members, and is assumed to be greater than or equal to zero, i.e.,  $\alpha_t \geq 0$ . Note that when  $\alpha_t = 0$ , the PDS scheme for period  $t$  is reduced to a constant wholesale pricing scheme where  $w_t = w_t^0$ . The linear PDS model (2) is explained as follows: If the retail price  $p_t$  is greater (less) than  $p_t^0$  by one dollar, then the wholesale price  $w_t$  is greater (less) than  $w_t^0$  by  $\alpha_t$  dollars. To assure that  $w_t \geq c_p$ , the value of  $w_t^0$  should be properly chosen. The “Equilibrium Analysis” section assumes that  $w_t^0$  is properly given so that  $w_t$  is no less than  $c_p$ . In “Supply Chain Coordination,” we find the well-designed value of  $w_t^0$  that satisfies the condition and coordinates the supply chain.

We begin by developing the supplier’s discounted profit function. To get it we need to find the expected profit of the supplier for period  $t$ ,  $t = 1, 2, \dots, \infty$ . As assumed in the introduction, the supplier has a short time to process the retailer’s order and the supplier’s order is fully satisfied by his upstream member. At the beginning of each period the supplier receives the retailer’s order with quantity  $q_p$  and attempts to satisfy the order using his products available in stock. If the supplier’s inventory level is greater than or equal to the retailer’s order size  $q_p$ , then the retailer’s order is fully satisfied, the leftover is carried over to period  $t + 1$ , and the supplier incurs a holding cost. Otherwise, the retailer’s order is partially filled and the unsatisfied part is lost with a shortage penalty cost absorbed by the supplier. Thus, the supplier’s expected profit function for period  $t$  is formulated as shown in Box 1.

Box 1.

$$\Pi_t(Q_t; q_t, p_t) = E[w_t \min(Y_t, q_t) - H_t(Y_t - q_t)^+ - K_t(q_t - Y_t)^+ - c_t Q_t], \quad (3)$$

where  $K_t$  is the unit shortage costs;  $Y_t$  is the supplier's order-up-to level at the beginning of period  $t$ , and it is computed as  $Y_t = Q_t + X_t$  in which  $X_t$  denotes the leftover transferred from period  $t - 1$ .  $X_t$  is the *state* at the supplier echelon for period  $t$ , and it can be computed as:

$$X_t = \begin{cases} X_1, & t = 1, \\ (Y_{t-1} - q_{t-1})^+, & t \geq 2. \end{cases} \quad (4)$$

Box 2.

$$\Pi(\mathbf{Q}; \mathbf{q}, \mathbf{p}) = E \left\{ \sum_{t=1}^{\infty} \beta^{t-1} [w_t \min(Y_t, q_t) - H_t(Y_t - q_t)^+ - K_t(q_t - Y_t)^+ - c_t Q_t] \right\}, \quad (5)$$

where  $\mathbf{Q} \equiv (Q_t, t = 1, \dots, +\infty)$ ;  $\mathbf{q} \equiv (q_t, t = 1, \dots, +\infty)$ ; and  $\mathbf{p} \equiv (p_t, t = 1, \dots, +\infty)$ .

We assume that, at the beginning of the first period, the starting inventory  $X_1$  is given.

Letting  $\beta$  denote the discount factor per period, we find that the profit  $\Pi_t$  in (3) for period  $t$  is equivalent to the value  $\beta^{t-1}\Pi_t$  at the beginning of the first period. Thus, the discounted profit of the supplier can be written as shown in Box 2.

Next, we consider the discounted profit function of the retailer. Note that whether or not the retailer's order placed at the beginning of period  $t$  can be fully satisfied depends on the supplier's inventory level  $Y_t$ . The retailer receives her order quantity  $q_t$  or  $Y_t$ , whichever is smaller. After receiving the products, the retailer's inventory is increased to the order-up-to level  $y_t$ , which can be computed by using the formula  $y_t = \min(q_t, Y_t) + x_t$ . Here  $x_t$  is the *state* of the retailer for period  $t$ , and represents the leftover transferred from period  $t - 1$ , which is found as:

$$x_t = \begin{cases} x_1, & t = 1, \\ [y_{t-1} - \hat{D}_{t-1}]^+, & t \geq 2, \end{cases} \quad (6)$$

where  $D_{t-1}$  denotes the actual demand in period  $t - 1$  and is known to the retailer at the beginning of period  $t$ ; and  $x_1$  is the given starting inventory level for the first period.

Using  $y_t$ , the retailer attempts to satisfy the demand  $D_t(p_t, \varepsilon)$  that is determined by (1). If  $D_t(p_t, \varepsilon) \geq y_t$ ,  $y_t$  units of demand are satisfied and  $[D_t(p_t, \varepsilon) - y_t]$  units are lost with a penalty cost  $k_t[D_t(p_t, \varepsilon) - y_t]$  charged to the retailer, where  $k_t$  is the unit shortage cost. Otherwise, if  $D_t(p_t, \varepsilon) \leq y_t$ , the leftover  $[y_t - D_t(p_t, \varepsilon)]$  is carried over to the next period (i.e., period  $t + 1$ ) and the retailer incurs a holding cost  $h_t[y_t - D_t(p_t, \varepsilon)]$ , where  $h_t$  is the unit holding cost. As a result, we develop the retailer's expected profit function for period  $t$  as: (see Box 3)

We have constructed the two members' objective functions (5) and (8). The supplier and the retailer make their decisions by solving the problems  $\max_{\mathbf{Q}} \Pi(\mathbf{Q}; \mathbf{q}, \mathbf{p})$  and  $\max_{q_t, p_t} \pi(\mathbf{q}, \mathbf{p}; \mathbf{Q})$ , respectively. In the next section, we will analyze



Box 3.

$$\pi_t(q_t, p_t; Q_t) = E\{p_t \min[y_t, D_t(p_t, \varepsilon)] - h_t[y_t - D_t(p_t, \varepsilon)]^+ - k_t[D_t(p_t, \varepsilon) - y_t]^+ - w_t \min(q_t, Y_t)\}. \quad (7)$$

Thereby, the retailer's objective (discounted profit) function is:

$$\pi(\mathbf{q}, \mathbf{p}; \mathbf{Q}) = \sum_{t=1}^{\infty} \beta^{t-1} E\{p_t \min[y_t, D_t(p_t, \varepsilon)] - h_t[y_t - D_t(p_t, \varepsilon)]^+ - k_t[D_t(p_t, \varepsilon) - y_t]^+ - w_t \min(q_t, Y_t)\}.$$

Since  $\min[y_t, D_t(p_t, \varepsilon)] = y_t - [y_t - D_t(p_t, \varepsilon)]^+$  and  $\min[q_t, Y_t] = q_t - [q_t - Y_t]^+$ , we simplify the retailer's objective function to

$$\pi(\mathbf{q}, \mathbf{p}; \mathbf{Q}) = \sum_{t=1}^{\infty} \beta^{t-1} E\{p_t y_t - w_t Y_t - (p_t + h_t)[y_t - D_t(p_t, \varepsilon)]^+ - k_t[D_t(p_t, \varepsilon) - y_t]^+ + w_t(Y_t - q_t)^+\}. \quad (8)$$

the two maximization problems to get the best response functions of the two members, which is then used to obtain the equilibrium solutions.

## EQUILIBRIUM ANALYSIS

We now conduct the best-response analysis for each supply chain member. Specifically, when the retailer's decision is  $(q_t, p_t)$ ,  $t = 1, 2, \dots, \infty$ , the supplier maximizes his objective function  $\Pi(\mathbf{Q}; \mathbf{q}, \mathbf{p})$  to find the optimal response  $Q_t^B$  which is in terms of  $q_t$  and  $p_t$ . Similarly, the retailer can obtain her best responses  $q_t^B$  and  $p_t^B$  by maximizing  $\pi(\mathbf{q}, \mathbf{p}; \mathbf{Q})$  given that the supplier's decision is  $Q_t$ . The analytical results will be used later to compute the equilibrium solutions.

From (5) and (8), we find that the discounted profit of each supply chain member is the sum of expected profits that are converted to the first period by the factor  $\beta$ . Since our game model assumes a stationary demand distribution that is independent across the periods, we can break down the multi-period game into the multiple *identical*

single-period games. As a result, solving (5) and (8) for the best response solutions is equivalent to solving single-period objective functions (3) and (7) for period  $t$ ,  $t = 1, 2, \dots, \infty$ . Note that, if we relax the assumption of stationary demand, we cannot break down the multi-period game and our game analysis would be too complicated to be intractable and present the analytical results. Cachon and Netessine (2004) gave a discussion regarding the assumption of stationary demand and the technique of breaking down a multi-period stochastic supply-chain game into multiple single-period games. For some similar applications, see Cachon and Zipkin (1999) and Netessine, Rudi, and Wang (2005).

One could find that the stochastic game is quite similar to the single-period static game. We briefly provide our explanations as follows: (i) the stochastic game considers the important and realistic issue that the leftover for a period are carried over to the next period, which is different from a static game; (ii) investigating the stochastic game gives some results (e.g., our discussion on whether or not an equilibrium decision is stationary over the

periods) that cannot be envisioned by the static game; (iii) we conduct the game analysis for the case in which the supply chain members have a long-term partnership rather than a single-period temporary business relationship. The long-term partnership no doubt plays an important role in supply chain coordination.

### Supplier's Best-Response Analysis

We analyze the objective function (3) to obtain the supplier's best-response  $Q_t^B$  for period  $t$  given the retailer's decision  $(q_t, p_t)$ . For the period, the state of the supplier is the leftover  $X_t$  transferred from period  $t-1$ , which is computed by (4).

**Theorem 1.** *For period  $t, t = 1, 2, \dots, +\infty$ , the supplier's best response is*

$$Q_t^B = (q_t - X_t)^+, \quad (9)$$

where

$$X_t = \begin{cases} X_1 \text{ (given)}, & t = 1, \\ [(Q_{t-1}^B + X_{t-1}) - q_{t-1}]^+, & t \geq 2. \end{cases}$$

**Proof.** The proof of this theorem and the proofs of all subsequent theorems in our main paper are given in Appendix A. ■

Using (9) we compute the supplier's order-up-to level  $Y_t^B$  as

$$Y_t^B = Q_t^B + X_t = (q_t - X_t)^+ + X_t = \max(q_t, X_t). \quad (10)$$

**Remark 1.** Theorem 1 suggests that the supplier adopts the *base stock* inventory policy as his best-response strategy for each period. When the retailer's order quantity  $q_t$  is given and known to the supplier, the supplier makes his production

decision according to the comparison between  $X_t$  and  $q_t$ . If  $X_t \geq q_t$ , the supplier's production quantity for period  $t$  is zero. Otherwise, the supplier manufactures  $(q_t - X_t)$  units of products to shift his inventory level up to  $q_t$ . Furthermore, we conclude that the best response adopted by the supplier is *stationary* over the infinite horizon. ◁

### Retailer's Best-Response Analysis

We analyze the retailer's profit maximization problem (7) for period  $t$  to find her best response  $(q_t^B, p_t^B)$  as the supplier chooses his production quantity  $Q_t$ . Replacing the retailer's order-up-to level  $y_t$  with  $\min(q_t, Y_t) + x_t$ , we re-write the maximization problem for period  $t$  as shown in Box 4.

For the best-response analysis, we use the following three steps: (i) fix the retail price  $p_t$  and find the best-response order quantity  $q_t^B$ ; (ii) fix  $q_t$  and find the best-response price  $p_t^B$ ; (iii) find the retailer's best-response  $(q_t^B, p_t^B)$ . In the first step, we compare  $q_t$  and  $Y_t$  and have: (see Box 5)

**Lemma 1.** *For a given value of  $p_t$ , the function  $\pi_t(q_t, p_t; Q_t)$  is strictly concave in order quantity  $q_t$ .*

**Proof.** The proof of this lemma and the proofs of all subsequent lemmas in our main paper are given in Appendix B. ■

Solving (27) we can find the optimal order quantity for a given  $p_t$ .

**Theorem 2.** *For a retail price  $p_t$ , the retailer's optimal order quantity  $(q_t^B)$  is*

$$\hat{q}_t = \begin{cases} q_t^0(p_t), & q_t^0(p_t) \leq Y_t, \\ Y_t + \theta_t, & q_t^0(p_t) \geq Y_t, \end{cases}$$

where  $\theta_t$  is an arbitrary value in the range  $[0, +\infty)$ , and

Box 4.

$$\max_{q_t, p_t} \pi_t(q_t, p_t; Q_t) = E\{p_t \min[\min(q_t, Y_t) + x_t, D_t(p_t, \varepsilon)] - h_t[\min(q_t, Y_t) + x_t - D_t(p_t, \varepsilon)]^+ - k_t[D_t(p_t, \varepsilon) - (\min(q_t, Y_t) + x_t)]^+ - w_t \min(q_t, Y_t)\}, \quad (11)$$

where  $x_t$  denotes the state for period  $t$  and is computed by using (6).

Box 5.

If  $q_t \leq Y_t$ , the expected profit function (11) is reduced to

$$\pi_{t1}(q_t, p_t; Q_t) = E\{p_t \min[q_t + x_t, D_t(p_t, \varepsilon)] - h_t[q_t + x_t - D_t(p_t, \varepsilon)]^+ - k_t[D_t(p_t, \varepsilon) - (q_t + x_t)]^+ - w_t q_t\}. \quad (12)$$

If  $q_t \geq Y_t$ , the expected profit function (11) is written as

$$\pi_{t2}(q_t, p_t; Q_t) = E\{p_t \min[Y_t + x_t, D_t(p_t, \varepsilon)] - h_t[Y_t + x_t - D_t(p_t, \varepsilon)]^+ - k_t[D_t(p_t, \varepsilon) - (Y_t + x_t)]^+ - w_t Y_t\}. \quad (13)$$

which is independent of the decision variable  $q_t$ .

$$q_t^0(p_t) = \left( D(p_t) F^{-1} \left[ \frac{p_t + k_t - w_t}{p_t + h_t + k_t} \right] - x_t \right)^+. \quad (14)$$

Next we find the optimal retail price  $p_t$  for a given order quantity  $q_t$ .

**Lemma 2.** For any given  $q_t$ , the objective function  $\pi_t(q_t, p_t; Q_t)$  for period  $t$  is strictly concave in the retail price  $p_t$ .  $\square$

Using Theorem 2 and Lemma 2, we can find the best-response retail price  $p_t^B$  and order quantity  $q_t^B$  which maximize the objective (profit) function  $\pi_t(q_t, p_t; Q_t)$  in (11).

**Theorem 3.** The retailer's best response is obtained as shown in Box 6.  $\square$

## EQUILIBRIUM SOLUTION

We use the best-response results given by Theorems 1 and 3 to find the Nash equilibrium for period  $t$ .

**Theorem 4.** The Nash equilibrium for period  $t$  is obtained as shown in Box 7.  $\square$

The Nash equilibrium in Theorem 4 suggests that the supplier should adopt a *base stock* policy in each time period. We notice that, by using the base-stock strategy, the supplier's production quantity is always equal to the retailer's order quantity after a period. Particularly, if, in a period, the supplier's stock is reduced to a level that is lower than the retailer's order quantity, the supplier schedules his production and increases his inventory level to the size of the retailer's order. As a result, at the end of the period, the supplier's inventory level is decreased to zero after the retailer's order is satisfied; and for any following periods, the state

Box 6.

$$(q_t^B, p_t^B) = \begin{cases} (q_t^0(\tilde{p}_t), \tilde{p}_t), & \text{if } \pi_t(q_t^0(\tilde{p}_t), \tilde{p}_t; Q_t) \geq \pi_t(Y_t + \theta_t, \hat{p}_t; Q_t), \\ (Y_t + \theta_t, \hat{p}_t), & \text{if } \pi_t(q_t^0(\tilde{p}_t), \tilde{p}_t; Q_t) \leq \pi_t(Y_t + \theta_t, \hat{p}_t; Q_t), \end{cases} \quad (15)$$

where  $\tilde{p}_t \equiv \arg \max_{q_t^0(p_t) \leq Y_t} \pi_t(q_t^0(p_t), p_t; Q_t)$  and  $\hat{p}_t \equiv \arg \max_{q_t^0(p_t) \geq Y_t} \pi_t(Y_t + \theta_t, p_t; Q_t)$ .

Box 7.

$$(Q_t^N, q_t^N, p_t^N) = ((q_t^0(\bar{p}_t) - X_t)^+, q_t^0(\bar{p}_t), \bar{p}_t), \quad (16)$$

where  $\bar{p}_t$  is the optimal solution maximizing

$$\max_{p_t} \pi_t(q_t^0(p_t), p_t; Q_t) = E\{(p_t - w_t)q_t^0(p_t) + p_t x_t - (p_t + h_t)[q_t^0(p_t) + x_t - D_t(p_t, \varepsilon)]^+ - k_t[D_t(p_t, \varepsilon) - (q_t^0(p_t) + x_t)]^+\}.$$

(starting inventory) for each period is zero and the supplier's equilibrium production lot size equals the retailer's order quantity. We plot Figure 1 to illustrate the equilibrium solutions in the infinite horizon.

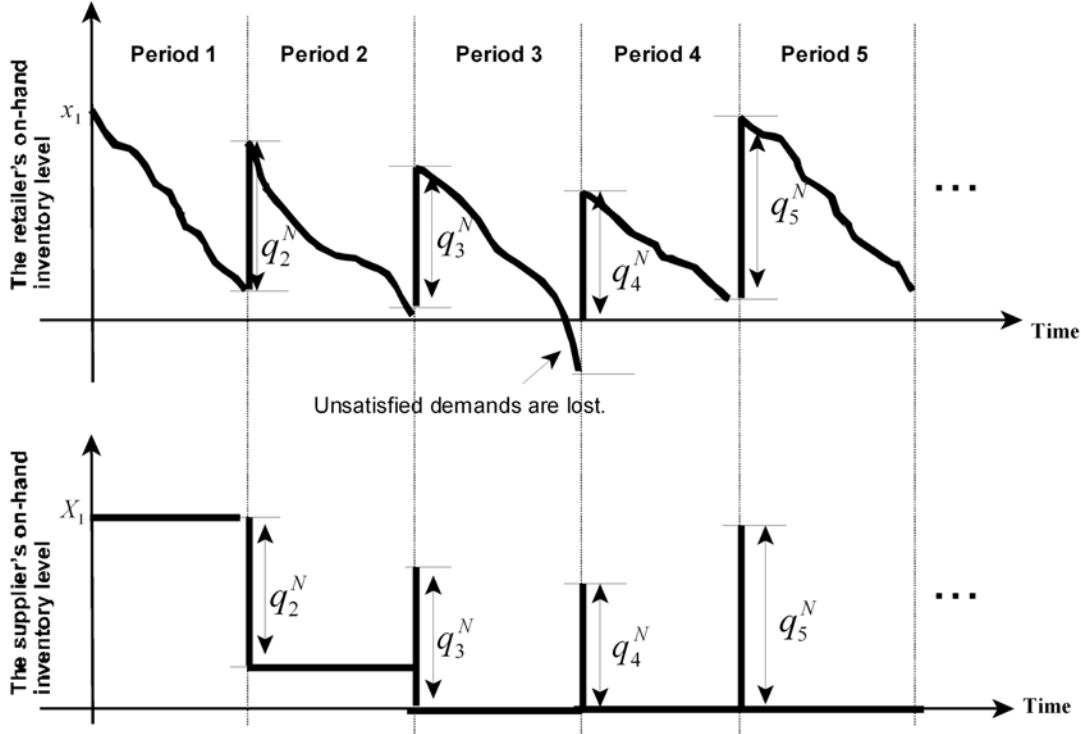
**Remark 2.** According to Figure 1, the Nash equilibrium solutions over the time horizon are *stationary* after some specific period when the inventory level is reduced to zero. However, prior to the period, the equilibrium could be *non-stationary*. For example, we assume that the starting inventory level  $X_t$  for period  $t$  is positive. If  $q_t^0(\bar{p}_t) \leq X_t$ , Theorem 4 indicates that the Nash equilibrium for this period is  $(Q_t^N, q_t^N, p_t^N) = (0, q_t^0(\bar{p}_t), \bar{p}_t)$ , which implies that the supplier does not schedule his production for period  $t$ . In period  $t + 1$ , if  $q_{t+1}^0(\bar{p}_{t+1}) > X_{t+1}$ , then the Nash equilibrium for the period is  $(Q_{t+1}^N, q_{t+1}^N, p_{t+1}^N) = (q_{t+1}^0(\bar{p}_{t+1}) - X_{t+1}, q_{t+1}^0(\bar{p}_{t+1}), \bar{p}_{t+1})$ , which is different from the schedule for period  $t$ . For this example, the equilibria for all periods after period  $t + 1$  are stationary. ◀

In the theory of stochastic games, we use the concept of Markov perfect equilibrium (MPE) to characterize the equilibrium behaviors of the supplier and the retailer for all periods. The MPE is defined as a profile of Markov strategies that yields a Nash equilibrium in every proper subgame; see Fudenberg and Tirole (1992, Ch. 13). Theorem 4 indicates that a unique Nash equilibrium for each time period always exists if the PDS scheme is designed such that the wholesale price  $w_t$  is positive.

**Theorem 5.** *If the base wholesale price  $w_t^0$  is properly designed to ensure positive wholesale price  $w_t$ , then Markov perfect equilibrium (MPE) always exists in the two-echelon supply chain in an infinite horizon. ◻*

**Example 1.** In the numerical example we compute the Nash equilibrium solutions for 10 periods. For the demand function (1), we assume that  $D(p_t) = -2p_t + 100$  and  $\varepsilon$  is a normally-distributed random variable with mean value 5 and variance 1, i.e.,  $\varepsilon \sim N(5, 1)$ . In order to assure the positive

Figure 1. The equilibrium production quantity of the supplier and order size of the retailer in the infinite horizon



value of  $\varepsilon$ , we truncate the normal distribution function at zero and assume that the probability of negative values are added to that of zero. (For an application of the assumption, see Netessine, Rudi, and Wang [2005].) Moreover, for simplicity we set the values of PDS parameters in (2) to the following:  $\alpha_t = 0.2, t=1, \dots, 10$ , and the discount factor  $\beta = 0.6$ . The values of the other parameters and actual demands for ten periods (i.e.,  $D_{\square, t}, t=1, \dots, 10$ ) are given in Table 1.

Next, we specify our computation for period 1, and directly present our results for the other periods in a table. At the beginning of period 1, the available stocks for the supplier and the retailer are assumed to be 200 units and 180 units, respectively. According to Theorem 4 we maximize  $\pi_1(q_1^0(p_1), p_1; Q_1)$  and find Nash-equilibrium price  $p_1^N = \$33.1$ . Using the linear PDS scheme (2) we have the wholesale price

$w_1 = w_1^0 - \alpha_t(p_1^0 - p_1^N) = \$20.62$ , and then compute the retailer's order quantity  $q_1^0(p_1^N) = 0$  units, which means that the retailer does not order new products and her inventory level is 180 units, i.e.,  $y_1 = q_1^0(p_1^N) + x_1 = 180$ . Since  $q_1^0(p_1^N)$  is zero, the supplier has no sale revenue. However, the supplier incurs a holding cost, and his profit for period 1 is  $\Pi_1 = -2 \times 200 = -\$400$ . The expected profit of the retailer for period 1 is computed as \$5112, and the actual profit for the retailer, denoted by  $\pi_{\square, t}$ , is computed as shown in Box 8.

The unsold products totaling 20 [obtained by computing  $(y_1 - D_{\square, 1})$ ] units are carried to period 2. At the beginning of the second period, the available inventory levels at the supplier and the retailer are 200 and 20, i.e.,  $X_2 = 200$  and  $x_2 = 20$ . We find the optimal decisions for the other nine periods and provide the results in Table 2.

Table 1. The parameter values in Example 1

$D_{\square_1}$	$D_{\square_2}$	$D_{\square_3}$	$D_{\square_4}$	$D_{\square_5}$	$D_{\square_6}$	$D_{\square_7}$	$D_{\square_8}$	$D_{\square_9}$	$D_{\square_{10}}$
160	130	140	150	120	150	110	100	120	120
$H_1$	$H_2$	$H_3$	$H_4$	$H_5$	$H_6$	$H_7$	$H_8$	$H_9$	$H_{10}$
2	3	3	2.5	3.5	2	3.5	3	3.5	3
$K_1$	$K_2$	$K_3$	$K_4$	$K_5$	$K_6$	$K_7$	$K_8$	$K_9$	$K_{10}$
5	7	8	6.5	8	6	8.5	7.5	9	8.5
$c_1$	$c_2$	$c_3$	$c_4$	$c_5$	$c_6$	$c_7$	$c_8$	$c_9$	$c_{10}$
15	16	18	17	16	16	17	17	18	19
$w_1^0$	$w_2^0$	$w_3^0$	$w_4^0$	$w_5^0$	$w_6^0$	$w_7^0$	$w_8^0$	$w_9^0$	$w_{10}^0$
20	22	25	23	24	22	25	24	26	26
$h_1$	$h_2$	$h_3$	$h_4$	$h_5$	$h_6$	$h_7$	$h_8$	$h_9$	$h_{10}$
5	5.5	6.5	6	5.5	4.5	4	4.5	4	4
$k_1$	$k_2$	$k_3$	$k_4$	$k_5$	$k_6$	$k_7$	$k_8$	$k_9$	$k_{10}$
11	12	12	12	13	12	10	11	12	11
$p_1^0$	$p_2^0$	$p_3^0$	$p_4^0$	$p_5^0$	$p_6^0$	$p_7^0$	$p_8^0$	$p_9^0$	$p_{10}^0$
30	32	36	35	36	33	35	35	36	36

Box 8.

$$\begin{aligned} \hat{\pi}_1 &= p_1^N \min[q_1^0(p_1^N) + x_1, \hat{D}_1] - h_1[q_1^0(p_1^N) + x_1 - \hat{D}_1]^+ \\ &\quad - k_1[\hat{D}_1 - (q_1^0(p_1^N) + x_1)]^+ - w_1 q_1^0(p_1^N) \\ &= 33.1 \times 160 - 5 \times 20 - 11 \times 0 - 20.62 \times 0 = \$5196. \end{aligned}$$

Using the profits above, we compute ten-period discounted profits for the supplier and the retailer as follows: the supplier's discounted profit is

$$\Pi(\mathbf{Q}; \mathbf{q}, \mathbf{p}) = \sum_{t=1}^{10} \beta^{(t-1)} \Pi_t(Q_t; q_t, p_t) = \$2285.94;$$

and the retailer's expected and actual discounted profits are respectively

$$\begin{aligned} \pi(\mathbf{q}, \mathbf{p}; \mathbf{Q}) &= \sum_{t=1}^{10} \beta^{(t-1)} \pi_t(q_t, p_t; Q_t) = \$7110.34, \\ \hat{\pi}(\mathbf{q}, \mathbf{p}; \mathbf{Q}) &= \sum_{t=1}^{10} \beta^{(t-1)} \hat{\pi}_t(q_t, p_t; Q_t) = \$7707.40. \triangleleft \end{aligned}$$

Now, using the results in Table 2, we discuss the equilibrium decisions and expected profits of the two supply chain members for ten periods. From Figure 2, we find that, except for periods 1 to 3, the retailer's equilibrium prices ( $p_t^N$ ,  $t = 3, \dots, 10$ ) and order quantities ( $q_t^N$ ,  $t = 3, \dots, 10$ )

Table 2. The Results (i.e., optimal decisions and corresponding profits) obtained for the first ten periods

Period		1	2	3	4	5	6	7	8	9	10
Supplier	$X_t$	200	200	92	0	0	0	0	0	0	0
	$Q_t^N$	0	0	21	126	121	132	114	117	84	108
	$Y_t$	200	200	113	126	121	132	114	117	84	108
	$w_t$	20.62	23.02	25.46	23.44	24.34	22.72	25.64	24.52	26.64	25.56
	$\Pi_t$	-400	2199	2501	811	1010	888	985	881	726	818
Retailer	$x_t$	180	20	0	0	0	1	0	4	21	0
	$p_t^N$	33.1	37.1	38.3	37.2	37.7	36.6	38.2	37.6	39.2	38.8
	$q_t^N$	0	108	113	126	121	132	114	117	84	108
	$y_t$	180	128	113	126	121	133	114	121	105	108
	$\pi_t$	5112	1716	979	1199	1093	1315	998	1198	1445	897
	$\pi \square_t$	5196	2227	1135	1442	1571	1669	1264	794	1698	1193

are negatively correlated since they change in a reverse direction across the periods. For each period the retailer’s ordering decision is based on her demand forecast. Note that demand is decreasing in the retailer’s price  $p_t$  since  $dD(p_t)/dp_t < 0$ . If the retailer increases her price, the demand decreases and the retailer correspondingly reduces her order quantity. Otherwise, if the retailer decreases the price, her order quantity should be increased. For the first period, the retailer has a sufficient starting inventory to satisfy the end demand, so that the retailer needn’t place an order with the supplier and a few units of products are carried to period 2. To meet the customer demand and reduce the inventory cost for the second period, the retailer increases the price and orders some units from the supplier. For period 3, the retailer continues increasing her price but orders less products.

The supplier’s production quantity is equal to the retailer’s order size after period 4. For period  $t$ ,  $t \geq 4$ , the supplier’s starting inventory is zero; and, according to Theorem 4, the supplier adopts

the base stock policy so that the inventory level (after production) equals the retailer’s order quantity.

We plot Figure 3 to show the changes of profits at each supply chain member over ten periods in an infinite horizon. We find that the retailer’s expected and actual profits are not significantly different for each period. Moreover, we find that the supplier’s profit ( $\Pi_t$ ) and the retailer’s profits ( $\pi \square_t$  and  $\pi_t$ ) change in a reverse direction. Particularly, the supplier’s profit increases (decreases) when the retailer’s profit decreases (increases), and vice versa. During period 1, the retailer has sufficient inventory to satisfy the demand and does not need to order the new products from the supplier, thus resulting in zero revenue at the supplier echelon. In period 2, the supplier sells most of products in stock to the retailer and carries a few units to period 3 so that the supplier incurs a higher profit, whereas the retailer has to pay for the shortage cost and her profit decreases. After period 2 the supplier chooses production quantity to make his inventory level equal to the re-

Figure 2. The supplier's equilibrium production quantity ( $Q_t^N$ ) and the retailer's equilibrium price ( $p_t^N$ ) and order size ( $q_t^N$ ) over the first ten periods in an infinite horizon

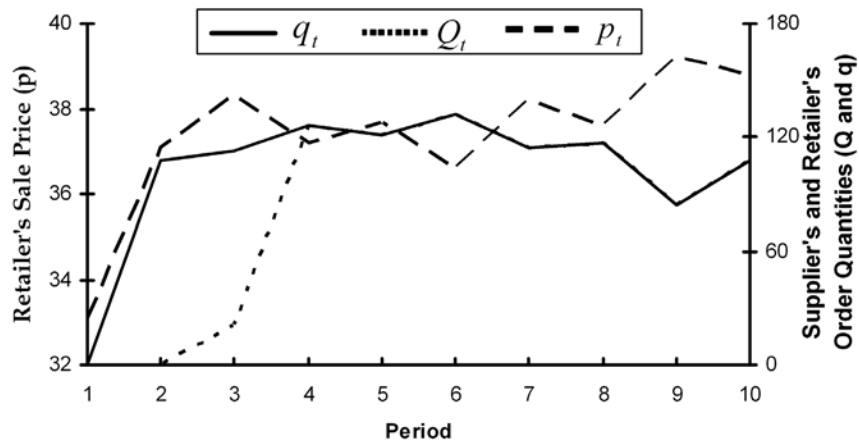
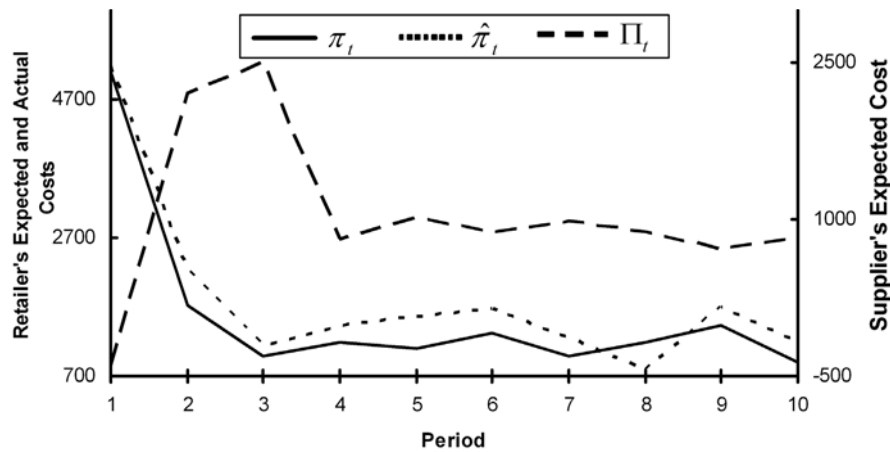


Figure 3. The supplier's profits ( $\Pi_t$ ,  $t = 1, \dots, 10$ ) and the retailer's expected and actual profits ( $\pi_t$  and  $\hat{\pi}_t$ ,  $t = 1, \dots, 10$ ) over the first ten periods in an infinite horizon



tailer's order quantity. In addition, the supplier's wholesale price is determined based on the retailer's price, as indicated in (2). As a result, the supplier's profit depends on not only the retailer's purchase quantity but also her price. If the retailer reduces purchase quantity and sale price, then the supplier's sale quantity and wholesale price are both decreasing and the supplier's profit is reduced. However, the retailer's profit would increase as her purchase cost is reduced.

## SUPPLY CHAIN COORDINATION

In this section we examine whether or not a wholesale pricing scheme (a PDS scheme or a constant wholesale pricing scheme) can be found to achieve supply chain coordination for each period. Under a wholesale pricing scheme, the equilibrium solutions chosen by both supplier and retailer are identical to the globally optimal solutions maximizing the supply chain-wide discounted profit. In addition, the two members are better off than



Box 9.

If  $q_t \leq Y_t = Q_t + X_t$ , then the discounted profit function is

$$\begin{aligned} G_t(Q_t, q_t, p_t \mid q_t \leq X_t) &= \Pi_t(Q_t; q_t, p_t) + \pi_t(q_t, p_t; Q_t) \\ &= E\{q_t(p_t + H_t) - (c_t + H_t)(Q_t + X_t) + c_t X_t + p_t x_t \\ &\quad - (p_t + h_t)[q_t + x_t - D_t(p_t, \varepsilon)]^+ - k_t[D_t(p_t, \varepsilon) - (q_t + x_t)]^+\}. \end{aligned} \quad (17)$$

If  $q_t \geq Y_t = Q_t + X_t$ , then the discounted profit function is

$$\begin{aligned} G_t(Q_t, q_t, p_t \mid q_t \geq X_t) &= \Pi_t(Q_t; q_t, p_t) + \pi_t(q_t, p_t; Q_t) \\ &= E\{(p_t - c_t)(Q_t + X_t) + p_t x_t - K_t[q_t - (Q_t + X_t)] \\ &\quad - (p_t + h_t)[Y_t + x_t - D_t(p_t, \varepsilon)]^+ - k_t[D_t(p_t, \varepsilon) - (Y_t + x_t)]^+\}. \end{aligned} \quad (18)$$

in the non-cooperative situation. Thus, in order to find a proper wholesale pricing scheme, we need to find the globally optimal solutions and compare the solutions with the Nash equilibrium solutions obtained in the ‘‘Equilibrium Analysis’’ section. By equating the two solutions, we can derive the conditions under which the parameters  $\alpha_p, p_0,$  and  $w_0$  make the supply chain coordinated. To entice both members to cooperate for supply chain coordination, we use the game-theoretic solution concept—Nash arbitration scheme—to divide the chainwide profit generated by cooperation between the two supply chain members, and compute the side-payment transfer.

### Maximization of Supply Chain-Wide Discounted Profit

Now we find the globally optimal solution that maximizes the system-wide discounted profit. We compute the system-wide discounted profit function for period  $t$ , denoted by  $G_t(Q_t, q_t, p_t)$ , as the sum of the discounted profits of the supplier and the retailer, i.e.,  $G_t(Q_t, q_t, p_t) = \Pi_t(Q_t; q_t, p_t) + \pi_t(q_t, p_t; Q_t)$ . Since  $Y_t = Q_t + X_t$ , we can simplify the objective function for the two cases shown in Box 9.

**Theorem 6.** *Given the retailer’s decisions  $(q_t, p_t)$ , the supplier’s globally optimal production quantity is obtained as  $Q_t^*(q_t, p_t) = (q_t - X_t)^+$ ,  $t = 1, 2, \dots, +\infty$ .  $\square$*

Theorem 6 indicates that, in order to maximize the supply chain-wide profit, the supplier chooses the production quantity by comparing  $X_t$  and  $q_t$  for each period. Next, we find the globally optimal solutions  $(q_t^*, p_t^*)$  that maximize  $G_t((q_t - X_t)^+, q_t, p_t)$ .

**Theorem 7.** *For a given retail price  $p_t$ , the retailer’s globally optimal order quantity is: (see Box 10)  $\square$*

In (19)  $\zeta_t$  and  $\eta_t$  can be explained as the retailer’s *desired* order quantities under different conditions for period  $t$ . As Theorem 7 suggests, at the beginning of each period, the retailer compares the supplier’s starting inventory level with her desired order quantities to determine whether or not to place an order with the supplier. Particularly, if the supplier’s stock available at the beginning of a period is less than the two desired order quantities, then the retailer should place an order for the smaller desired quantity  $\eta_t$ . (Note that  $\zeta_t \geq \eta_t$  accord-

Box 10.

$$q_t^*(p_t) = \begin{cases} \zeta_t, & \text{if } \zeta_t \leq X_t, \\ \eta_t, & \text{if } \eta_t \geq X_t, \\ X_t, & \text{otherwise,} \end{cases} \quad (19)$$

where

$$\zeta_t = \left[ D(p_t)F^{-1} \left( \frac{p_t + H_t + k_t}{p_t + h_t + k_t} \right) - x_t \right]^+, \quad \eta_t = \left[ D(p_t)F^{-1} \left( \frac{p_t + k_t - c_t}{p_t + h_t + k_t} \right) - x_t \right]^+.$$

ing to (24).) If the starting inventory at the supplier is greater than the two desired order quantities, then the retailer should order  $\zeta_t$  (the larger desired) units of products. Otherwise, the retailer's order quantity equals the supplier's starting inventory.

**Remark 3.** Our above analysis implies that the optimal order quantity chosen by the retailer must be close to the supplier's starting inventory level for each period in an infinite horizon. This follows the fact that, in order to maximize the system-wide profit, the two supply chain members should jointly determine their inventory decisions in the supply chain. According to Theorem 6, the supplier adopts the *base stock* policy. In particular, if, at the beginning of a period, the retailer's order quantity is greater than the starting inventory of the supplier, the supplier produces new products and makes his order-up-to level equal to the retailer's order quantity. Otherwise, the supplier does not schedule his production and uses the stock (carried from the last period) to satisfy the retailer's order. Therefore, we base the retailer's ordering decision on the supplier's starting inventory and make the retailer's order quantity as close to the supplier's starting inventory as possible. Otherwise, both members could experience the losses in their profits. For example, if the supplier's starting inventory is greater than the two

desired order quantities and the retailer chooses the smaller one rather than the larger desired one, then the supplier incurs a greater holding cost and the retailer's shortage cost is increased. As another example, we assume that, when the supplier's starting inventory is less than the retailer's two desired order quantities, the retailer chooses the larger one rather than the smaller one. This leads to a higher purchasing and holding costs for the retailer. Thus, the optimal solution maximizing the system-wide profit is given as shown in Theorem 7. ◀

We now analyze the profit function  $G_t$  to find the retail price  $p_t$  for any given order quantities  $(Q_t, q_t)$ .

**Theorem 8.** For period  $t$  the system-wide profit function is strictly concave in the retail price  $p_t$ . ◻

From Theorems 7 and 8, we develop the following procedure for finding the globally optimal solution.

- We solve the maximization problem  $\max_{p_t} G_t(0, \zeta_t, p_t)$ , subject to  $\zeta_t \leq X_t$ . If the optimal solution exists, we denote it by  $p'_t$  and compute the corresponding objective value as  $G_t(0, \zeta_t(p'_t), p'_t)$ .

Box 11.

$$\begin{aligned}
 & (Q_t^*, q_t^*, p_t^*) \\
 = & \begin{cases} (0, \zeta_t(p_t'), p_t'), & \text{if } p_t' \text{ exists and } G_t(0, \zeta_t(p_t'), p_t') = \bar{\pi}^t, \\ (\eta_t(p_t'') - X_t, \eta_t(p_t''), p_t''), & \text{if } p_t'' \text{ exists and } G_t(\eta_t(p_t'') - X_t, \eta_t(p_t''), p_t'') = \bar{\pi}^t, \\ (0, X_t, p_t''') & \text{if } p_t''' \text{ exists and } G_t(0, X_t, p_t''') = \bar{\pi}^t. \end{cases} \quad (20)
 \end{aligned}$$

- We solve the maximization problem  $\max_{p_t} G_t(\eta_t - X_t, \eta_t, p_t)$  subject to  $X_t \leq \eta_t$ . If the optimal solution exists, we denote it by  $p_t''$  and compute the corresponding objective value as  $G_t(\eta_t(p_t'') - X_t, \eta_t(p_t''), p_t'')$ .
- We solve the maximization problem  $\max_{p_t} G_t(0, X_t, p_t)$  subject to  $\eta_t \leq X_t \leq \zeta_t$ . If the optimal solution exists, we denote it by  $p_t'''$  and compute the corresponding objective value as  $G_t(0, X_t, p_t''')$ .
- Letting  $\bar{\pi}^t$  denote the maximum of the objective values computed in the above steps, we obtain the globally optimal solution  $(Q_t^*, q_t^*, p_t^*)$  ( $t = 1, 2, \dots, +\infty$ ) as shown in Box 11.

### Design of a Wholesale Pricing Scheme for Supply Chain Coordination

In order to properly design a wholesale pricing scheme to coordinate the two-echelon supply chain, we find the appropriate values of the PDS parameters ( $w_t^0$ ,  $p_t^0$ , and  $\alpha_t$ ) that make the Nash equilibrium solutions (16) identical to the optimal solutions (20) maximizing the discounted system-wide profit.

**Theorem 9.** *If the globally optimal solution for period t is  $(\eta_t(p_t'') - X_t, \eta_t(p_t''), p_t'')$  and  $p_t''$*

is also the optimal solution for the unconstrained maximization problem  $\max_{p_t} G_t(\eta_t(p_t) - X_t, \eta_t(p_t), p_t)$ , then the supply chain can be coordinated in period t with a wholesale pricing scheme where  $\alpha_t = 0$  and  $w_t^0 = c_t$ .  $\square$

**Remark 4.** From Theorem 9 we obtain two important conclusions below.

1. A condition for supply chain coordination is  $\alpha_t = 0$ , which implies that, when the supply chain is coordinated, the supplier's wholesale price  $w_t$  (paid by the retailer to the supplier) is not associated with the retailer's price. This means that, when the PDS scheme is reduced to a constant wholesale pricing scheme, the supply chain could be coordinated. Since the supplier adopts the base stock inventory policy where the inventory level after production equals the retailer's order quantity, the inventory risk in the supply chain is absorbed by the retailer. Moreover, the retailer's price affects the demand. Hence, the retailer's purchasing and pricing decisions play the important roles in improving supply chain performance.
2. Under a properly-designed wholesale pricing scheme,  $w_t$  is equal to the supplier's unit purchasing cost  $c_t$ , so resulting in zero profit for the supplier. Although the supplier is worse off, the system-wide performance is still improved.  $\triangleleft$

Box 12.

$$\begin{aligned}\phi_t &= \frac{G_t(Q_t^*, q_t^*, p_t^*) + \Pi_t(Q_t^N; q_t^N, p_t^N) - \pi_t(q_t^N, p_t^N; Q_t^N)}{2}, \\ \varphi_t &= \frac{G_t(Q_t^*, q_t^*, p_t^*) - \Pi_t(Q_t^N; q_t^N, p_t^N) + \pi_t(q_t^N, p_t^N; Q_t^N)}{2}.\end{aligned}$$

According to our discussion in Remark 4, we find that the supplier is worse off while the supply chain is coordinated by a proper wholesale pricing scheme (which is a special form of the PDS scheme). If no other scheme is involved to allocate the chainwide profit between the supplier and the retailer, the supplier would lose an incentive to cooperate with the retailer to achieve the supply chain coordination. In order to entice both supply chain members, we should consider the problem of “fairly” allocating the system-wide profit generated by supply chain coordination. Here, under a “fair” allocation scheme, two supply chain members are better off than in the non-cooperative situation. Moreover, Theorem 9 indicates that this supply chain couldn’t be coordinated by using a wholesale pricing scheme. For this case, we should also find an allocation scheme that “fairly” divides the chainwide profit between two members so that both of them have incentives to cooperate for supply chain improvement.

### Allocation of System-Wide Profit under Supply Chain Coordination

We apply Nash arbitration scheme—a solution concept in the theory of cooperative games—to derive the formula of allocating the system-wide profit  $G_t(Q_t^*, q_t^*, p_t^*)$ , which is incurred by both members under supply chain coordination for period  $t$  Nash arbitration scheme (a.k.a. Nash bargaining scheme) was developed by Nash (1950). For a two-player game with the *status quo*  $(\square_0, \varphi_0)$ , the scheme suggests a unique solu-

tion  $(\square, \varphi)$  by solving the following constrained nonlinear problem  $\max (\square - \square_0)(\varphi - \varphi_0), s.t. \square \geq \square_0$  and  $\varphi \geq \varphi_0$ . Let  $\square$  and  $\varphi$  denote the allocations to the supplier and the retailer, respectively. The solution  $(\square, \varphi)$  is an undominated Pareto optimal solution, so that any other solutions cannot make both players better. In our game, for period  $t$  we determine  $\square_t$  and  $\varphi_t$  such that  $\phi_t + \varphi_t = G_t(Q_t^*, q_t^*, p_t^*)$ . Thus, any point satisfying the equality is an undominated Pareto optimal. The status quo point corresponds to the minimum profits that two players could achieve if they do not cooperate, thereby representing the “security” levels guaranteed to the two players. For our game, the status quo is  $(\Pi_t(Q_t^N; q_t^N, p_t^N), \pi_t(q_t^N, p_t^N; Q_t^N))$ .

**Theorem 10.** *When we use Nash arbitration scheme to allocate the system-wide profit  $G_t(Q_t^*, q_t^*, p_t^*)$  for period  $t$ , the supplier and the retailer respectively obtain: (see Box 12)□*

After finding the allocation approach suggested by Nash arbitration scheme, we consider how to implement the allocation scheme. In particular, when the supplier and the retailer cooperate for supply chain coordination, the system-wide profit is:

$$G_t(Q_t^*, q_t^*, p_t^*) = \Pi_t(Q_t^*; q_t^*, p_t^*) + \pi_t(q_t^*, p_t^*; Q_t^*)$$

where the supplier and the retailer have their “local” profits  $\Pi_t(Q_t^*; q_t^*, p_t^*)$  and  $\pi_t(q_t^*, p_t^*; Q_t^*)$ , respectively. In order to let the two supply chain

members obtain  $\square_i$  and  $\phi_i$ , we need to compute the side payment transferred from one member to the other member. For example, as Theorem 9 indicates, the profit incurred by the supplier is zero under supply chain coordination with a wholesale pricing (reduced PDS) scheme. For this case, we compute the side-payment transfer from the retailer to the supplier so that the allocation to the supplier is  $\square_i$ . Otherwise, the supplier would have no incentive to stay with the retailer for supply chain coordination.

**Theorem 11.** *For period  $t$ , the side payment transferred between the supplier and the retailer is  $[\max(S, R) - \min(S, R)]/2$ , where  $S \equiv \Pi_t(Q_t^*; q_t^*, p_t^*) - \Pi_t(Q_t^N; q_t^N, p_t^N)$  and  $R \equiv \pi_t(q_t^*, p_t^*; Q_t^*) - \pi_t(q_t^N, p_t^N; Q_t^N)$ .  $\square$*

As shown by Theorem 9, the supplier's local profit  $\Pi_t(Q_t^*; q_t^*, p_t^*)$  would be zero when the supply chain is coordinated by a constant wholesale pricing scheme where the wholesale price is equal to the supplier's purchase cost, i.e.,  $w_t = c_t$ . For this case, the retailer transfers the side payment  $(R - S)/2$  to the supplier.

To illustrate supply chain coordination with the constant wholesale pricing scheme (i.e.,  $w_t = c_t$ ) and the allocation approach in terms of Nash arbitration scheme, we consider the following example with the parameter values given in Example 1.

**Example 2.** Using the parameter values in Example 1, we numerically investigate whether or not a constant wholesale pricing scheme can coordinate the supply chain, and compute the allocations of the system-wide profit to the two supply chain members. Similar to Example 1, we present a particular computation for period 1 and directly give the results for the other periods. For the first period we begin by obtaining the globally optimal solutions  $(Q_1^*, q_1^*, p_1^*)$ . We find that  $p_1^*$  does not exist, and we get two possible optimal solutions as:  $(0, \zeta_1(p_1'), p_1') = (0, 149, 24.5)$  and

$(0, X_1, p_1''') = (0, 200, 15.93)$ . The corresponding system-wide profits are  $G_t(0, \zeta_1(p_1'), p_1') = \$5708$  and  $G_t(0, X_1, p_1''') = \$4851$ . Thus, the optimal solution is:

$$(Q_1^*, q_1^*, p_1^*) = (0, \zeta_1(p_1'), p_1') = (0, 149, 24.5)$$

and the resulting system-wide profit is \$5708, which is greater than the sum of two members' profits given in Table 2. However, for the period, we cannot achieve supply chain coordination with a constant wholesale pricing scheme, as indicated in Theorem 9. The supplier's wholesale price is attained as:

$$w_1 = w_1^0 - \alpha_1(p_1^0 - p_1^*) = \$18.9.$$

The supplier's expected profit is computed as  $\Pi_t = \$2118$  and the retailer's expected profit is  $\pi_t = \$3590$ . We notice that the supplier is better off than in the non-cooperative situation but the retailer is worse off. In order to entice the retailer to cooperate with the supplier in the first period, we use Theorem 11 to compute the side payment  $(S - R)/2$  transferred from the supplier to the retailer. Since  $S = \$2518$  and  $R = -1522$ , the side payment is computed as \$2020. According to the side-payment scheme (SPS), the supplier transfers \$2020 to the retailer, and the supplier and the retailer have the profits as \$98( $\$2118 - \$2020$ ) and \$5610( $\$3590 + \$2020$ ), respectively. With the allocation both supply chain members are better off.

Next, we find the globally optimal solutions and compute the corresponding system-wide profit for periods 2 through 10. If in a period the retailer's optimal price is  $p_t''$ , the supply chain can be coordinated with the constant wholesale pricing scheme where  $w_t = c_t$ . Moreover, for each period, we find the side payment scheme so that both members have incentives to cooperate for supply chain coordination. Our result is given in Table 3.

*Table 3. The globally optimal solutions and side-payment schemes (SPS) for supply chain coordination over the first ten periods*

Period		1	2	3	4	5	6	7	8	9	10
Supplier	$X_t$	200	51	0	0	0	0	0	0	0	0
	$Q_t^*$	0	0	0	125	156	123	142	110	94	113
	$Y_t$	200	51	0	125	156	123	142	110	94	113
	$w_t$	18.9	22.3	18	17	16	16	17	17	18	19
Retailer	$x_t$	180	169	169	29	4	40	13	45	55	29
	$p_t^*$	24.5	33.5	33.9	35.1	34.7	34.5	35	35.1	35.6	36.1
	$q_t^*$	149	51	0	125	156	123	142	110	94	113
	$y_t$	329	220	169	154	160	163	155	155	149	142
Pricing Scheme?		No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SPS?		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Before SPS	$\Pi_t$	2118	1137	0	0	0	0	0	0	0	0
	$\pi_t$	3590	4061	4922	2567	2294	2896	2344	2871	2942	2366
After SPS	$\Pi_t$	98	2841	3222	1090	1106	1235	1166	1277	1112	1144
	$\pi_t$	5610	2357	1700	1477	1188	1661	1178	1594	1830	1222

From Table 3 we find that, from period 1 to period 2, the supply chain cannot be coordinated by a wholesale pricing scheme. For the two periods, we use the side-payment schemes given by Theorem 11 to fairly allocate the chainwide profit so that both members have incentives to cooperate for supply chain coordination. The supplier's inventory level is reduced to zero at the beginning of period 3 and afterward the supply chain can be coordinated with the constant wholesale pricing schemes ( $w_t = c_p$ ,  $t = 3, 4, \dots, +\infty$ ), which leads to zero profits for the supplier. In order to entice the supplier to cooperate with the retailer for supply chain coordination, we use the side-payment schemes to allocate the system-wide profits between the two supply chain members. It is noticed that both supply chain members are better off after profit allocation with side-payment schemes. In addition, we compute the discounted profits for ten periods as follows: (i)

before the wholesale pricing and side-payment schemes the supplier and the retailer have discounted profits \$2800 and \$9138, respectively; (ii) after the side-payment schemes they have the discounted profits \$3108 and \$8831. Thus, under supply chain coordination, both supply chain members are better off than in the non-cooperative case. (Note that, as Example 1 indicates, for the non-cooperative case, the supplier's and the retailer's expected discounted profits are \$2285.94 and \$7110.34, respectively.) <

Next we examine the variations in the wholesale prices ( $w_t$ ) and sale prices ( $p_t$ ) after coordinating the supply chain. From Figure 4 (a), we find that the prices (i.e.,  $w_t(p_t^*)$  and  $p_t^*$ ) chosen by the supplier and the retailer under the constant wholesale pricing and side-payment schemes are lower than those (i.e.,  $w_t(p_t^N)$  and  $p_t^N$ ) in Example 1. In this example, the two supply chain

Figure 4. The supplier's and the retailer's prices and production/order quantities before and after supply chain coordination

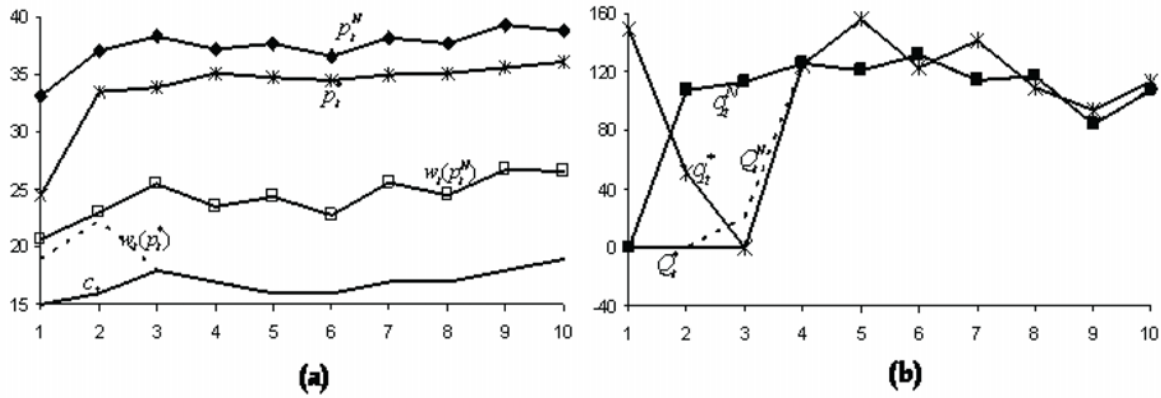
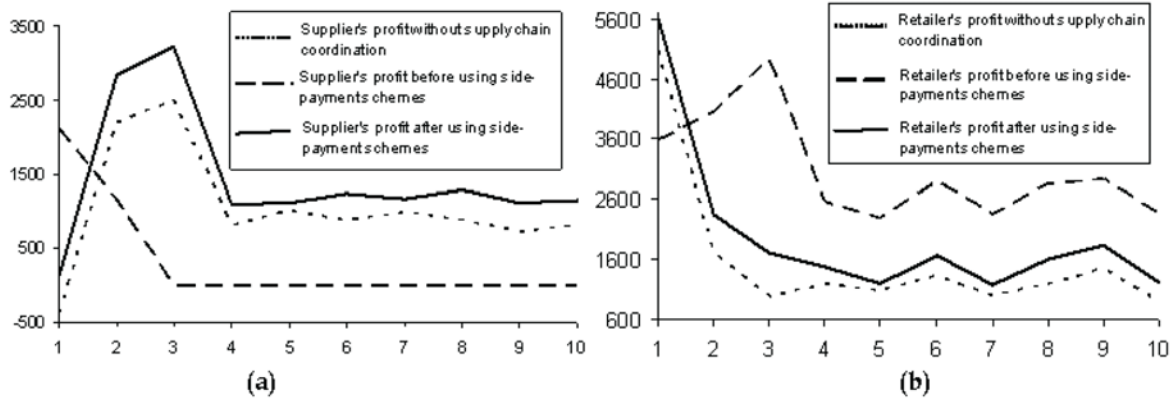


Figure 5. The expected profits of the supplier and the retailer under supply chain coordination



members make their pricing and purchasing decisions to maximize the system-wide profit. Since the demand is a decreasing function of the retail price, they could choose a lower sale price to attract more demand and thus increase the overall profit. As Figure 4 (b) indicates, under supply chain coordination, the retailer's purchase quantities  $q_t^*$  for periods 1 through 3 are significantly different from those ( $q_t^N$ ,  $t = 1, 2, 3$ ) in the non-cooperative situation. For example, without supply chain coordination, the retailer does not place an order with the supplier for the first period since

he has sufficient stock (i.e., 180 units). This results in a negative profit for the supplier and a lower overall profit. In order to increase the system-wide profit, the retailer's ordering decision for the first period is raised to  $q_t^1$ , as shown in Figure 4 (b). The supplier's production quantities are based on the retailer's ordering decisions, since the supplier adopts the base stock policy.

From Figure 5, we can find that, when the supply chain is coordinated with the constant wholesale pricing and SPS schemes, both supply chain members are better off. Moreover, when the two members cooperate for supply chain

coordination, the supplier incurs a lower profit locally and the retailer accomplishes a higher profit except for period 1. In order to entice the supplier to join the coalition we use constant side-payment schemes to transfer some amounts from the retailer to the supplier so that they are both better off.

## **SUMMARY AND CONCLUDING REMARKS**

In this paper, we consider two-echelon supply chains with wholesale pricing schemes in an infinite horizon. Assuming that the supplier's wholesale price is determined by a linear PDS function, we develop a stochastic game where the supplier chooses his production quantity and the retailer determines her order size and retail price. We first solve the stochastic game to find the best response functions for both members. According to the best response analysis, the supplier uses a *base stock* policy, whereas the retailer chooses her optimal solutions based on some specific conditions. By using the best response analysis, we show that for each period a unique equilibrium—which could be *non-stationary* over the periods—always exists for the supply chain.

We next compute the optimal solution that maximizes the supply chain-wide profit for each period. In order to examine whether or not the supply chain can be coordinated, we analyze the globally optimal solution and Nash equilibrium for each time period, and find the conditions under which supply chain coordination is achieved. We show that, if the supply chain is coordinated, the supplier's wholesale price  $w_t$  must equal the unit purchasing cost  $c_t$  so that the PDS scheme is reduced to a constant wholesale pricing scheme. However, the supplier is worse off under the constant PDS scheme since the supplier's profit is reduced to zero due to  $w_t = c_t$ . In order to entice the supplier to cooperate with the retailer for supply

chain coordination, we use the Nash arbitration scheme to allocate the system-wide profit between the two supply chain members, and compute the side-payment scheme to implement the allocation approach suggested by Nash arbitration scheme.

Our paper assumes the stationary demand across the periods in the infinite horizon. It would be more interesting to investigate the supply chain in future by relaxing the assumption. Moreover, we could relax the assumption to examine the game models in Cachon and Zipkin (1999) and Netessine, Rudi, and Wang (2005).

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**ENDNOTES**

<sup>1</sup> <http://www.meicpg.com/news/2010-trade-promotion-management-survey>. (Last accessed August 2010.)

<sup>2</sup> <http://www.investopedia.com/terms/c/cpg.asp>. (Last accessed August 2010.)

<sup>3</sup> <http://searchcrm.techtarget.com/definition/consumer-packaged-goods>. (Last accessed August 2010.)

## APPENDIX A PROOFS OF THEOREMS

### Proof of Theorem 1

In order to simplify our analysis, we compare  $Y_t$  and  $q_t$  to re-write the supplier's objective function (3). Recalling that  $Y_t = Q_t + X_p$ , we have

$$\Pi_t(Q_t; q_t, p_t) = \begin{cases} \Pi_{t1}, & \text{if } Q_t + X_t \geq q_t, \\ \Pi_{t2}, & \text{if } Q_t + X_t \leq q_t, \end{cases} \quad (21)$$

where  $\Pi_{t1} \equiv (w_t + H_t)q_t - H_t(Q_t + X_t) - c_t Q_t$  and  $\Pi_{t2} \equiv (w_t + K_t)(Q_t + X_t) - K_t q_t - c_t Q_t$ . Note that  $\Pi_{t1} = \Pi_{t2}$  when  $Q_t + X_t = q_t$ . To find the supplier's best response, we consider the following two cases:

1.  $q_t \geq X_t$ . We find from (21) that the supplier's profit function is  $\Pi_{t2}$  when  $Q_t = 0$ . As  $\Pi_{t2}$  is an increasing function of  $Q_t$  due to  $w_t \leq c_p$ , we increase the value of  $Q_t$  to raise the supplier's profit  $\Pi_{t2}$ . Noticing that  $\Pi_{t1} = \Pi_{t2}$  when  $Q_t = q_t - X_p$ , we find that, if  $Q_t$  is greater than  $q_t - X_p$ , the profit  $\Pi_{t1}$  is reduced since  $\Pi_{t1}$  is a decreasing function of  $Q_t$ . Hence, for this case, the optimal solution maximizing  $\Pi_t(Q_t; q_t, p_t)$  is obtained as  $Q_t = q_t - X_p$ .
2.  $q_t \leq X_t$ . In this case, the objective function is the decreasing function  $\Pi_{t1}$ , so the optimal production quantity is zero, i.e.,  $Q_t = 0$ .

In conclusion, we reach the best response function (9). ■

### Proof of Theorem 2

According to Lemma 1, we can find the optimal solution  $q_t^0(p_t)$  by equating (27) to zero and solving the resulting equation. If  $q_t^0(p_t) \leq Y_t$ , then the retailer's objective function is (12) and the optimal order quantity is  $q_t^0(p_t)$ . Otherwise, her objective function is (13) which is independent of  $q_t$ . That is, when the supplier's order quantity  $Q_t$  and the retail price  $p_t$  are not changed, the retailer's profit for period  $t$  is a constant. Hence, when  $q_t^0(p_t) \geq Y_t$ , the retailer's optimal order quantity is an arbitrary number greater than or equal to  $Y_t$ . ■

### Proof of Theorem 3

According to Theorem 2, we find an optimal order quantity, considering some specific conditions. In order to get the best response for the retailer, we should compute the optimal retail price for each possible order quantity and compare the resulting objective values (profits). If the condition  $q_t^0(p_t) \leq Y_t$  is satisfied, Theorem 2 suggests that  $q_t = q_t^0(p_t)$ . For this case we can find the optimal price by maximizing the objective function  $\pi_t(q_t^0(p_t), p_t; Q_t)$  subject to  $q_t^0(p_t) \leq Y_t$ . The solution is denoted by  $\tilde{p}_t$ . Lemma 2 shows that  $\tilde{p}_t$  exists. The corresponding profit is  $\pi_t(q_t^0(\tilde{p}_t), \tilde{p}_t; Q_t)$ .

If  $q_t^0(p_t) \geq Y_t$ , Theorem 2 indicates that the optimal order quantity is  $Y_t + \theta_t$  where  $\theta_t \in [0, +\infty)$ . We maximize  $\pi_t(Y_t + \theta_t, p_t; Q_t)$  subject to  $q_t^0(p_t) \geq Y_t$ , and denote the solution by  $p_{\square_t}$ . Substituting  $p_{\square_t}$  into (13) gives the profit  $\pi_t(Y_t + \theta_t, p_{\square_t}; Q_t)$ .

Comparing  $\pi'_R(q_t^0(\tilde{p}_t), \tilde{p}_t; Q_t)$  and  $\pi'_R(Y_t + \theta_t, \hat{p}_t; Q_t)$ , we obtain the best-response solution  $(q_t^B, p_t^B)$  for the retailer as (15). ■

## Proof of Theorem 4

Theorem 3 indicates that the retailer's best response is  $(q_t^0(\tilde{p}_t), \tilde{p}_t)$  or  $(Y_t + \theta_t, p_{\square_t})$ , where  $q_t^0(\tilde{p}_t) \leq Y_t$ . From (9) and (10) we find the supplier's best-response quantity  $Q_t^B = (q_t - X_t)^+$  and order-up-to inventory level  $Y_t^B = \max(q_t, X_t)$ . We analyze the following two cases:

- If the retailer's order quantity  $q_t^B$  is  $q_t^0(\tilde{p}_t)$  which is less than or equal to  $Y_t$ , then  $Y_t^B = X_t \geq q_t^0(\tilde{p}_t)$  and  $Q_t^B = (q_t^B - X_t)^+ = 0$ . In order to find  $\tilde{p}_t$ , we replace  $q_t$  in (12) with  $q_t^0(p_t)$  and maximize the resulting function  $\pi_t(q_t^0(p_t), p_t; Q_t)$  subject to  $q_t^0(p_t) \leq Y_t = X_t$ .
- If the retailer's order quantity  $q_t^B$  is  $Y_t + \theta_t$ , we find from (10) that  $\theta_t = 0$  and  $q_t^B = Y_t^B \geq X_t$ , so that  $Q_t^B = (q_t^B - X_t)^+ = Y_t^B - X_t$ . In order to find  $p_{\square_t}$ , we maximize the function (13) subject to  $q_t^0(p_t) \geq Y_t$ . We notice that the function (13) is identical to (12) when the supplier manufactures  $(Y_t^B - X_t)$  units of products to increase his order-up-to level  $Y_t$  to the retailer's order quantity  $q_t$ . Hence, if the retailer's order quantity  $q_t$  is greater than or equal to  $X_t$ , the supplier's order-up-to level  $Y_t$  equals  $q_t$ , as indicated by (10). For this case, the retailer chooses her optimal order quantity  $q_t$  and price  $p_t$  by maximizing (12) subject to  $q_t \geq X_t$ . Since  $q_t^0(p_t)$  is the optimal solution of maximizing (12) without any constraint, we can find  $p_{\square_t}$  by replacing  $q_t$  with  $q_t^0(p_t)$  and maximizing  $\pi_t(q_t^0(p_t), p_t; Q_t)$  subject to  $q_t^0(p_t) \geq X_t$ .

Note that the retailer has the identical objective function  $\pi_t(q_t^0(p_t), p_t; Q_t)$  for both cases, but has different constraints ( $q_t^0(p_t) \leq X_t$  and  $q_t^0(p_t) \geq X_t$  for the cases 1 and 2, respectively). We can find an optimal price for the retailer by simply maximizing the unconstrained function  $\pi_t(q_t^0(p_t), p_t; Q_t)$  below:

$$\begin{aligned} \pi_t(q_t^0(p_t), p_t; Q_t) &= E\{p_t \min[q_t^0(p_t) + x_t, D_t(p_t, \varepsilon)] - h_t[q_t^0(p_t) + x_t - D_t(p_t, \varepsilon)]^+ \\ &\quad - k_t[D_t(p_t, \varepsilon) - (q_t^0(p_t) + x_t)]^+ - w_t q_t^0(p_t)\} \\ &= E\{(p_t - w_t)q_t^0(p_t) + p_t x_t - (p_t + h_t)[q_t^0(p_t) + x_t - D_t(p_t, \varepsilon)]^+ \\ &\quad - k_t[D_t(p_t, \varepsilon) - (q_t^0(p_t) + x_t)]^+\}. \end{aligned}$$

Let  $p_{\square_t}$  denote the optimal price. If the retailer's order quantity  $q_t^0(\bar{p}_t)$  is less than or equal to the supplier's starting inventory level  $X_t$  at the beginning of period  $t$ , i.e.,  $q_t^0(\bar{p}_t) \leq X_t$ , then the retailer's order is fully satisfied and the supplier does not schedule his production for the period. Otherwise, if the

supplier's beginning inventory  $X_t$  is less than the retailer's order  $q_t^0(\bar{p}_t)$ , then the supplier should produce new products to increase his inventory level to  $q_t^0(\bar{p}_t)$ . Thus, the supplier's equilibrium solution  $Q_t^N$  is  $(q_t^0(\bar{p}_t) - X_t)^+$ , and the retailer's equilibrium quantity  $q_t^N$  is  $q_t^0(\bar{p}_t)$  and price  $p_t^N$  is  $p_t^*$ . ■

### Proof of Theorem 5

The result is obtained according to our discussion presented immediately before this theorem. ■

### Proof of Theorem 6

For period  $t$ , the supplier determines his optimal production quantity  $Q_t$  based on his state (the starting inventory  $X_t$ ). When  $X_t \geq q_t$ , the objective function (17) applies. Since  $c_t \geq 0$  and  $H_t \geq 0$ , we reduce the supplier's order quantity to zero in order to maximize  $G_t(Q_t, q_t, p_t)$ . Thus,  $Q_t^*(q_t, p_t) = 0$  when  $X_t \geq q_t$ .

When  $X_t \leq q_t$ , the supplier produces new products to satisfy the retailer's order since the starting inventory is insufficient. When the retailer's order quantity equals the supplier's order-up-to level (i.e.,  $q_t = Y_t = Q_t + X_t$ ), the functions (17) and (18) are both reduced to:

$$G_t(Q_t, q_t, p_t) = E\{(p_t - c_t)q_t + p_t x_t - (p_t + h_t)[q_t + x_t - D_t(p_t, \varepsilon)]^+ - k_t[D_t(p_t, \varepsilon) - (q_t + x_t)]^+\}, \quad (22)$$

which does not include the holding and shortage costs of the supplier. On the other hand, when  $q_t \neq Y_t$ , the two costs are involved and reduce the supply chain-wide profit. Thus, in order to maximize the supply chain profit for period  $t$ , the supplier's order-up-to level is equal to the retailer's order quantity, i.e.,  $Y_t^* = Q_t^* + X_t = q_t$ . In conclusion, we obtain the result. ■

### Proof of Theorem 7

Similar to the proof of Theorem 6, we consider the problem for each of two case:  $X_t \geq q_t$  and  $X_t \leq q_t$ .

When  $q_t \leq X_t$ , Theorem 6 suggests that the supplier's order quantity is zero. This results in the system-wide profit function:

$$G_t(Q_t^*, q_t, p_t | q_t \leq X_t) = E\{q_t(p_t + H_t) - H_t X_t + p_t x_t - (p_t + h_t)[q_t + x_t - D_t(p_t, \varepsilon)]^+ - k_t[D_t(p_t, \varepsilon) - (q_t + x_t)]^+\}.$$

The first- and second-order partial derivatives of  $G_t(Q_t^*, q_t, p_t | q_t \leq X_t)$  w.r.t.  $q_t$  are:

$$\frac{\partial G_t(Q_t^*, q_t, p_t | q_t \leq X_t)}{\partial q_t} = p_t + H_t + k_t - (p_t + h_t + k_t)F\left[\frac{q_t + x_t}{D(p_t)}\right],$$

$$\frac{\partial^2 G_t(Q_t^*, q_t, p_t | q_t \leq X_t)}{\partial q_t^2} = -\frac{p_t + h_t + k_t}{D(p_t)} f\left[\frac{q_t + x_t}{D(p_t)}\right] < 0,$$

which implies that the function  $G_t(Q_t^*, q_t, p_t \mid q_t \leq X_t)$  is a strictly concave function in  $q_t$ . Equating the first-order derivative to zero and solving it yields:

$$q_t = \left[ D(p_t)F^{-1} \left( \frac{p_t + H_t + k_t}{p_t + h_t + k_t} \right) - x_t \right].$$

Recalling that  $H_t \leq h_t$ , the ratio  $(p_t + H_t + k_t)/(p_t + h_t + k_t)$  is in the range  $(0, 1]$ . Since  $0 \leq q_t \leq X_t$ , we write the retailer's optimal order quantity as:

$$\hat{q}_t(p_t) = \min \left\{ \left[ D(p_t)F^{-1} \left( \frac{p_t + H_t + k_t}{p_t + h_t + k_t} \right) - x_t \right]^+, X_t \right\},$$

When  $q_t \geq Y_p$ , we find from Theorem 6 that the supplier's order-up-to level equals the retailer's order size (i.e.,  $Q_t^* + X_t = q_t$ ). Taking the first- and second-order partial derivatives of (22) w.r.t.  $q_t$ , we have:

$$\begin{aligned} \frac{\partial G_t(Q_t^*, q_t, p_t \mid q_t \geq X_t)}{\partial q_t} &= p_t + k_t - c_t - (p_t + h_t + k_t)F \left[ \frac{q_t + x_t}{D(p_t)} \right], \\ \frac{\partial^2 G_t(Q_t^*, q_t, p_t \mid q_t \geq X_t)}{\partial q_t^2} &= -\frac{p_t + h_t + k_t}{D(p_t)} f \left[ \frac{y_t}{D(p_t)} \right] < 0. \end{aligned} \quad (23)$$

As a result, the profit function  $G_t(Q_t^*, q_t, p_t \mid q_t \geq X_t)$  for period  $t$  is strictly concave in  $q_t$ . Equating (23) to zero and solving it for  $q_t$  gives the solution as:

$$q_t = \left[ D(p_t)F^{-1} \left( \frac{p_t + k_t - c_t}{p_t + h_t + k_t} \right) - x_t \right].$$

Similarly, considering the constraint  $q_t \geq X_p$ , we obtain:

$$\bar{q}_t(p_t) = \max \left\{ \left[ D(p_t)F^{-1} \left( \frac{p_t + k_t - c_t}{p_t + h_t + k_t} \right) - x_t \right]^+, X_t \right\}.$$

To determine the globally optimal solution  $q_t^*(p_t)$ , we need to compare  $\hat{q}_t(p_t)$  and  $\bar{q}_t(p_t)$ . Since  $(p_t + H_t + k_t) > (p_t + k_t - c_t)$ , we find that  $F^{-1}[(p_t + H_t + k_t)/(p_t + h_t + k_t)] > F^{-1}[(p_t + k_t - c_t)/(p_t + h_t + k_t)]$  and:

$$\left[ D(p_t)F^{-1}\left(\frac{p_t + H_t + k_t}{p_t + h_t + k_t}\right) - x_t \right]^+ \geq \left[ D(p_t)F^{-1}\left(\frac{p_t + k_t - c_t}{p_t + h_t + k_t}\right) - x_t \right]^+. \quad (24)$$

Let  $\zeta_t$  and  $\eta_t$  respectively denote the LHS and RHS of (24). Comparing them with  $X_r$ , we analyze four cases as follows:

1. If  $\zeta_t \leq X_r$ , we find from (24) that  $\eta_t \leq X_r$ . Consequently, we have  $q_{\square_t}(p_t) = \zeta_t$  and  $q_{\square_t}(p_t) = X_r$ , so that the maximum conditional profits are  $G_t(0, \zeta_t, p_t | q_t \leq X_r)$  and  $G_t(0, X_r, p_t | q_t \geq X_r)$ . As  $G_t(0, X_r, p_t | q_t \geq X_r) = G_t(0, X_r, p_t | q_t \leq X_r)$ , the globally optimal order quantity of the retailer for the case is  $\zeta_t$ .
2. If  $\eta_t \geq X_r$ , then  $\zeta_t \geq X_r$ . As a result, we have that  $q_{\square_t}(p_t) = X_r$  and  $q_{\square_t}(p_t) = \eta_t$ , so the maximum conditional profits are  $G_t(0, X_r, p_t | q_t \leq X_r)$  and  $G_t(\eta_t - X_r, \eta_t, p_t | q_t \geq X_r)$ . Similarly, we obtain the globally optimal order quantity of the retailer as  $\eta_t$ .
3. If  $\zeta_t \geq X_r$  and  $\eta_t \leq X_r$ , then  $q_{\square_t}(p_t) = X_r$  and  $q_{\square_t}(p_t) = X_r$ , so the globally optimal solution is  $q_t^*(p_t | \zeta_t \leq X_r, \eta_t \leq X_r) = X_r$ .
4. If  $\zeta_t \leq X_r$  and  $\eta_t \geq X_r$ , we find that  $\zeta_t \leq \eta_t$  which is contrary to (24).

Summarizing the above results, we have (19). ■

## Proof of Theorem 8

Using (2) we replace  $w_t$  with  $(w^0 - \alpha_t(p^0 - p_t))$  for the function  $G_t(Q_t, q_t, p_t)$ . Partially taking the first-order derivative of  $G_t(Q_t, q_t, p_t)$  w.r.t.  $p_t$ , we have:

$$\begin{aligned} \frac{\partial G_t(Q_t, q_t, p_t)}{\partial p_t} &= \frac{\partial \Pi_t(Q_t; q_t, p_t)}{\partial p_t} + \frac{\partial \pi_t(q_t, p_t; Q_t)}{\partial p_t} \\ &= (q_t + x_t) - k_t D'(p_t) \mu - E[q_t + x_t - D_t(p_t, \epsilon)]^+ \\ &\quad + (p_t + h_t + k_t) D'(p_t) \int_0^{\frac{q_t + x_t}{D(p_t)}} x f(x) dx. \end{aligned}$$

We find the second-order partial derivative as:

$$\frac{\partial^2 G_t(Q_t, q_t, p_t)}{\partial p_t^2} = \frac{\partial^2 \Pi_t(Q_t; q_t, p_t)}{\partial p_t^2} + \frac{\partial^2 \pi_t(q_t, p_t; Q_t)}{\partial p_t^2} = \frac{\partial^2 \pi_t(q_t, p_t; Q_t)}{\partial p_t^2}.$$

Using Lemma 2, we have that  $\partial^2 G_t(Q_t, q_t, p_t) / \partial p_t^2 < 0$ , and reach the concavity of the objective function  $\Pi_t(Q_t; q_t, p_t)$ . ■

### Proof of Theorem 9

For supply chain coordination we choose the values of PDS parameters to make  $(Q_t^N, q_t^N, p_t^N)$  identical to  $(Q_t^*, q_t^*, p_t^*)$ , i.e.,  $(Q_t^N, q_t^N, p_t^N) = (Q_t^*, q_t^*, p_t^*)$  when the parameter values are properly designed. From Theorems 4 and 7 we find that  $q_t^N = q_t^*$  if and only if

$$q_t^* = \eta_t = \left[ D(p_t) F^{-1} \left( \frac{p_t + k_t - c_t}{p_t + h_t + k_t} \right) - x_t \right]^+ \text{ and } w_t = c_t.$$

Moreover, we notice from Theorems 4 and 7 that  $p_t^N$  and  $p_t^*$  are obtained by respectively solving:

$$\max_{p_t} \pi_t(q_t^N, p_t; (q_t^N - X_t)^+) = E\{(p_t - w_t)q_t^N + p_t x_t - (p_t + h_t)[q_t^N + x_t - D_t(p_t, \varepsilon)]^+ - k_t[D_t(p_t, \varepsilon) - (q_t^N + x_t)]^+\}, \quad (25)$$

and:

$$\max_{p_t} G_t(q_t^* - X_t, q_t^*, p_t | q_t^* \geq X_t) = E\{(p_t - c_t)q_t^* + p_t x_t - (p_t + h_t)[q_t^* + x_t - D_t(p_t, \varepsilon)]^+ - k_t[D_t(p_t, \varepsilon) - (q_t^* + x_t)]^+\}. \quad (26)$$

The problem (26) is the same as (25) if we add the constraint  $q_t^* \geq X_t$  to (25) and replace  $w_t$  with  $c_t$ . Hence, in order to coordinate the supply chain with a wholesale pricing scheme, the globally optimal solution for period  $t$  must be  $(\eta_t(p_t'') - X_t, \eta_t(p_t''), p_t'')$ , and  $p_t''$  is the optimal solution of the unconstrained maximization problem  $\max_{p_t} G_t(\eta_t(p_t) - X_t, \eta_t(p_t), p_t)$ . Note that  $w_t$  in (25) is a variable of  $p_t$  but  $c_t$  in (26) is a given constant. In order to assure that  $p_t^N = p_t^*$ , we set the value of  $\alpha_t$  to 0, so that  $w_t = w_t^0$ , which is a constant. ■

### Proof of Theorem 10

To allocate the profit  $G_t(Q_t^*, q_t^*, p_t^*)$  between the supplier and the retailer, we solve the following maximization problem:

$$\begin{aligned} \max \quad & [\phi_t - \Pi_t(Q_t^N; q_t^N, p_t^N)][\varphi_t - \pi_t(q_t^N, p_t^N; Q_t^N)] \\ \text{s.t.} \quad & \phi_t \geq \Pi_t(Q_t^N; q_t^N, p_t^N), \varphi_t \geq \pi_t(q_t^N, p_t^N; Q_t^N), \text{ and } \phi_t + \varphi_t = G_t(Q_t^*, q_t^*, p_t^*). \end{aligned}$$



Replacing  $\phi_t$  with  $G_t(Q_t^*, q_t^*, p_t^*) - \phi_t$  in the objective function, we write our maximization problem to the following:

$$\max[\phi_t - \Pi_t(Q_t^N; q_t^N, p_t^N)][-\phi_t + G_t(Q_t^*, q_t^*, p_t^*) - \pi_t(q_t^N, p_t^N; Q_t^N)].$$

Differentiating the function w.r.t.  $\phi_t$ , equating it to zero and solving the resulting equation, we find:

$$\phi_t = \frac{G_t(Q_t^*, q_t^*, p_t^*) + \Pi_t(Q_t^N; q_t^N, p_t^N) - \pi_t(q_t^N, p_t^N; Q_t^N)}{2}.$$

Since  $\varphi_t = G_t(Q_t^*, q_t^*, p_t^*) - \phi_t$ , we have:

$$\varphi_t = \frac{G_t(Q_t^*, q_t^*, p_t^*) - \Pi_t(Q_t^N; q_t^N, p_t^N) + \pi_t(q_t^N, p_t^N; Q_t^N)}{2}.$$

Noting that  $G_t(Q_t^*, q_t^*, p_t^*) \geq G_t(Q_t^N, q_t^N, p_t^N) = \Pi_t(Q_t^N; q_t^N, p_t^N) + \pi_t(q_t^N, p_t^N; Q_t^N)$ , we find that  $\phi_t \geq \Pi_t(Q_t^N; q_t^N, p_t^N)$  and  $\varphi_t \geq \pi_t(q_t^N, p_t^N; Q_t^N)$ . Thus, we arrive to the result. ■

### Proof of Theorem 11

The differences between local profits incurred by two members and the allocations of  $G_t(Q_t^*, q_t^*, p_t^*)$  to them are:

$$\begin{aligned} \Pi_t(Q_t^*; q_t^*, p_t^*) - \phi_t &= \frac{[\Pi_t(Q_t^*; q_t^*, p_t^*) - \Pi_t(Q_t^N; q_t^N, p_t^N)] - [\pi_t(q_t^*, p_t^*; Q_t^*) - \pi_t(q_t^N, p_t^N; Q_t^N)]}{2}, \\ \pi_t(q_t^*, p_t^*; Q_t^*) - \varphi_t &= \frac{[\pi_t(q_t^*, p_t^*; Q_t^*) - \pi_t(q_t^N, p_t^N; Q_t^N)] - [\Pi_t(Q_t^*; q_t^*, p_t^*) - \Pi_t(Q_t^N; q_t^N, p_t^N)]}{2}. \end{aligned}$$

Defining  $S \equiv \Pi_t(Q_t^*; q_t^*, p_t^*) - \Pi_t(Q_t^N; q_t^N, p_t^N)$  and  $R \equiv \pi_t(q_t^*, p_t^*; Q_t^*) - \pi_t(q_t^N, p_t^N; Q_t^N)$ , we consider two cases as follows:

1. If  $S \geq R$ , we find that  $\Pi_t(Q_t^*; q_t^*, p_t^*) \geq \phi_t$  and  $\pi_t(q_t^*, p_t^*; Q_t^*) \leq \varphi_t$ . For this case, the supplier incurs a higher profit locally than the allocation to him, whereas the retailer's local profit is less than the allocation to her. Hence, the supplier transfers a side payment [amounting to  $\Pi_t(Q_t^*; q_t^*, p_t^*) - \phi_t$ ] to the retailer. Using  $S$  and  $R$ , we write the side-payment transfer as  $(S - R)/2$ .
2. If  $S \leq R$ , we find that  $\Pi_t(Q_t^*; q_t^*, p_t^*) \leq \phi_t$  and  $\pi_t(q_t^*, p_t^*; Q_t^*) \geq \varphi_t$ . For this case, the side-payment transfer from the retailer to the supplier is amount of  $[\pi_t(q_t^*, p_t^*; Q_t^*) - \varphi_t]$  which is computed as  $(R - S)/2$ .

In conclusion, we find the side-payment transfer between the two members for period  $t$ . ■

## APPENDIX B PROOFS OF LEMMAS

### Proof of Lemma 1

The first- and second-order partial derivatives of function (12) with respect to  $q_t$  are:

$$\frac{\partial \pi_{it}(q_t, p_t; Q_t)}{\partial q_t} = p_t + k_t - w_t - (p_t + h_t + k_t)F\left[\frac{q_t + x_t}{D(p_t)}\right], \quad (27)$$

$$\frac{\partial^2 \pi_{it}(q_t, p_t; Q_t)}{\partial q_t^2} = -\frac{p_t + h_t + k_t}{D(p_t)} f\left[\frac{q_t + x_t}{D(p_t)}\right] < 0,$$

which leads to the result. ■

### Proof of Lemma 2

Replacing  $w_t$  in (11) with RHS of (2) and partially differentiating the function  $\pi_t(q_t, p_t; Q_t)$  w.r.t.  $p_t$ , we have:

$$\begin{aligned} \frac{\partial \pi_t(q_t, p_t; Q_t)}{\partial p_t} &= y_t - \alpha_t \min(q_t, Y_t) - k_t D'(p_t) \mu - E[y_t - D_t(p_t, \varepsilon)]^+ \\ &\quad + (p_t + h_t + k_t) D'(p_t) \int_0^{y_t/D(p_t)} x f(x) dx. \end{aligned} \quad (28)$$

The second-order partial derivative is:

$$\begin{aligned} \frac{\partial^2 \pi_t(q_t, p_t; Q_t)}{\partial p_t^2} &= -k D''(p_t) \mu + 2 D'(p_t) \int_0^{y_t/D(p_t)} x f(x) dx + (p_t + h_t + k_t) D''(p_t) \int_0^{y_t/D(p_t)} x f(x) dx \\ &\quad - (p_t + h_t + k_t) [D'(p_t)]^2 \frac{y_t^2}{[D(p_t)]^3} f\left(\frac{y_t}{D(p_t)}\right). \end{aligned}$$

Since  $dD(p_t) / dp_t < 0$  and  $d^2 D(p_t) / dp_t^2 = 0$ , we simplify the above and have:

$$\frac{\partial^2 \pi_t(q_t, p_t; Q_t)}{\partial p_t^2} = 2 D'(p_t) \int_0^{y_t/D(p_t)} x f(x) dx - (p_t + h_t + k_t) [D'(p_t)]^2 \frac{y_t^2}{[D(p_t)]^3} f\left(\frac{y_t}{D(p_t)}\right) < 0,$$

thereby reaching the concavity of the function  $\pi'_R(q_t, p_t; Y_t)$  in  $p_t$ . ■

## Chapter 4

# Small Manufacturers vs. Large Retailers on RFID Adoption in the Apparel Supply Chain

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### **ABSTRACT**

*The apparel industry is one of the most rapidly growing sectors of the radio frequency identification (RFID) market, and within it, large retailers have been driving RFID adoption. However, the continuation of this industry's fast-paced growth is questionable due to the uncertainty associated with how manufacturers, especially small ones, would react to the retailer-led RFID initiative. The literature suggests that the relationship between small manufacturers and large retailers could promote or inhibit RFID adoption among the manufacturers. In order to study the impact of the relationship between small manufacturers and large retailers on the small manufacturers' RFID adoption decisions, this research develops a 2×2 (two-by-two) game model and conducts outcome stability analysis. The results show that, in the 2×2 game framework, (i) the retailer's opportunistic behavior is unlikely to occur due to the strong stability associated with the manufacturer's do-nothing option; (ii) the do-nothing option, however, may lead to missed opportunities for both parties; (iii) the retailer's pressure tactic is not effective in persuading the small manufacturer to adopt RFID; and (iv) the retailer's collaborative strategy also does not guarantee the manufacturer's RFID adoption. The discussion of these results concludes with specific suggestions for how to encourage RFID adoption among the small apparel manufacturers.*

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## INTRODUCTION

Radio frequency identification (RFID) is a wireless technology that uses transmitted radio signals to tag an item and to track and trace its movement without human intervention (Moon & Ngai, 2008). Since the introduction of RFID supplier mandates in 2003 by some of the world's leading retailers, such as Wal-Mart and METRO, RFID has attracted significant interest from the retail community, representing an enhancement over the existing bar code technology for managing product flows within supply chains.

Within the apparel industry, RFID adoption has also been led by well-known large retailers: Marks & Spencer, Gap, and Benetton (Moon & Ngai, 2008). Apparel has been one of the most rapidly growing sectors of the RFID market (RFID Update, 2008c), as well as one of the leading sectors of RFID's item-level application — as opposed to pallet- or case-level — along with pharmaceuticals, books, and DVDs (RFID Update, 2006; 2007c; 2008a). Apparel retailers are especially interested in RFID's ability to automatically track individual products inside the stores because it can, for example, reduce inventory count and product search times, increase staff availability for customer assistance, and collect data on customer shopping behaviors to improve customer retention and sales promotion (Moon & Ngai, 2008). In addition, the collection of real-time sales and inventory data enabled by RFID can facilitate automatic replenishment. This aspect of RFID is particularly appealing for apparel retailers because timely replenishment can increase their profits substantially by reducing the risk of stockouts for popular items and by lowering on-hand inventory to avoid taking losses on markdowns of unpopular items (Forza & Vinelli, 1997).

In fact, the concept of automatic replenishment has been known as one of the Quick Response (QR) practices by the United States (U.S.) apparel industry since the mid-1980s (Şen, 2008). In order to better compete with inexpensive foreign

imports, the QR practices focused on improving the apparel supply chain's responsiveness by sharing key data, using bar code and electronic data interchange (EDI) technologies, and practicing vendor-managed inventory (VMI) and automatic replenishment (CPA Journal, 1992). The progress of QR, however, turned out to be slow and limited. A review of the literature reveals that many apparel manufacturers adopted QR partially or did not adopt it at all (CPA Journal, 1992).

In the U.S., the majority of apparel manufacturers are small. In 2007, approximately 80% of establishments in apparel manufacturing were self-employed businesses, and for the remaining 20%, the average number of employees per establishment was 25 (U.S. Census Bureau, 2007). Small businesses typically have limited financial, technical, and management resources, and it is this scarcity of resources that has made it difficult for small apparel manufacturers to adopt new technologies in general (Hunter & Valentino, 1995). One QR study found that the firms with higher sales volumes, more employees, more stock-keeping units (SKUs), and more plants were more likely to adopt QR than smaller firms (Sullivan & Kang, 1999).

For small firms, there is one well-known factor that influences their adoption of new technologies: pressure from large trading partners (Morrell & Ezingard, 2002). In the apparel supply chain, large retailers hold significant bargaining power over small manufacturers due to retail consolidation, and may demand favorable terms in price, service, delivery, and product diversification and differentiation (Şen, 2008). Historically, however, the relationship between the apparel manufacturers and retailers has not been collaborative, and in regard to the QR adoption, many small manufacturers were more concerned about being disadvantaged by the retailers' opportunistic behavior than they were about the consequences of non-compliance (Hunter & Valentino, 1995). Their skepticism led to a reluctance to exchange sensitive information

with the retailers, which in turn led to non-adoption of QR (CPA Journal, 1992).

Considering that large apparel retailers are driving the current RFID initiative, just as they did the QR initiative in the 1980s, the future of RFID adoption within the apparel industry seems to be dependent on how the manufacturers — especially small ones — react to the retailer-led RFID initiative. Insights from the literature suggest that the relationship between small manufacturers and large retailers would play a significant role in influencing the former group's RFID adoption decision. For small apparel manufacturers with limited resources, an external factor — like pressure from large retailers — would likely have an impact on promoting the RFID adoption, but the historically adversarial relationship between the retailers and manufacturers might instead have an impact on inhibiting RFID adoption. This point casts doubt on the continuation of the fast-paced growth of RFID in the apparel industry. In the end, is the RFID initiative bound to repeat the same slow and limited adoption of the QR initiative?

The main objective of this research is to study the impact of the relationship between small manufacturers and large retailers on the small manufacturers' RFID adoption decisions. More specifically, this research addresses the following four questions:

1. How likely is the occurrence of the retailers' opportunistic behavior? Is the manufacturers' concern realistic or inflated?
2. For a small manufacturer, the do-nothing option of not adopting RFID may be a safe option, but is it always the best option?
3. How effective is a retailer's pressure tactic in persuading a small manufacturer to adopt RFID?
4. What can a retailer do, other than apply pressure, to encourage the small manufacturer to adopt RFID?

Currently, the RFID literature has been limited on the topic of the apparel industry or small-firm adoption. The impact of customer mandate on the RFID adoption decision has been studied by Barratt and Choi (2007) and by White, Johnson, and Wilson (2008), but these studies did not examine the relationship between small players and large players in sufficient detail. Therefore, from the perspectives of research and business, the four questions raised above are timely and relevant, and their answers have a significant implication in finding effective ways to promote RFID adoption among the small apparel manufacturers.

This research addresses the four questions by developing a 2×2 (two-by-two) game model and conducting stability analysis from the field of conflict analysis, a branch in game theory. The 2×2 game analysis was chosen over other research methods mainly because the central theme of this research is the relationship between small manufacturers and large retailers. As a multi-party decision-making model, the 2×2 game is suitable for studying how one player's decision may affect the other player's actions, and the game analysis provides a novel perspective on RFID adoption issues and complements prior RFID adoption factor studies based on empirical data. In the remainder of this paper, the construction of the 2×2 apparel model proceeds as follows. First, the relevant literatures are reviewed. Following that, the development of the apparel model and the results of the stability analysis are presented. The concluding section ends with a summary of contributions, management implication, and future research directions.

## **LITERATURE REVIEW**

This section reviews four selected areas from the RFID, technology adoption, and supply chain management literatures in order to provide a fundamental understanding of RFID benefits and adoption difficulties in the apparel supply chain.

## **RFID in the Apparel Industry**

RFID is a radio-based technology that identifies items with tags, and captures their movement without human intervention. Item identification occurs when a reader scans an area for tags that are tuned to the same frequency as the reader. In contrast to bar codes, wireless RFID does not require the product positioning for scanning. Hence, advanced automation of material handling is possible, and multiple tags can be scanned simultaneously without undoing the packaging (Kabachinski, 2005; Zebra Technologies, 2004). Furthermore, RFID tags are more robust and durable, and they can store more information than bar codes can (Sheffi, 2004), providing capabilities to track specific instances of individual items.

On the business side, an increasing number of pilots since 2007 show the fast-paced growth of RFID initiative within the apparel industry. In 2007, the German retailer METRO announced its item-level deployment of RFID for high-end men's apparel (RFID Update, 2007b). Other prominent announcements included Karstadt, Dillard's, Throttleman, NP Collection, Levi Strauss, and American Apparel (RFID Update, 2007a; 2007d; 2007e; 2007f; 2008b). In 2008, Marks & Spencer, which has been using RFID since 2003, announced its plan to tag the entire annual inventory of 350 million apparel items by 2010 (RFID Update, 2008d).

On the research side, RFID is one of flourishing areas in the management literature. An overview of the academic literature on RFID to date can be found in Ngai, Moon, Riggins, and Yi (2008) and in Visich, Li, Khumawala, and Reyes (2009). In particular to apparel, five articles examined the business value of RFID within the apparel industry. Moon and Ngai (2008) studied how RFID could add value in fashion retailing. Azevedo and Ferreira (2009) provided a case study on Throttleman's RFID experience. Bottani, Ferretti, Montanari, and Rizzi (2009) evaluated the profitability of RFID implementation between a

retail store and a distribution center. Thiesse, Al-Kassab, and Fleisch (2009) provided a case study on Galeria Kaufhof, a subsidiary of METRO, and formulated a set of propositions on value creation by RFID. Lastly, Wen, Chang, and Chang (2010) studied RFID benefits for a small-to-medium-sized Taiwanese apparel retailer at its distribution center using simulation software.

In regard to the topic of RFID adoption decisions, the factors thus far studied include customer mandates (Barratt & Choi, 2007; White et al., 2008); IT infrastructure (Bendoly, Citurs, & Konsynski, 2007; Whitaker, Mithas, & Krishnan, 2007); and perceived benefits and barriers of RFID adoption (Roh, Kunnathur, & Tarafdar, 2009; Shih, Chiu, Chang, & Yen, 2008). So and Sun (2010) identified four adoption factors for an RFID-based smart retail system in an apparel retailer; the factors were compatibility, costs, ease of use, and security. In addition, four articles studied RFID adoption factors from technological, organizational, and environmental perspectives (Lin, 2008; Tsai, Lee, & Wu, 2010; Wang, Wang, & Yang, 2010; Zailani, Fernando, & Zakaria, 2010). None of these adoption factor studies, however, focused specifically on small firms. Therefore, the coverage of the apparel industry or small-firm adoption has been limited within the RFID literature.

## **RFID Benefits**

For large apparel retailers, RFID-enabled automated tracking of in-store inventory can generate numerous benefits: instant notification of product availability on the shop floor; reduction of inventory count time and product search time, which in turn increases staff availability for customer assistance; reduction of theft, counterfeiting, and illegal product diversion; and enabling data collection on customer shopping behavior (Moon & Ngai, 2008). The data on sales, try-ons, and inventory availability can be used to improve marketing and promotion, personalized services,

customer retention, and product category management (Moon & Ngai, 2008; Thiesse et al., 2009).

In addition to these benefits, RFID has the potential to significantly improve supply chain visibility. When combined with other real-time location systems, such as global positioning system (GPS), RFID's ability to track individual items generates detailed sales and inventory data on a real-time basis. Moreover, RFID can improve the data accuracy by reducing human errors in error-prone operations such as counting and manual data entry. A German retailer, Karstadt, expected that the use of RFID would reduce shipment reporting errors and merchandise misplacement (RFID Update, 2007f). RFID's ability to provide accurate, real-time supply chain visibility facilitates QR practices of frequent inventory review and data sharing, VMI, and automatic replenishment, thereby promising substantial benefits for apparel retailers through the reductions of stockouts of popular and seasonal garments and markdowns of unpopular items. Marks & Spencer, NP Collection, and American Apparel consider the stockout reduction as the major contributor for a quick payback on their RFID investments (RFID Update, 2007e; 2008d; 2009a).

From a manufacturer's perspective, the literature on RFID benefits in the apparel supply chain has so far centered on the benefits for the retailers, and some of those benefits — such as retail floor management and customer relationship management — are not directly applicable to manufacturers. If, however, RFID-generated data are shared between retailers and manufacturers, then apparel manufacturers can benefit from the resulting supply chain visibility. Since small manufacturers tend to accumulate orders before production (Şen, 2008), the improved demand visibility would make it easier to achieve the economy of scale by combining orders from multiple retailers. Some of the general manufacturing-related benefits discussed in the RFID literature are also applicable for apparel manufacturers. For example, RFID can improve the tracking of

production processes (Bear, Stearns & Co. Inc., 2003). For apparel manufacturers, improved tracking of items such as fabrics and work-in-process can lead to the efficient management of a wide range of sizes, colors, and styles of garments, and can reduce inventory count time and inventory misplacement. RFID can also improve quality control by being able to track a variety of product and equipment issues. For example, Malden Mills tracked imperfections in Polartec fleece fabric using RFID (Bear, Stearns & Co. Inc., 2003).

### **RFID Adoption Challenges**

Although apparel is one of the rapidly growing sectors of the RFID market, the overall rate of RFID adoption in supply chain applications remains slow (RFID Update, 2009b). Various adoption challenges have been discussed in the literature, including a lack of return on investment (ROI), unreliable performance, the popularity of bar codes, and potential invasion of consumer privacy (e.g., Smith, 2005; Twist, 2005). In fashion retailing, Moon and Ngai (2008) found that the retailers were particularly concerned about (i) the increased costs of hardware, software, operations, and maintenance of RFID systems; (ii) the difficulty of integrating RFID with the existing corporate information systems; and (iii) a lack of top management support and resistance by employees to try new technologies. Based on the technology adoption literature, small apparel manufacturers would likely face the same concerns as apparel retailers, but the impact from each may be more severe for manufacturers than it is for retailers. Below, the three concerns are discussed from a small manufacturer's perspective.

Any increase in operational cost is a serious concern for small firms with limited financial reserves (Morrell & Ezingard, 2002). Compared to large retailers, resource-constrained apparel manufacturers would have a hard time justifying RFID investment, especially when the ROI is uncertain, technical performance is inconsistent,

and the use of bar codes is already established in the industry. A low education requirement for employees in apparel manufacturing may also incur a high training cost (Adewole, 2005). For a small manufacturer with a limited production capacity, inventory cost may also increase in the attempt to satisfy the retailers' increasing order frequency, which is a possible consequence of RFID implementation. In apparel manufacturing, it is risky to stock high levels of products, even yarns and textiles, because fashion changes so quickly (Forza & Vinelli, 1997). Alternatively, some small manufacturers may attempt to ensure service levels by improving manufacturing responsiveness. However, this requires significant investment in manufacturing technologies such as CAD and CAM, and the small-batch production generally increases change-over costs.

The system integration issue is also a serious concern for small apparel manufacturers with limited financial and technical resources. In the 1990s, many apparel manufacturers did not even have material requirements planning (MRP) systems (Forza & Vinelli, 1997). In the early 2000s, the ability of small apparel firms to integrate information technology (IT) was considered low (Morrell & Ezingard, 2001). Without integration of RFID and the corporate information systems, small manufacturers would not be able to take advantage of RFID-generated data.

Finally, cultural changes often occur slowly within small organizations (Hunter & Valentino, 1995). Therefore, when RFID adoption is under consideration, small firms would likely experience both a lack of management support and resistance by employees.

### **Supply Chain Collaboration Benefits and Risks**

When a small manufacturer considers RFID adoption in response to a large retailer's initiative, the joint use of the technology becomes an opportunity to collaborate on various operational aspects.

Based on the supply chain management literature, collaboration with a larger trading partner can bring many benefits to the smaller firm in the form of improved access to supply chain-related information for all parties, as well as the resulting information-sharing, which helps to reduce the demand uncertainty and the bullwhip effect in the supply chain. Some of the operational benefits that can result from supply chain collaboration are: lower inventory cost, fewer backorders, shorter cycle time, better capacity utilization, and better product availability (Lin, Huang, & Lin, 2002; Småros, Lehtonen, Appelqvist, & Holmström, 2003). More specifically for the small manufacturer, a close working relationship with a large retailer typically results in steady business from the retailer, which leads to income security (Hingley, 2001). The manufacturer can also gain access to larger markets through the retailer, leading to a growth opportunity (Blundel & Hingley, 2001). An association with an established retailer can improve the small manufacturer's reputation and credibility in the marketplace (Hingley, 2001). Finally, working with the retailer can facilitate knowledge and innovation transfers by exposing the small firm to new ideas and methodologies (Blundel & Hingley, 2001).

In spite of many potential benefits, supply chain collaboration also presents various risks. In the start-up phase, selecting a partner can be a difficult and risky process that involves many attributes (Angeles & Nath, 2003), and there is no guarantee that the collaboration will last (Matopoulos, Vlachopoulou, Manthou, & Manos, 2007). Furthermore, working together presents some risks since collaboration generally leads to decreased independence over internal operations and increased dependence on partners (Matopoulos et al., 2007). Collaboration can also make internal data and activities transparent to external parties through increased information-sharing, which can in turn lead to confidentiality breaches, information leaks to third parties, and even exploitation involving price renegotiation, partner switching,



Figure 1.  $2 \times 2$  game in the normal form

		Player 2	
		Strategy 1	Strategy 2
Player 1	Strategy 1	Outcome (a) Xa, Ya	Outcome (b) Xb, Yb
	Strategy 2	Outcome (c) Xc, Yc	Outcome (d) Xd, Yd

$X_i$  = Player 1's preference ranking for outcome  $i$ ,  $i = a, b, c, d$   
 $Y_i$  = Player 2's preference ranking for outcome  $i$ ,  $i = a, b, c, d$

and market competition (Lee & Whang, 2000; Matopoulos et al., 2007; Şen, 2008).

### MODEL DEVELOPMENT

The literature review provided a fundamental understanding of RFID benefits and adoption risks within the context of the apparel supply chain. Based on this understanding, this section develops a  $2 \times 2$  game model for examining RFID adoption decision-making by small apparel manufacturers. First, a basic  $2 \times 2$  game model and four stability concepts are described. Then, the apparel game model is developed.

#### Basic Model

A  $2 \times 2$  game is a decision-making analysis model that consists of two players, and each player faces a decision between two mutually exclusive strategies. The total number of possible outcomes is four, that is, the number of options for one player multiplied by the number of options for the other player. Each player is assumed to be able to rank the four outcomes from the most preferred to the least preferred. In a non-cooperative setting, the players make their decisions independently with-

out consulting each other, but the outcome of their decisions is dependent on one another since, in a  $2 \times 2$  game, one player alone cannot determine the unique outcome. Figure 1 shows the components of a basic  $2 \times 2$  game in a conventional representation referred to as the normal form.

Although limited in the numbers of players and options, a  $2 \times 2$  game can capture the fundamental nature of the interdependence between two players' decisions. The  $2 \times 2$  game framework has been used to study many well-known political and social decision-making phenomena, such as the prisoners' dilemma, game of chicken, kidnapping, and union-management negotiation (Fraser, 1993; Rapoport & Chammah, 1965; Young, 1975). Some historic conflicts, such as the 1914 Germany-Austria crisis and the 1962 Cuban missile crisis, have also been studied using  $2 \times 2$  games (Fraser, 1993; Snyder & Diesing, 1977).

One of the key insights that can be gained from a  $2 \times 2$  game is which outcome is more likely to occur than other outcomes. This insight is achieved by the analysis of outcome stability and is useful for evaluating the players' strategy choices. An outcome is said to be *stable* if it can be expected to persist, should it arise (Fraser, 1993). In general, an outcome is expected to persist in a  $2 \times 2$  game if both players would not deviate from their

chosen strategies based on certain rationales. In game theory, a number of different rationales have been formalized by various game theorists. In this study, four stability concepts are examined. Their definitions are given below.

- *Nash rationality*: An outcome is Nash rational (stable) if it is the player's best outcome given the other player's strategy (Nash, 1951).
- *Fraser-Hipel sequential stability*: An outcome is Fraser-Hipel sequentially stable if it is Nash rational, or if it is not Nash rational but the player is not motivated to depart from the outcome because, if moved, the other player would make a sequential move and would put the player in a less preferred outcome (Fraser & Hipel, 1984).
- *Stackelberg stability*: With Stackelberg stability, one player is the leader and is assumed to make the first move, while the other player is the follower. An outcome is Stackelberg stable for the leader if it is the best possible outcome among the follower's Nash rational outcomes, from which the follower is assumed not to move away (Von Stackelberg, 1952).
- *Pareto optimality*: An outcome is Pareto optimal if there are no other outcomes that are preferred by both players. The Pareto optimality is a concept in economics, and its stability is based on the fact that further improvement for both parties is not available.

## **Apparel Model**

Based on the basic 2×2 game model, this section develops the apparel game model. The two players in the apparel model are a small manufacturer and a large retailer. Therefore, the unit of analysis for this research is these two entities. For the manufacturer, the decision under consideration is whether or not to adopt RFID. For the retailer,

the focus of this research is on the decision that is available to the retailer and that affects the manufacturer's decision regarding RFID adoption. With this focus, the retailer's decision to be studied is whether or not to collaborate with the manufacturer, assuming that the retailer's decision to adopt RFID has already been made. In the apparel industry, collaboration opportunities between manufacturers and retailers exist in areas such as product design, category management, sales forecast, and distribution and inventory management. In this research, collaboration is defined from the retailer's perspective as its intent to work cooperatively with the manufacturer on a long-term basis, as opposed to a short-term, transaction-only basis, in the area of distribution and inventory management. A choice of collaborators is readily available for the retailer due to the large number of small manufacturers. Moreover, in the QR literature, a lack of collaboration between manufacturers and retailers was shown to have an impact on the QR adoption level.

Note that a typical apparel supply chain also includes textile manufacturers for converting fiber to fabric before fabric is converted into garments in apparel manufacturing. In the 2×2 game model, however, the involvement of textile manufacturers is left out because small firms do not typically consider integrating their suppliers in their decision-making (Vaaland and Heide, 2007).

With the two players and their decisions as defined above, the apparel game consists of the following four outcomes: (a) *no RFID/no collaboration*, in which the manufacturer decides not to adopt RFID, and the retailer decides not to collaborate with the manufacturer; (b) *no RFID/collaboration*, in which the manufacturer decides not to adopt RFID, and the retailer decides to collaborate; (c) *RFID/no collaboration*, in which the manufacturer adopts RFID, and the retailer does not collaborate; (d) *RFID/collaboration*, in which the manufacturer adopts RFID, and the retailer collaborates. Figure 2 shows the 2×2 apparel game model in the normal form.

**Small Manufacturers vs. Large Retailers on RFID Adoption in the Apparel Supply Chain**

Figure 2. 2x2 apparel game model

		Large Retailer	
		No Collaboration	Collaboration
Small Manufacturer	No RFID	Outcome (a) Xa, Ya	Outcome (b) Xb, Yb
	RFID	Outcome (c) Xc, Yc	Outcome (d) Xd, Yd

$X_i$  = Manufacturer's preference ranking for outcome  $i$ ,  $i = a, b, c, d$

$Y_i$  = Retailer's preference ranking for outcome  $i$ ,  $i = a, b, c, d$

**Players' Preferences**

In order to carry out stability analysis, each player's preference information is needed in terms of ranking the four outcomes from most preferred to least preferred. For the apparel model in this study, the players' preferences are based on the overview of RFID benefits and risks provided in

the literature review. Below discusses the benefits and risks that are specific to each outcome and to each party. Figures 3 and 4 summarize the main benefits and risks, respectively.

*Figure 3 outcome (a).* This outcome is a result of inaction by both parties and therefore represents the status quo. This outcome is used as a point of reference for comparing the other three outcomes

Figure 3. RFID benefits in the apparel model

		Large Retailer	
		No Collaboration	Collaboration
Small Manufacturer	No RFID	Outcome (a) <b>Manufacturer</b> - Status quo - Result of inaction - No additional benefits <b>Retailer</b> - Status quo - Result of inaction - No additional benefits	Outcome (b) <b>Manufacturer</b> - Increased access to retailer's supply chain data - Operational improvements due to increased data sharing - Income security, growth opportunity, better reputation, knowledge transfer <b>Retailer</b> - Increased access to manufacturer's supply chain data - Operational improvements due to increased data sharing
	RFID	Outcome (c) <b>Manufacturer</b> - Improved internal inventory data quality (accuracy, item-level, real-time) - Operational improvements due to improved inventory data - Edge over competitors with no RFID <b>Retailer</b> - RFID tagging by manufacturer - Improved shipment data accuracy - Limited improvement in real-time supply chain visibility - Limited improvement in automatic replenishment	Outcome (d) <b>Manufacturer</b> - Improved internal inventory data quality - Improved supply chain visibility - Operational improvements due to data quality - Operational improvements due to data sharing - Income security, growth opportunity, better reputation - RFID knowledge transfer from retailer - Economy of scale in production <b>Retailer</b> - RFID tagging by manufacturer - Improved supply chain visibility - Operational improvements due to data quality - Operational improvements due to data sharing - Improved automatic replenishment

**Small Manufacturers vs. Large Retailers on RFID Adoption in the Apparel Supply Chain**

Figure 4. RFID risks in the apparel model

		Large Retailer			
		No Collaboration		Collaboration	
		Outcome (a)		Outcome (b)	
Small Manufacturer	No RFID	<p><b>Manufacturer</b></p> <ul style="list-style-type: none"> <li>- Status quo</li> <li>- Result of inaction</li> <li>- No additional risks</li> </ul>	<p><b>Retailer</b></p> <ul style="list-style-type: none"> <li>- Status quo</li> <li>- Result of inaction</li> <li>- No additional risks</li> </ul>	<p><b>Manufacturer</b></p> <ul style="list-style-type: none"> <li>- Partner selection risk</li> <li>- Increased dependency on retailer</li> <li>- Limited exposure risks: confidentiality breach, information leak, renegotiating terms, partner switching, retailer getting involved in manufacturing</li> </ul>	<p><b>Retailer</b></p> <ul style="list-style-type: none"> <li>- Partner selection risk</li> <li>- Increased dependency on manufacturer</li> <li>- Limited exposure risks: confidentiality breach, information leak, manufacturer getting involved in retailing</li> </ul>
	RFID	<p><b>Manufacturer</b></p> <ul style="list-style-type: none"> <li>- RFID hardware, software, and training costs</li> <li>- IT integration difficulties</li> <li>- Lack of management support</li> <li>- Employee resistance</li> <li>- Costly decision to reverse</li> <li>- Potential retailer's opportunistic behavior: inventory cost shifting, forced data sharing, exposure risks</li> </ul>	<p><b>Retailer</b></p> <ul style="list-style-type: none"> <li>- Increased troubleshooting due to manufacturer's inexperience with RFID</li> </ul>	<p><b>Manufacturer</b></p> <ul style="list-style-type: none"> <li>- RFID hardware, software, and training costs</li> <li>- IT integration difficulties</li> <li>- Lack of management support</li> <li>- Employee resistance</li> <li>- Costly decision to reverse</li> <li>- Partner selection risk</li> <li>- Increased dependency on retailer</li> <li>- Exposure risks due to increased internal operation transparency</li> </ul>	<p><b>Retailer</b></p> <ul style="list-style-type: none"> <li>- Increased troubleshooting due to manufacturer's inexperience with RFID</li> <li>- Partner selection risk</li> <li>- Increased dependency on manufacturer</li> <li>- Exposure risks due to increased internal operation transparency</li> </ul>

in terms of *additional* RFID benefits from the reference point.

*Figure 3outcome (b).* For this outcome, the additional benefits compared to the status quo are generated from supply chain collaboration between two parties. An increase in collaboration mainly improves the access to each party's supply chain data, which in turn provides operational improvements, such as lower inventory costs, fewer backorders, and shorter cycle times (Lin, Huang, & Lin, 2002; Småros, Lehtonen, Appelqvist, & Holmström, 2003). For the small manufacturer in particular, collaboration with a larger retailer provides the additional benefits of income security, growth opportunities, better reputation, and knowledge transfer (Blundel & Hingley, 2001; Hingley, 2001).

*Figure 3outcome (c).* For the manufacturer, RFID adoption can lead to the improvement in internal operations, such as better inventory tracking and equipment monitoring by having the accurate, item-level inventory data on a real-time basis. Also, RFID adoption may provide an edge over the competitors who have not adopted

RFID in terms of securing business from the retailer. However, without collaboration with the retailer, the use of RFID would not lead to the improved demand visibility because data sharing between the two parties would likely be minimal, as observed in the context of QR adoption (CPA Journal, 1992). For the retailer, the benefits such as better shop floor operation and customer relationship management are associated with the use of RFID at the retail site and are independent of the manufacturer's RFID use. The main benefit from the manufacturer adopting RFID is that RFID tagging can be done at the manufacturing site rather than at the retail site. Tagging by the manufacturer would free up the retailer's tagging effort and would improve inventory and shipment accuracy along the supply chain. However, without collaboration, the benefits from the real-time inventory visibility and improved QR practices would be limited due to minimal data sharing between the parties.

*Figure 3outcome (d).* The use of RFID by both parties would improve the quality of supply chain data in terms of accuracy, details, and

timing of availability. In addition, both parties benefit from supply chain collaboration. The increased access to higher-quality supply chain data would then lead to improved supply chain visibility and operational benefits. For the apparel manufacturer in particular, under this outcome, the knowledge transfer from the retailer regarding RFID implementation is likely and valuable, and the real-time supply chain visibility makes it easier to achieve the economy of scale in production. For the retailer, the improved supply chain visibility would lead to the improvement on QR practices, such as automatic replenishment.

*Figure 4outcome (a).* This outcome, as stated previously, is a result of inaction by both parties. It represents the status quo and acts as the reference point for comparing the other three outcomes in terms of additional risks.

*Figure 4outcome (b).* For both parties, the primary risks associated with this outcome are the supply chain collaboration risks. For this outcome to actually occur, both parties must first overcome the difficulties associated with forming a collaborative relationship (Angeles & Nath, 2003; Matopoulos et al., 2007). Once collaboration is established, the parties must deal with their increased dependency as well as various exposure risks, such as confidentiality breaches and information leaks (Lee & Whang, 2000; Matopoulos et al., 2007; Şen, 2008). The retailer's bargaining power makes the manufacturer more vulnerable to some aspects of the exposure risks, such as the retailer's renegotiation request on better terms, potential partner switching by the retailer, and the retailer getting involved in apparel manufacturing through the private-label offering (Şen, 2008). On the other hand, these are not particularly serious risks for the retailer, who holds the significant bargaining power and has a large pool of alternative partners. Without the use of RFID by the manufacturer, however, the general extent of the exposure risks may be limited for both parties due to the partial internal transparency.

*Figure 4outcome (c).* For the manufacturer, the primary risks associated with this outcome are RFID adoption-related costs and difficulties. In addition to hardware, software and training costs, the small manufacturer likely faces additional inventory or production-related costs (Adewole, 2005; Forza & Vinelli, 1997). Integration of RFID and corporate information systems would be a challenge, and a lack of management support and employee resistance may have to be dealt with (Hunter & Valentino, 1995; Morrell & Ezingear, 2001). Furthermore, RFID adoption is difficult to reverse once implementation begins. Switching back to the former technology would be costly, and if RFID is implemented according to a particular retailer's specifications, then accommodating another retailer with different specifications could also be costly. RFID adoption without the retailer's collaboration is particularly risky in terms of the retailer's opportunistic behavior. With its bargaining power, the retailer may impose RFID tagging and a certain service level on the manufacturer. Without collaboration benefits in return, these activities would imply shifting inventory costs from the retailer to the manufacturer if the manufacturer's production capacity is limited and if the order frequency from the retailer increases as a result of RFID implementation. The retailer may also insist that the manufacturer shares its RFID-generated data with the retailer, and this can lead to some of the exposure risks discussed for outcome (b), but without any of the collaboration benefits to offset the risks. From the retailer's perspective, this outcome is relatively risk-free. The only notable risk is that the amount of troubleshooting may increase for the retailer in dealing with the technical problems and errors associated with the manufacturer's RFID inexperience.

*Figure 4outcome (d).* For the manufacturer, costs and various difficulties associated with adopting RFID are significant risks with this outcome, as they were with outcome (c). The supply chain collaboration risks existing for outcome

(b) are present here as well. Compared to (b), the extent of the exposure risks would be greater for this outcome due to the increased internal transparency that results from the use of RFID by both parties. Finally, with RFID use by the manufacturer, the retailer may have to deal with the manufacturer's inexperience in terms of errors and operation interruptions, as discussed for (c).

**METHODOLOGY**

In the last section, the framework for the 2x2 apparel game model was established, and Figures 3 and 4 provided a systematic comparison of the RFID benefits and risks by outcome and by party. This section now describes stability analysis. In order to provide robustness to the findings, this research also employs a sensitivity analysis approach, which is described in turn.

**Stability Analysis**

As mentioned previously, one of the key insights that can be gained from a 2x2 game is the identification of which outcome is more stable, and therefore, more likely to persist than other outcomes, should it arise. This research applies four stability concepts to the apparel model: Nash rationality, Fraser-Hipel sequential stability, Stackelberg stability, and Pareto optimality. By examining these four concepts, this research cap-

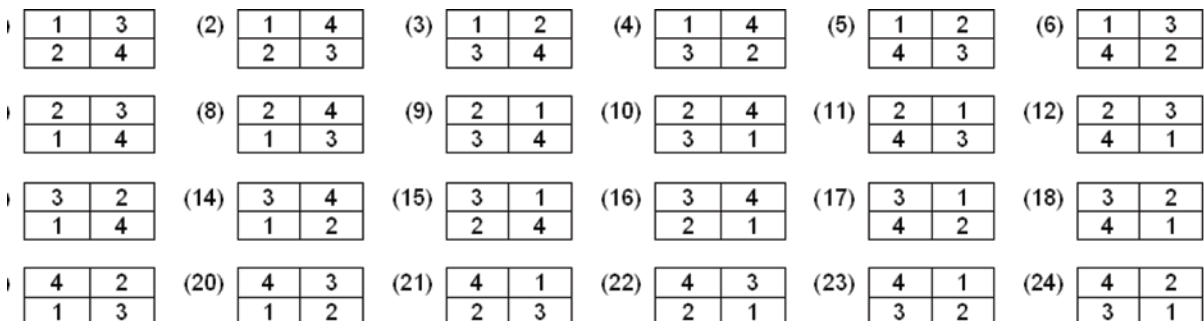
tures multiple aspects of stability and increases the robustness of the findings. Note that many stability concepts can be considered from an individual player's perspective or a group perspective. For this research, the focus is on the group stability. An outcome is *group stable* if it is stable for both players individually (Fraser, 1993).

In terms of stability computation, first note that a 2x2 game with four outcomes has a total of 4! = 24 possible strict rankings (rankings without ties). Figure 5 displays all 24 rankings in the normal form, represented by four cells, and within those cells, the most preferred outcome is denoted by 4 and the least preferred by 1. Then, a 2x2 game has a total of 576 (= 24 rankings for one player x 24 rankings for the other player) possible ranking combinations. Fraser (1993) computed the four stability concepts as well as others from individual and group perspectives, and cataloged the results for all 576 combinations of rankings. Since Fraser's catalog has a complete coverage, instead of reproducing all computations, this research refers to Fraser (1993) for identification of outcome stability. However, as a quick reference, sample calculations of four stability concepts are provided in Appendix A.

**Sensitivity Analysis**

In order to conduct stability analysis on the apparel model, two basic approaches exist. One approach is to identify the best representative of

Figure 5. 24 possible rankings of four outcomes for one player



each player's preference from the 24 rankings in Figure 5, which results in one unique combination of two players' rankings, and apply stability concepts to this combination. The second approach is a sensitivity analysis approach, which identifies a range of possible alternative rankings, instead of singling out a ranking for each player's preference, and examines which outcome has strong stability over the range and how sensitive that stability is to different rankings. This research employs the sensitivity analysis approach for the following reasons.

First, based on Figures 3 and 4, it is not obvious which one of the 24 rankings in Figure 5 is the best representative of each player's preference for the apparel model. For both parties, outcome (d) has the highest number of itemized benefits, but it also has the highest number of risks. On the other hand, outcome (a) has the lowest number of risks but also has the lowest number of benefits. Second, some of the benefits and risks are difficult to quantify, making the comparison of the four outcomes using one unit of measure a difficult task. For example, the knowledge transfer from the retailer is a possible benefit for the manufacturer in outcomes (b) and (d), but its value is difficult to measure because knowledge itself is difficult to quantify. Third, even if a unique ranking of outcomes can be determined for each player, one specific instance of ranking may not provide sufficient robustness to the conclusion of stability analysis since it would represent a specific circumstance between a particular manufacturer and a particular retailer.

For the sensitivity analysis, the range of the manufacturer's alternative rankings is determined as follows. Figure 3 shows that the benefits for outcome (c) are generally limited due to a lack of collaboration benefits. Moreover, the main benefit of (c), the improvement in internal operations by the use of RFID, has not so far been a strong incentive for the apparel manufacturers to con-

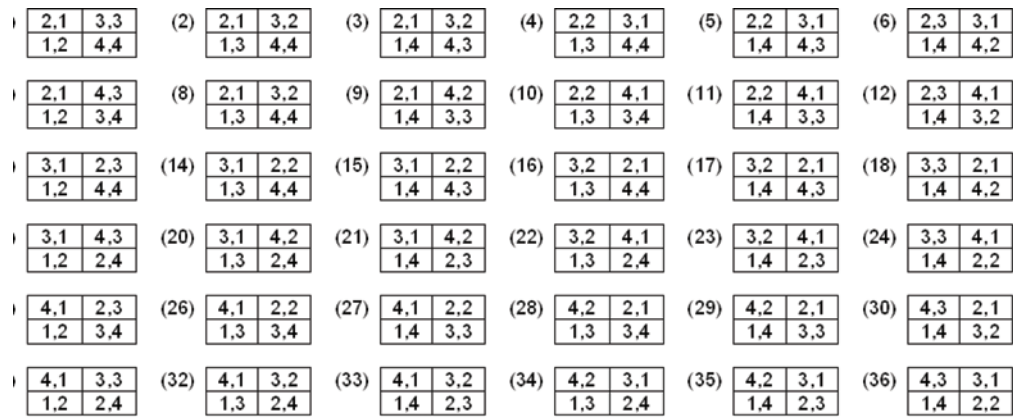
sider adopting RFID. Hence, in terms of benefits, (c) is one of the worst along with (a), the status quo. In addition, Figure 4 shows that (c) has the RFID-related risks and the risk of the retailer's opportunistic behavior, while (d) has the RFID-related risks and exposure risks. Between (c) and (d), the retailer's opportunistic behavior under the no-collaboration orientation is likely more believable and more worrisome to the manufacturer than are the exposure risks under the collaboration orientation, based on the history of the QR initiative in the 1980s. Hence, in terms of risks, (c) is one of the worst along with (d). This makes (c) presumably the manufacturer's least preferred outcome since it is the worst in terms of benefits and risks. Based on this observation, the rankings that show (c) as the least preferred are considered as possible rankings for the manufacturer, which are rankings 7, 8, 13, 14, 19, and 20 in Figure 5.

For the retailer, Figure 3 shows that outcome (c) has more benefits than (a), and outcome (d) has more benefits than (b), whereas Figure 4 shows that the increase in risk from (a) to (c) and from (b) to (d) is marginal. Hence, regardless of its own decision, the retailer generally prefers the manufacturer to adopt RFID. This observation from the 2x2 apparel game reflects the real-life observation of the world's leading retailers, such as Wal-Mart and METRO, requiring their suppliers to adopt RFID. Based on this observation, rankings 2, 4, 6-8, 10, 12-16, 18-24 from Figure 5 are not appropriate representatives of the retailer's preference since, in those rankings, (a) has a higher ranking than (c), or (b) has a higher ranking than (d). This leaves six rankings — 1, 3, 5, 9, 11, and 17 — as possible rankings for the retailer's preference.

Figure 6 shows all 36 combinations of the manufacturer's and the retailer's possible rankings. Within each cell, the first number represents the manufacturer's preference, and the second number represents the retailer's preference.



Figure 6. Sensitivity analysis



## RESULTS AND DISCUSSION

For each of 36 possible apparel games shown in Figure 6, Figure 7 provides the results of outcome stability along with the reference number used in Fraser (1993), and Table 1 presents a summary of stability results. Recall that this research refers to Fraser (1993) for identification of outcome stability, but sample calculations of four stability concepts are provided in Appendix A. Based on Figure 7 and Table 1, each of the four research questions raised in the Introduction is discussed below.

### Retailer’s Opportunistic Behavior

The concern for the retailer’s opportunistic behavior played a significant role in inhibiting the QR adoption among the small apparel manufacturers in the 1980s. Hence, it is critical to understand the likelihood of the retailer’s opportunistic behavior when a small manufacturer considers RFID adoption.

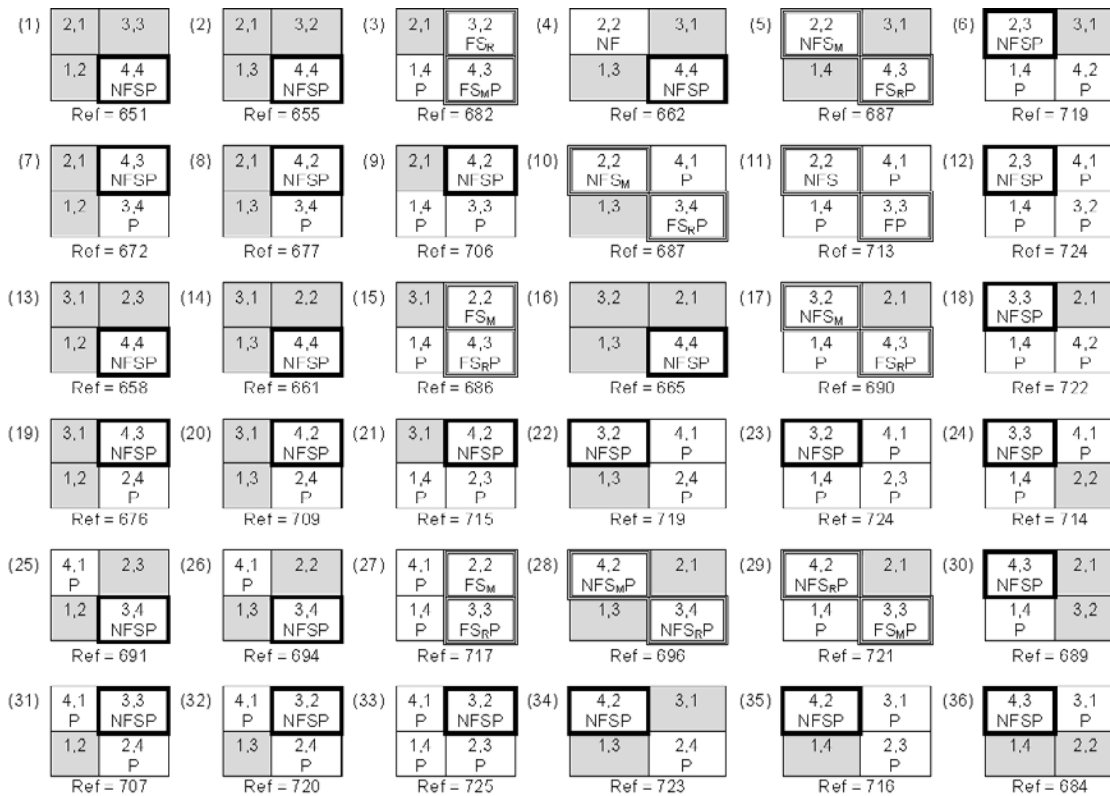
In the 2×2 apparel game, Figure 4 shows that the retailer’s opportunistic behavior is a risk associated with outcome (c). With its bargaining power, the retailer may impose RFID tagging and a higher service level on the manufacturer without collaboration benefits in return, resulting in cost-

shifting and exposure risks. By examining Table 1, among the four outcomes, (c) has the lowest stability since it has the lowest total of stability concepts (row 7), the lowest instances of exhibiting all four stability concepts within one game (row 8), and the highest instances of zero stability concepts within one game (row 9). Based on the low stability of (c), the retailer’s opportunistic behavior is deemed unlikely to persist, should it arise, and hence, the manufacturer’s concern is not warranted.

Individual examination of the four stability concepts reveals the following additional insight into the unlikelihood of the retailer’s opportunistic behavior. Figure 7 shows that outcome (c) is not Nash rational or Fraser-Hipel sequential stable for all 36 scenarios in the sensitivity analysis. This means that (c) is not the manufacturer’s preferred outcome, given the retailer’s no-collaboration strategy. Hence, if the retailer’s collaboration is not believable, then the manufacturer would likely choose the no-RFID strategy since (a) would produce a better outcome than (c). Moreover, Figure 7 shows that (c) is Pareto optimal for 15 out of 36 games (games 3, 6, 9, 11, 12, 15, 17, 18, 21, 23, 24, 27, 29, 30, and 33), and in these 15 cases, (c) is the most preferred outcome by the retailer. This indicates that, in the 2×2 apparel game, the manufacturer’s preference structure



Figure 7. Results of stability analysis



N = Nash rationality  
 F = Fraser-Hipel sequential stability  
 S = Stackelberg group stability  
 S<sub>M</sub> = Stackelberg when Manufacturer is leader  
 S<sub>R</sub> = Stackelberg when Retailer is leader  
 P = Pareto optimality  
 Ref = Game reference number in Fraser (1993)

= Outcome with all four stability concepts  
 = Outcome with no stability concepts  
 = Split stability between two outcomes in one game

is the stronger determinant than the retailer's in terms of stability of (c). Lastly, a lack of resources and bargaining power makes the manufacturer an obvious follower, rather than a leader, in terms of Stackelberg stability. However, the manufacturer would be more concerned about the retailer's opportunistic behavior if the manufacturer has to make the first move before knowing the retailer's intent. Based on Figure 7, in all 36 games, (c) is not Stackelberg stable from a group perspective,

and therefore, regardless of who makes the first move, the retailer's opportunistic behavior is deemed unlikely to persist.

### Manufacturer's Missed Opportunity

For small apparel manufacturers with limited resources, do-nothing is a valid and safe option that is often cost-effective. In the QR adoption, it turned out to be the choice of many small manu-

**Small Manufacturers vs. Large Retailers on RFID Adoption in the Apparel Supply Chain**

*Table 1. Summary of stability results*

	<b>Out of 36 games in Figure 7 (except for row 7)</b>	<b>Outcome (a): no RFID/ no collaboration</b>	<b>Outcome (b): no RFID/ collaboration</b>	<b>Outcome (c): RFID/ no collaboration</b>	<b>Outcome (d): RFID/ collaboration</b>
1.	No. of Nash rationality	17	9	0	9
2.	No. of Fraser-Hipel sequential stability	17	12	0	17
3.	No. of Stackelberg group stability	11	9	0	8
4.	No. of Stackelberg when Manufacturer is the leader	4	2	0	2
5.	No. of Stackelberg when Retailer is the leader	1	1	0	6
6.	No. of Pareto optimality	18	17	15	32
7.	Total of rows 1-6	68	50	15	74
8.	No. of instances with all four stability concepts within one game	10	9	0	8
9.	No. of instances with zero stability concepts within one game	13	16	21	3

facturers. In the apparel game, the do-nothing strategy also avoids the retailer’s opportunistic behavior. Does a safe option, however, always yield the best outcome?

In the 2×2 apparel game, the manufacturer’s no-RFID strategy has two possible outcomes, (a) and (b), and the RFID strategy has possible outcomes of (c) and (d). As discussed previously, (c) has the lowest stability among the four outcomes. Hence, choosing the no-RFID strategy would result in a missed opportunity if outcome (d) has strong stability and is preferred to (a) and (b) by the manufacturer. Table 1 shows that outcome (d) has strong stability, exhibiting all four stability concepts in 8 instances out of 36 games (row 8). Out of these 8 instances, (d) is preferred over either of (a) and (b) in 6 games (games 1, 2, 4, 13, 14, and 16 in Figure 7). In addition, for 9 games that exhibit split stability (games 3, 5, 10, 11, 15, 17, and 27-29), (d) is always one of the two outcomes involved in splitting stability, and it is the preferred outcome between those two in 7 out of 9 cases (games 3, 5, 10, 11, 15, 17, and 27). Therefore, the manufacturer strictly choosing the

no-RFID strategy can lead to a missed opportunity in 6+7 = 13 out of 36 games.

Examination of these 13 games reveals the following additional insight into the missed opportunity. Among the 13 games, outcome (d) is the most preferred by both parties in 6 games (games 1, 2, 4, 13, 14, and 16 in Figure 7), and is mutually beneficial for both parties over the other outcome that splits stability in 7 games (games 3, 5, 10, 11, 15, 17, and 27). This indicates that, in fact, the missed opportunity applies not only to the manufacturer but also to the retailer. Furthermore, among the 13 games, (d) is Stackelberg stable when the retailer is the leader in 5 games (games 5, 10, 15, 17, and 27). This indicates that, even if the manufacturer is willing to reconsider the adoption of RFID in light of the opportunity for a better outcome, the desired result may depend on the retailer’s move and cannot always be achieved by the manufacturer alone.

**Retailer’s Pressure Tactic**

As can be seen in Figure 3, the retailer has a lot to gain from the manufacturer’s RFID adoption.

RFID tagging can be done at the manufacturing site rather than at the retail site, and the supply chain visibility would improve in terms of accuracy, details, and timing of availability. In the apparel supply chain, where large retailers hold significant bargaining power over small manufacturers, one of the possible tactics that the retailers may use to influence the manufacturers is the pressure tactic. How effective is it in persuading a small manufacturer to adopt RFID?

In the 2×2 apparel game, the effectiveness of the retailer's pressure tactic can be examined by studying the stability associated with the retailer's no-collaboration strategy. The no-collaboration strategy has two possible outcomes, (a) and (c), and between these two, (c) is associated with the manufacturer's decision to adopt RFID. Recall from the previous discussion that (c) has the lowest stability among the four outcomes. Moreover, a direct comparison of (a) and (c) in Table 1 shows that (a) has stronger stability than (c) in all aspects (rows 1-9). In fact, Figure 7 shows that neither (a) nor (c) has strong stability in 20 out of 36 games (games 1-4, 7-9, 13-16, 19-21, 25-27, and 31-33). Hence, the retailer's pressure tactic is not effective in creating strong stability for (c) in the context of the 2×2 apparel game.

Additional insight into the retailer's pressure tactic is as follows. Figure 7 shows that outcome (c) is the most preferred by the retailer in half of 36 games (games 3, 5, 6, 9, 11, 12, 15, 17, 18, 21, 23, 24, 27, 29, 30, 33, 35, and 36). However, among these 18 games, outcome (a) — not (c) — has strong or split stability in 12 games (games 5, 6, 11, 12, 17, 18, 23, 24, 29, 30, 35, and 36). This indicates that, in the 2×2 apparel game, the pressure tactic may be the reflection of the retailer's strong preference for (c), but the use of this tactic results in creating more stability for (a) than for (c).

### **Retailer's Collaboration Tactic**

In the 2×2 apparel game developed in this research, whether or not to collaborate with the manufacturer

was assigned as the retailer's strategy decision since the decision is readily available to the retailer, and since it affects the manufacturer's RFID adoption decision by making the collaboration benefits and risks a part of decision-making. In this framework, the alternative to the pressure tactic is the collaboration tactic. Below examines the effect of the retailer's offer to establish a long-term cooperative relationship with the manufacturer on the manufacturer's RFID decision.

In the 2×2 apparel game, the retailer's collaboration strategy has two possible outcomes, (b) and (d), and between these two, (d) is associated with the manufacturer's decision to adopt RFID. Based on Table 1, among the four outcomes, (d) generally has strong stability since it has the highest total of stability concepts (row 7), the lowest instances of zero stability concepts within one game (row 9), and 8 instances out of 36 games exhibiting four stability concepts (row 8). However, (b) also has 9 instances of exhibiting four stability concepts (row 8), and for 9 games that have split stability, (b) and (d) show split stability in 3 cases (games 3, 15, and 27). Hence, although (d) has strong stability, (b) also has strong stability in 9+3 = 12 out of 36 games. Furthermore, in 10 out of 36 games in Figure 7 (games 6, 12, 18, 22-24, 30, and 34-36), neither (b) nor (d) has strong stability. These results indicate that the retailer's collaboration tactic seems to be more effective than the pressure tactic since (d) has stronger stability than (c). However, the collaboration tactic does not necessarily guarantee strong stability for (d) over the sensitivity range. In other words, in some cases, the collaboration tactic may not ensure the manufacturer's RFID adoption.

Under what condition, then, does outcome (d) hold strong stability? Based on 36 apparel scenarios considered in Figure 7, one observation is that (d) exhibits strong stability when it is the most preferred outcome by both parties, as in games 1, 2, 4, 13, 14, and 16. However, a further examination reveals a more general condition: (d) holds strong or split stability if it is mutually more

beneficial over (b) for both parties, as in games 1-5, 13-17, and 25-29. In games 6, 18, and 30, however, (d) is mutually beneficial over (b), but (d) does not hold strong stability. In these three games, (b) and (d) are the least and second least preferred outcomes by the retailer. This means that, if the *retailer* does not value collaboration with the manufacturer, then the collaboration tactic would not ensure the manufacturer's RFID adoption.

## **CONCLUSION**

The main objective of this research was to study the impact of the relationship between small manufacturers and large retailers on the small manufacturers' RFID adoption decisions. This research developed a 2×2 apparel game model and conducted stability analysis for a range of possible alternative scenarios. The 2×2 game model systematically compared a small manufacturer and a large retailer in terms of RFID benefits and risks, and provided insight into the likelihoods of the two parties' RFID-related actions. By focusing specifically on small apparel manufacturers, this research was able to contribute to the literature on the topic of RFID adoption by small firms. Based on the 2×2 apparel model, the main findings of this research were:

1. The retailer's opportunistic behavior is unlikely to occur due to the strong stability associated with the manufacturer's do-nothing option.
2. The do-nothing option, however, may lead to missed opportunities for both parties.
3. The retailer's pressure tactic is not effective in persuading the small manufacturer to adopt RFID.
4. The retailer's collaborative strategy also does not guarantee the manufacturer's RFID adoption.

## **Managerial Implications**

The main findings of this research provide valuable management insight into how to effectively promote RFID adoption among small apparel manufacturers. Finding (i) mentioned above is useful for reassuring small manufacturers that the concern for retailers' opportunistic behavior is not necessary when RFID adoption is considered. However, this finding alone is not effective in encouraging the adoption of RFID among the manufacturers because, in a 2×2 game context, the retailer's opportunistic behavior was avoided by the manufacturer's choice not to adopt RFID. Two findings (i) and (ii) together, on the other hand, could provide strong encouragement for small manufacturers to consider RFID by highlighting that the manufacturers' do-nothing option (i.e., the no-RFID strategy) is not always the best option for the manufacturers, and that retailers themselves would suffer from missed opportunities if they resort to taking advantage of the small manufacturers.

From a retailers' perspective, findings (iii) and (iv) suggest that the retailer's collaboration tactic is more effective than the pressure tactic in promoting RFID adoption among small apparel manufacturers. However, the examination of the stability conditions revealed that the collaboration tactic may not be effective if the retailer does not value collaboration with the manufacturer, that is, the two outcomes in the 2×2 apparel game that are associated with the retailer's collaboration strategy (the no RFID/collaboration and RFID/collaboration outcomes) are the two least preferred outcomes by the retailer. A managerial implication of this revelation is that the retailer must have a clear understanding of benefits and risks for *itself* from collaborative supply chain management and the joint use of RFID if the retailer wishes to persuade the manufacturer to adopt RFID through the collaboration tactic.

In addition, based on the 2×2 game framework, this research suggests a couple of ways to increase

the success of the retailer's collaboration tactic by making the RFID/collaboration outcome (outcome d) more attractive than the no RFID/collaboration (outcome b) for the manufacturer. To begin with, the retailer should realize that an offer for collaboration without any link to RFID implementation would increase benefits for outcomes (b) and (d) simultaneously, and hence, would not necessarily make (d) more attractive than (b). Consequently, the retailer's collaboration effort must be tied to the ease of RFID implementation for the manufacturer in order to make (d) more attractive than (b). Specifically, based on Figures 3 and 4, the areas of effective collaboration are: the improvement of supply chain visibility and data sharing practices; RFID technical knowledge transfer and personnel training; and integration of RFID and IT systems.

### **Limitations and Future Research**

The main limitation of this research is that, although a 2×2 game can capture the fundamental aspects of a multi-party decision-making situation, the small numbers of players and of strategic options may withhold further insight into the manufacturer's RFID adoption. Therefore, future research may extend the number of parties to include other players in the apparel supply chain, such as competitors of the small manufacturer, other retailers, and textile manufacturers. The number of options can also be extended to include different degrees of collaboration offered by the retailer and different areas of collaboration, such as new product development, category management, and joint sales promotion. In addition, future research can improve the understanding of the likelihoods of the two parties' RFID-related actions by tightening the sensitivity range. One way of doing this is to obtain detailed preference information by conducting a case study. Another way may be to obtain general preference characteristics by conducting a large-scale survey targeting the apparel manufacturers and retailers.

In conclusion, this research provided valuable insight into one of the timely issues surrounding the future of RFID technology: the potential reaction of small firms to the large retailer-led RFID initiative. The findings from this research showed that the relationship between small and large firms could indeed promote or inhibit the spread of RFID within the apparel industry, and based on these findings, practical insight into effective ways to promote RFID adoption among the small apparel manufacturers was gained.

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## KEY TERMS AND DEFINITIONS

**Fraser-Hipel Sequential Stability:** An outcome is Fraser-Hipel sequentially stable if it is Nash rational, or if it is not Nash rational but the player is not motivated to depart from the outcome because, if moved, the other player would make a sequential move and would put the player in a less preferred outcome.

**Nash Rationality:** An outcome is Nash rational (stable) if it is the player's best outcome given the other player's strategy.

**Pareto Optimality:** An outcome is Pareto optimal if there are no other outcomes that are preferred by both players.

**RFID (Radio Frequency Identification):** A wireless technology that uses transmitted radio signals to tag an item and to track and trace its movement without human intervention.

**Sensitivity Analysis:** Examination of outcome stability over a range of games.

**Stability Analysis:** Identification of an outcome that is more stable, and therefore, more likely to persist than other outcomes, should it arise.

**Stackelberg Stability:** With Stackelberg stability, one player is the leader and is assumed to make the first move, while the other player is the follower. An outcome is Stackelberg stable for the leader if it is the best possible outcome among the follower's Nash rational outcomes, from which the follower is assumed not to move away.

**2×2 Game:** A decision-making analysis model that consists of two players, and each player faces a decision between two mutually exclusive strategies.

## **APPENDIX**

In this section, sample calculations of four stability concepts are provided for one of  $2 \times 2$  games shown in Figure 7, namely, game 6. Recall that two players in the apparel game are Manufacturer and Retailer, and Figure 2 denoted the four game outcomes as: (a) no RFID/no collaboration; (b) no RFID/collaboration; (c) RFID/no collaboration; and (d) RFID/collaboration. Figure 7 displays  $2 \times 2$  games in the normal form, in which each game is represented by four cells. Within those cells, the most preferred outcome is denoted by 4 and the least preferred by 1. In particular to game 6, Manufacturer's preference over the four outcomes is: (a) = 2, (b) = 3, (c) = 1, and (d) = 4. Retailer's preference is: (a) = 3, (b) = 1, (c) = 4, (d) = 2.

### **A1. Nash Rationality**

An outcome is Nash rational (stable) if it is the player's best outcome given the other player's strategy (Nash, 1951).

For Manufacturer:

- Given Retailer's no-collaboration strategy, the best outcome is (a) since (a) > (c). Hence, (a) is Nash rational for Manufacturer individually.
- Given Retailer's collaboration strategy, the best outcome is (d) since (d) > (b). Hence, (d) is Nash rational for Manufacturer individually.

For Retailer:

- Given Manufacturer's no-RFID strategy, the best outcome is (a) since (a) > (b). Hence, (a) is Nash rational for Retailer individually.
- Given Manufacturer's RFID strategy, the best outcome is (c) since (c) > (d). Hence, (c) is Nash rational for Retailer individually.

From a group perspective:

- An outcome is group stable if it is stable for both players individually (Fraser, 1993).
- Hence, from a group perspective, only one outcome in game 6 is Nash rational, which is (a), since (a) is Nash rational for both players individually.

### **A2. Fraser-Hipel Sequential Stability**

An outcome is Fraser-Hipel sequentially (FHS) stable if it is Nash rational, or if it is not Nash rational but the player is not motivated to depart from the outcome because, if moved, the other player would make a sequential move and would put the player in a less preferred outcome (Fraser & Hipel, 1984).

For Manufacturer:

- Outcomes (a) and (d) are FHS stable because they are Nash rational.

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- Outcome (b) is not Nash rational, but Manufacturer is not motivated to depart from (b) to (d) (by changing from no-RFID to RFID strategy) because Retailer would make a sequential move from (d) to (c) (by changing from collaboration to no-collaboration strategy) since  $(c) > (d)$  for Retailer, and this Retailer's move would put Manufacturer in (c), a less preferred outcome than (b) for Manufacturer. Hence, (b) is FHS stable for Manufacturer individually.
- Outcome (c) is not Nash rational, and Manufacturer is motivated to depart from (c) to (a) because Retailer would not make a sequential move from (a) to (b) since  $(b) < (a)$  for Retailer. Hence, (c) is not FHS stable for Manufacturer individually.

For retailer:

- Outcomes (a) and (c) are FHS stable because they are Nash rational.
- Outcome (b) is not Nash rational, and Retailer is motivated to depart from (b) to (a) because Manufacturer would not make a sequential move from (a) to (c) since  $(c) < (a)$  for Manufacturer. Hence, (b) is not FHS stable for Retailer individually.
- Outcome (d) is not Nash rational, and Retailer is motivated to depart from (d) to (c) because Manufacturer would make a sequential move from (c) to (a) since  $(c) < (a)$  for Manufacturer, and this Manufacturer's move would put Retailer in (a), a more preferred outcome than (d) for Retailer. Hence, (d) is not FHS stable for Retailer individually.

From a group perspective:

- Outcome (a) is FHS stable in game 6 from a group perspective since (a) is FHS stable for both players individually.

### **A3. Stackelberg**

With Stackelberg stability, one player is the leader and is assumed to make the first move, while the other player is the follower. An outcome is Stackelberg stable for the leader if it is the best possible outcome among the follower's Nash rational outcomes, from which the follower is assumed not to move away (Von Stackelberg, 1952).

When Manufacturer is the leader:

- Outcomes (a) and (c) are Nash rational for the follower (Retailer).
- Outcome (a) is Stackelberg stable when Manufacturer is the leader because (a) is the best outcome among the follower's Nash rational outcomes, that is,  $(a) > (c)$  for Manufacturer.

When Retailer is the leader:

- Outcomes (a) and (d) are Nash rational for the follower (Manufacturer).
- Outcome (a) is Stackelberg stable when Retailer is the leader because (a) is the best outcome among the follower's Nash rational outcomes, that is,  $(a) > (d)$  for Retailer.

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From a group perspective:

- Outcome (a) is Stackelberg stable in game 6 from a group perspective since (a) is Stackelberg stable for both players individually.

### **A4. Pareto Optimality**

An outcome is Pareto optimal if there are no other outcomes that are preferred by both players.

- Outcome (a) is Pareto optimal because there are no other outcomes that are preferred by both players: (b) $\succ$ (a) for Manufacturer but not for Retailer; (c) $\succ$ (a) for Retailer but not for Manufacturer; and (d) $\succ$ (a) for Manufacturer but not for Retailer.
- Outcome (b) is not Pareto optimal because (d) $\succ$ (b) for both players.
- Outcome (c) is Pareto optimal because there are no other outcomes that are preferred by both players: (a) $\succ$ (c) for Manufacturer but not for Retailer; (b) $\succ$ (c) for Retailer but not for Manufacturer; and (d) $\succ$ (c) for Manufacturer but not for Retailer.
- Outcome (d) is Pareto optimal because there are no other outcomes that are preferred by both players: (a) $\succ$ (d) for Retailer but not for Manufacturer; (c) $\succ$ (d) for Retailer but not for Manufacturer; and (d) $\succ$ (b) for both Manufacturer and Retailer.

## Chapter 5

# Optimal Pricing and Inventory Decisions for Fashion Retailers Under Value-At-Risk Objective: Applications and Review

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### ABSTRACT

*Motivated by the popularity of Value-at-Risk (VaR) objective in finance, this chapter reviews and studies its application in fashion retail operations management. First, a formal optimization model is reviewed in which the fashion retailer aims at optimizing a VaR objective with both pricing and inventory decisions. Second, the detailed solution schemes are explored. Third, numerical examples are included to illustrate applications of the proposed models. Fourth, the performance of pure buyback contract and pure wholesale pricing contract in enhancing supply chain efficiency is examined. Insights are generated and future research directions are outlined.*

### INTRODUCTION

The fashion retailing problem and the newsvendor problem share many common features. The fashion retailer faces uncertain demands in selling fashion products. The purchase cost of a specific fashion

product is fixed, the selling season is short, the end-of-season markdown will clear the unsold leftover, and the fashion retailer needs to determine the order quantity of the fashion product from his supplier before the selling season starts. If we check the classical newsvendor problem (see, e.g., Lau, 1980), we can see that the problem faced by

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a fashion retailer is very close to the newsvendor problem. As a result, there are quite a number of studies which employ the newsvendor model to investigate supply chain management problems in fashion retailing. Examples include an investigation of trade promotion scan-back rebate scheme in fashion supply chains (Kurata & Yue, 2008), a mean-variance analysis of quick response fashion supply chains (Choi & Chow, 2008), and a study on risk hedging problem in multi-product fashion supply chains (Vaagen & Wallace, 2008).

Over the past few years, there are extensive studies of inventory models with the consideration of risk in the literature (see, e.g., Wu et al., 2009; Tapiero, 2005; Choi and Ruszczyrski, 2008). However, most of these studies do not consider pricing and only explore the corresponding optimal inventory policies. In addition, for those which include both inventory and pricing decisions, they only illustrate the technical details but do not show the applications of the algorithms (e.g. Chiu & Choi 2010). Since retail pricing is undoubtedly a crucial decision for fashion retailers and applications are important, we explore in this chapter the joint optimal pricing and stocking algorithms with an optimization objective based on the Value-at-Risk (VaR) function for a single-period product with price-dependent demand. We propose detailed algorithms to illustrate how the optimal pricing and stocking policies can be determined for different forms of price-dependent demand functions. This chapter can be taken as a review plus extended works supplementing the related literature (such as Gotoh & Takano, 2007; Chiu & Choi, 2010) with detailed algorithms, numerical analysis and discussions on channel coordination challenge.

The rest of the chapter is organized as follows. A literature review is first provided. The basic model is then discussed. Afterwards, the solution schemes are proposed and numerical examples are provided to further illustrate the findings. The performance of pure buyback contract and pure wholesale pricing contract in enhancing supply chain efficiency is examined. We finally

conclude with a discussion on probable future research directions.

## **LITERATURE REVIEW**

As we mentioned earlier, the newsvendor problem, despite being simple, has been employed widely to study stochastic supply chain inventory problems for fashion products. One of the major differences between the fashion retailing problem and the classical newsvendor problem is that the fashion retailer can (and actually will) decide the retail price by his own while the selling price of newspapers is fixed for the newsvendor in the classical newsvendor problem. In the literature, there are several extensions investigating pricing issue for newsvendor problem. For example, Petruzzi and Dada (1999) review and extend the newsvendor model with price-dependent demands. Under the respective analytical models, they study the newsvendor problem in which the optimal stocking quantity and selling price are jointly determined. Important theoretical insights and structural properties of the “price-setting” newsvendors are hence developed. Later on, Dana and Petruzzi (2001) extend the price-dependent demand newsvendor problem by considering the expected utility maximizing consumers who would choose between the firm’s product and the competitor’s product. Other related works which make use of price-dependent newsvendor models include a study of the supply chain coordination problem between a newsvendor and its supplier with price-dependent demand (Chiu et al., 2010), and a study of newsvendor model which captures the joint pricing and procurement of fashion products in the existence of clearance markets (Karakul, 2008). All these works include the joint optimal decisions in both inventory and price, and they are known to be more challenging than the works that focus solely on the inventory (i.e., quantity) decision. In fact, notice that even for the expected profit maximizing newsvendor

problem, the existence of a unique joint solution (of quantity and price) is not universally true for any distributions (see Petruzzi & Dada, 1999). Moreover, between the newsvendor problem and the fashion retailer's inventory and pricing problem, there exists another major difference in which the classical newsvendor model considers a fixed and known salvage value for the unsold products while this "salvage value" can vary or even be unknown for a fashion retailer (Ferdows et al., 2004). Even though we do not consider the salvage value issues in current chapter, some prior studies which extend the inventory decision model with investigation of this issue can be found (Cachon & Kok, 2007; Karakul, 2008).

In addition to the extensions with the price-dependent demand models, there are a lot of studies that extend the newsvendor problem in other directions. These extensions include the study of a newsvendor pricing game (Chen et al., 2004), the study of a capital constrained newsvendor problem (Dada & Hu, 2008), and the newsvendor problem research with resalable returns (Mostard & Teunter, 2006), etc. In particular, more and more studies related to the newsvendor problems explore risk related issues. For instance, pioneered by Lau (1980), the use of a mean-variance (MV) objective in the newsvendor setting has become popular in exploring risk averse newsvendors. Choi et al. (2008a) apply the MV analysis to study the newsvendor problems in which decision makers with different risk-attitudes are examined. Wu et al. (2009) perform MV analysis in the newsvendor setting with a stock-out cost and they demonstrate an interesting result that the optimal newsvendor quantity under the MV setting for a risk averse decision maker can be larger than that of the risk neutral case for a demand following a power distribution. Choi et al. (2008a) apply the MV analysis to the buyback contract in a two-stage supply chain. Besides the use of MV model, the VaR and conditional value-at-risk (CVaR) approaches have also been applied in the newsvendor problem and several inventory control models.

Some related works include: the incorporation of the CVaR and mean-CVaR in the newsvendor setting (Gotoh & Takano, 2007), the VaR approach in the multi-period inventory problem (Luciano et al., 2003), the multi-product newsvendor problem with VaR objective (Özler et al., 2008), optimal inventory control with VaR measures (Tapiero, 2005). Most recently, Chiu and Choi (2010) explore the structural properties and optimization problems of the newsvendor problem with VaR considerations. Although VaR (or CVaR) has been explored in the inventory related literature, the existing works seldom demonstrate the applications of the VaR approach in a relatively realistic setting. Plus, the issue of supply chain coordination with a supply chain agent which employs a VaR objective has not been explored. As a consequence, this chapter aims at reviewing some important results related to VaR objective in joint pricing and inventory problem, exploring the details of the respective applications, and examining the channel coordination issues. Numerical examples are included and future research directions are also discussed.

## **THE MODEL: A REVIEW**

In this section we review an analytical model which basically follows the standard newsvendor problem with price-dependent demands. First, we consider a fashion retailer which sells a short-life fashionable product with the unit purchasing cost (i.e., product's wholesale price)  $c$ , and the unit retail selling price  $r$ . Any unsold product will be cleared with a big discount at "markdown price" and we denote the net unit value of the leftover product as  $v$ . Notice that in the classical newsvendor problem,  $v$  is usually assumed to be positive. However, for the fashion retailer,  $v$  can be negative especially for some fast fashion retailers of which product turnover rate is very high and usually leftover has negative effects on their brand images and promotion of new products (Ferdows et al., 2004).

The fashion retailer makes two important decisions before the season starts: the optimal retail price and the optimal order quantity. For the demand functions, two common forms of price-dependent demand functions, namely the linear demand and the multiplicative demand, are considered (Petruzzi & Dada, 1999; Chiu & Choi, 2010): (a) The linear (L) demand:  $D_L(r)=k-ar+x$ , for  $0 < r \leq k/a$ , where  $k > 0$ ,  $a > 0$ ; and (b) The multiplicative (M) demand:  $D_M(r)=gr^{-b}x$ , where  $g > 0$  and  $b > 1$ . For both linear demand and multiplicative demand, we consider  $x$  as a non-negative random variable with mean  $\mu$  and standard deviation  $\sigma$ , with a density function  $f(\cdot)$  and a cumulative distribution function  $F(\cdot)$ . We define the inverse function of  $F(\cdot)$  by  $F^{-1}(\cdot)$ , and  $\bar{F}(\cdot) = 1 - F(\cdot)$ .

Noting that the above fashion retailing model is similar to the newsvendor model with price-dependent demand. Therefore, we can apply the price-dependent demand newsvendor problem to capture the fashion retailing problem. Now, we consider the case that the fashion retailer is risk-sensitive and it follows the VaR approach to determine the joint optimal retail price and order quantity. We first define  $\Pi_i(q, r)$  as the fashion retailer's profit under demand function  $i=L, M$ . For a given confidence level  $\alpha$ , where  $0 < \alpha < 1$ , suppose that a fashion retailer wants to determine the optimal quantity and selling price so that the following is achieved,

$$\Pr(\Pi_i(q, r) \leq V) = 1 - \alpha,$$

where  $V$  is the profit threshold, and the probability of having  $\Pi_i(q, r) \leq V$  is  $1 - \alpha$ . Notice that  $V$  is called the VaR, with a confidence level of  $\alpha$ .

Now, in our optimization problem, the fashion retailer would like to maximize  $V$  by selecting the optimal price and quantity subject to a constraint that the probability of having  $\Pi_i(q, r) \leq V$  is no larger than  $1 - \alpha$ :

$$\max_{(q,r)} V$$

$$\text{s.t. } \Pr(\Pi_i(q, r) \leq V) \leq 1 - \alpha.$$

Notice that the above optimization problem has been defined and employed in the literature (Chiu and Choi, 2010). For a notational purpose, we define  $C(\alpha) = F^{-1}(1 - \alpha)$ .

## A SOLUTION SCHEME

With the model reviewed and defined, we present the solution schemes in this section for both the linear and multiplicative price dependent demand functions. Based on the structural properties of the optimization problem defined above and the analytical results revealed in the literature (Chiu and Choi, 2010), we have the following two algorithms for any given confidence level  $0 < \alpha < 1$ ,

For the Linear Price Dependent Demand - Algorithm L:

*Step 1.* Define and compute:  $K_{L-} = k - ac$ ,  $K_{L+} = k + ac$ .

*Step 2.* Compute  $C(\alpha)$ .

*Step 3.* If  $K_{L-} > C(\alpha)$ : The optimal retail price =  $0.5(C(\alpha) + K_{L+})a^{-1}$ , the optimal quantity =  $0.5(C(\alpha) + K_{L-})$ , the corresponding optimal VaR =  $0.25(C(\alpha) + K_{L-})a^{-1}$ , and the corresponding service level =  $1 - \alpha$ ; otherwise, the optimal retail price =  $ka^{-1}$ , the optimal quantity =  $C(\alpha)$ , the corresponding optimal VaR =  $C(\alpha) + K_{L-})a^{-1}$ , and the corresponding service level =  $1 - \alpha$ .

For the Multiplicative Price Dependent Demand - Algorithm M:

*Step 1.* Define and compute:  $B = (b - 1)$ ,  $Z = bc$ , and  $\beta = B/Z$ .

*Step 2.* Compute  $C(\alpha)$ .



Table 1(a). Parameter setting of Example 1

$c$	$\mu$	$\sigma$	$a$	$k$	$B$	$g$
100	100	10	0.5	200	1.5	10000

Step 3. The optimal retail price =  $Z/B$ , the optimal quantity =  $gC(\alpha)(B/Z)^b$ , the corresponding optimal VaR =  $gC(\alpha)b^{-1} (B/Z)^{b-1}$ , and the corresponding service level =  $1-\alpha$ .

### NUMERICAL EXAMPLE

In this section, we present two numerical examples.

**Example 1.** In this numerical example,  $x$  follows a normal distribution with mean  $\mu$  and standard deviation  $\sigma$ , and the market parameters are given in Table 1(a).

The optimal joint solution of retail pricing and stocking quantity (inventory) under the linear demand and the multiplicative demand, and the corresponding optimal VaR values for different  $\alpha$  are shown in Table 1(b). Moreover, the service level and the stock out probability for different values are also shown in Table 1(b). Note that for

the sake of simplicity, the salvage value  $v$  is set as zero in Table 1(b).

Notice that  $\alpha$  and  $VaR_{i,\alpha}$  have some managerial meanings for the fashion retailer. The fashion retailer with a VaR objective can make optimal decisions based on its own managerial requirements; for example, a VaR fashion retailer who wants to provide a 95% inventory service level to the customer should follow the row with  $\alpha=0.05$  in Table 1(b) in setting the respective parameters (i.e., set the optimal price = 300 and optimal quantity =224 under the multiplicative demand case). Another fashion retailer (with VaR objective and under the linear demand case) who wants to sell the fashion product at a price 340, should follow the row with  $\alpha=0.85$  in Table 1(b), i.e., set the optimal quantity=120, and bear a high sold out probability of 0.85 but only a small maximum attainable profit of 28713.

**Example 2.** In this numerical example, the focus is on the profits of the VaR fashion retail-

Table 1(b). Optimal retail price and stocking inventory of Example 1

$\alpha$	Service level	Sold out probability	Linear Demand			Multiplicative Demand		
			Price	Quantity	VaR	Price	Quantity	VaR
0.05	0.95	0.05	366.45	133	35497.41	300.00	224	44821.06
0.15	0.85	0.15	360.36	130	33894.79	300.00	212	42479.25
0.25	0.75	0.25	356.74	128	32958.97	300.00	205	41086.13
0.35	0.65	0.35	353.85	127	32220.72	300.00	200	39973.12
0.45	0.55	0.45	351.26	126	31564.94	300.00	195	38973.69
0.55	0.45	0.55	348.74	124	30936.64	300.00	190	38006.35
0.65	0.35	0.65	346.15	123	30294.12	300.00	185	37006.92
0.75	0.25	0.75	343.26	122	29586.52	300.00	179	35893.91
0.85	0.15	0.85	339.64	120	28712.63	300.00	173	34500.78
0.95	0.05	0.95	333.55	117	27273.14	300.00	161	32158.97

*Table 2(a). Values of market parameters of Example 5.2*

$c$	$\mu$	$\sigma$	$a$	$k$	$b$	$g$	$v$
100	100	30	0.5	200	1.5	10000	0

*Table 2(b). Optimal retail price and stocking inventory of Example 5.2*

$\alpha$	Service level	Sold out probability	Linear Demand			Multiplicative Demand		
			Price	Quantity	VaR	Price	Quantity	VaR
0.05	0.95	0.05	399.35	150	44803.90	300.00	287	57483.15
0.55	0.45	0.55	346.23	123	30314.65	300.00	185	37039.01
0.95	0.05	0.95	300.65	100	20131.09	300.00	97	19496.88

ers with  $\alpha = 0.05$  (high service level),  $\alpha = 0.55$  (middle between high service level and high stock out probability) and  $\alpha = 0.95$  (high stock out probability), when  $x$  varies. Here,  $x$  follows a normal distribution, and the market parameters are given in Table 2(a).

The optimal joint solution of retail price and stocking quantity under the linear demand and multiplicative demand, and the corresponding optimal VaRs with  $\alpha = 0.05$ ,  $\alpha = 0.55$  and  $\alpha = 0.95$  are as shown in Table 2(b). The profit of the VaR fashion retailers having  $\alpha = 0.05$ ,  $\alpha = 0.55$  and  $\alpha = 0.95$ , under different market situation, i.e., different values of  $x$ , are summarized in Table 2(c).

Table 2(c) shows that the maximum attainable profit of the VaR fashion retailer is decreasing in  $\alpha$ , while the probability of achieving the maximum profit is increasing in  $\alpha$ . Moreover, when the market situation is bad, i.e.,  $x$  is small, the profit of the VaR fashion retailer is increasing in  $\alpha$ . For some cases, e.g., when both  $x$  and  $\alpha$  are small, the VaR fashion retailer suffers a loss. Furthermore, the variation of profit under both the linear demand and the multiplicative demand cases for  $\alpha = 0.05$  is the biggest among the three listed cases. Therefore, a small  $\alpha$  of the VaR fashion retailer implies that the VaR fashion retailer shares (1) a high maximum attainable profit, (2) a low probability

*Table 2(c). Profit of VaR fashion retailers in Example 5.2*

$x$	$F(x)$	Profit under LD			Profit under MD		
		$\alpha=0.05$	$\alpha=0.55$	$\alpha=0.95$	$\alpha=0.05$	$\alpha=0.55$	$\alpha=0.95$
20	0.0038	-6849.70	3921.47	10914.72	-17194.57	-6972.50	1798.56
40	0.0228	1137.21	10846.07	16927.80	-5647.57	4574.51	13345.57
60	0.0912	9124.12	17770.67	20131.09	5899.44	16121.51	19496.88
80	0.2525	17111.03	24695.28	20131.09	17446.45	27668.52	19496.88
100	0.5000	25097.94	30314.65	20131.09	28993.45	37039.01	19496.88
120	0.7475	33084.86	30314.65	20131.09	40540.46	37039.01	19496.88
140	0.9088	41071.77	30314.65	20131.09	52087.46	37039.01	19496.88
160	0.9772	44803.90	30314.65	20131.09	57483.15	37039.01	19496.88

that achieves the maximum profit, and (3) a high variation of profit.

## COORDINATION

We now consider a supply chain in which there are two echelons with one upstream manufacturer and a downstream retailer. The retailer takes the VaR objective (we call it “VaR retailer”) and makes the optimal pricing and ordering quantity decisions accordingly. In the literature, under the expected profit maximizing model, owing to the double marginalization effect, a decentralized supply chain would not be optimal by itself. In particular, for the case when the retailer only makes the ordering quantity decision, a supply contract in the form of a pure wholesale pricing contract (PWPC) cannot lead to an optimal supply chain (i.e., cannot coordinate the supply chain) whereas a pure buyback contract (PBC) can. For the case when the retailer makes both the retail pricing and ordering quantity decisions, both pure PWPC and PBC will fail to coordinate the supply chain even though PBC can enhance the supply chain’s efficiency. In the following, we compare the performance of PBC and PWPC in enhancing the supply chain’s efficiency with a VaR fashion retailer (as we modelled in the earlier sections).

First, we represent the unit production cost of the product by  $p$ , and the optimal supply chain price and product quantity are denoted by  $q_{SC^*}$  and  $r_{SC^*}$ , respectively. Under PBC, the manufacturer promises to buyback any unsold quantity by the retailer and the respective unit buyback price is denoted by  $E$ . Second, in order to guarantee the existence and uniqueness of  $q_{SC^*}$  and  $r_{SC^*}$  we need some mild conditions on the demand distribution. To be specific, we assume that  $\forall x \geq 0$ : (a)  $F(x)$  has a unique inverse function, and (b)  $(1-F(x))^2/f(x)$  is decreasing in  $x$  (Petruzzi and Dada, 1999). For the multiplicative case, the logic is similar and hence we omit the details here.

We proceed to explore the performance of PWPC. First, we have Observation 1.

**Observation 1:** *Under PWPC: (a) For the multiplicative demand function: The supply chain can be coordinated if and only if  $q_{SC^*} = gC(\alpha) [(b-1)/bc]^b$  and  $r_{SC^*} = bc/(b-1)$ . (b) For the linear demand function: (i) When  $c < (k-C(\alpha))/a$ : The supply chain can be coordinated if and only if  $q_{SC^*} = 0.5(C(\alpha) + k - ac)$  and  $r_{SC^*} = 0.5(C(\alpha) + k + ac)a^{-1}$ . (ii) When  $c \geq (k-C(\alpha))/a$ : The supply chain can be coordinated if and only if  $q_{SC^*} = C(\alpha)$  and  $r_{SC^*} = ka^{-1}$ .*

**Proof of Observation 1:** First, notice that by definition, coordination means providing incentive to make the retailer’s optimal decisions under VaR objective to be the same as the supply chain’s best decisions. Second, following Algorithms L and M, we can find the closed form expressions for the optimal decisions of the retailer under different demand functions. Combining the above two points yield the necessary and sufficient conditions and complete the proof. (Q.E.D.)

Obviously, *the required necessary and sufficient conditions as summarized by Observation 1 are unlikely to be satisfied in a general supply chain*. In other words, PWPC probably fails to coordinate the supply chain with price-dependent demands but in most cases (the multiplicative demand case, and case (b-i) of the linear demand), the retailer’s optimal decisions do depend on the wholesale price  $c$  and hence adjusting  $c$  can enhance the supply chain’s efficiency by making the retailer’s optimal decisions closer to  $q_{SC^*}$  and  $r_{SC^*}$ . We summarize the key findings in Proposition 1:

**Proposition 1:** *In general, PWPC cannot coordinate the supply chain with a VaR retailer but it can enhance the supply chain’s efficiency by making the optimal pricing and ordering decisions of the VaR fashion retailer closer to the optimal decisions of the supply chain.*

Suppose that we consider a scenario in which there is a fixed retail selling price policy in the supply chain, i.e., the retailer sells the product at

a fixed retail price (which is exogenously given). This case arises in several situations, e.g., when there is a recommended standard price as requested by the fashion brand owner (for branding positioning reason), etc. In this case, the retailer only makes a decision on the optimal ordering quantity and coordination becomes achievable by the PWPC. Proposition 2 summarizes the result and the proof is similar to the proof of Observation 1.

**Proposition 2:** *Under PWPC and the retail selling price is exogenous: (a) For the multiplicative demand function: The supply chain can be coordinated if and only if  $c=(b-1)[gC(\alpha)/q_{SC^*}]^{1/b}$ . (b) For the linear demand function: The supply chain can be coordinated by settling the wholesale  $c$  such that  $c=(C(\alpha)+k-2q_{SC^*})/a$  and  $c<(k-C(\alpha))/a$ .*

Following the same logic, we proceed to explore PBC. From Algorithms L and M, it is easy to prove Proposition 3:

**Proposition 3:** *PBC has zero impact on the optimal pricing and ordering decisions of the fashion retailer under the VaR objective. As a result, it is an ineffective incentive alignment scheme for enhancing supply chain's efficiency.*

Proposition 3 shows an interesting result that counter-intuitively, PBC can neither coordinate the supply chain with a VaR fashion retailer, nor enhance the supply chain's efficiency. This result shows a big challenge to the existing literature on the effectiveness of PBC and calls for more research to investigate the performance of different supply contracts in coordinating the supply chain when individual agents take different optimization objectives (Choi et al., 2008b).

## CONCLUSION AND FUTURE RESEARCH DIRECTIONS

VaR is a popular performance measure/objective and a hot topic in risk management. Based on the existing literature, this chapter reviews and studies VaR's application in deriving the optimal pricing and inventory decisions in fashion retailing. We first review the standard analytical model and discuss the VaR related optimization model for the fashion retailer. We then propose two detailed solution schemes, one for the linear price dependent demand and one for the multiplicative price dependent demand. Numerical examples are included to illustrate applications of the proposed models and to reveal some properties of the solutions. For future research directions, one can extend the work by further considering the effect of advertising with "advertising-effort and price" dependent consumer demands and examine the respective optimal decisions with a VaR objective. Following our analysis on channel coordination, one can investigate whether some hybrid policies can successfully achieve channel coordination when the fashion retailer takes a VaR objective. It is interesting to explore the joint pricing and stocking inventory decisions for the fashion retailer with a VaR objective in both the multi-period and multi-product cases. This extension is challenging while deserves deep investigation.

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## **KEY TERMS AND DEFINITIONS**

**Newsvendor Problem:** Is a classical single-period inventory model with stochastic demand.

**Value-at-Risk (VaR):** It is a useful and popular objective in risk analysis.

**Linear Demand:** Is a widely used price-dependent demand model which is a linear function of the retail price.

**Multiplicative Demand:** Is a widely used price-dependent demand model under which demand is the product of market parameters and the retail price.

**Price-Dependent Demand Newsvendor Problem:** Is an extension of the newsvendor problem with price-dependent demand model.

## Section 2

# Quantitative Empirical Research

*This section includes chapters that employ empirical data for quantitative analysis. The approaches include data-driven research, survey-based statistical analysis (and its review), intelligent systems, and empirical gaming models.*

## Chapter 6

# Quality and Environmental Management Systems in the Fashion Supply Chain

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### ABSTRACT

*Consumers and stakeholders have rising concerns over product quality and environmental issues, and therefore, quality and environmental management have become important topics for today's fashion products manufacturers. This chapter presents some empirical evidence of the adoption of quality management systems (QMS) and environmental management systems (EMS) and their impact on fashion and textiles related firms' supply chain efficiency. Although both management systems are commonly adopted in the manufacturing industries and becoming a passport to business, their actual impacts specifically on the fashion supply chain have not been explored. By investigating the adoption of ISO 9000 (a quality management system) and ISO 14000 (an environmental management system) in the U.S. fashion and textiles firms, we estimate their impact on manufacturers' supply chain performance. Based on 284 publicly listed fashion and textiles manufacturing firms in the U.S., we find that fashion and textiles firms operating cycle time had shortened by 15.12 days in a five-year period. In the cross-sectional analysis, the results show that early adopters of ISO 9000 and high-tech textiles related firms obtained more supply chain benefits. We only find mixed results of the impact of ISO 14000 on supply chain performance.*

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## **BACKGROUND**

The quality of textiles products at each stage in the fashion supply chain is essential for the success of a fashion product. The quality level delivered to the final customer is the result of quality management practices of each link in the fashion supply chain, thus each actor is responsible for their own quality issues (Romano & Vinelli, 2001). This is because the quality of the final product that reaches the customers is clearly the results of a chain of successive, inter-linked phases: spinning, weaving, apparel and distribution, and thus quality management in supply chain are particularly relevant in the fashion and textiles industries (Romano & Vinelli, 2001).

Quality management is defined as an integrated approach to achieve and sustain high quality output, focusing on the maintenance and continuous improvement of processes and defect prevention at all levels and in all functions of the organization to meet or exceed customer expectation (Flynn, Schroeder, & Sakakibara, 1994). The customer expectations on the quality of a product, however, are not just its physical attributes and workmanship. According to ISO 9000, quality is defined as customer expectations over actual performance (ISO, 2004). Consumers' expectations on fashion products, nowadays, also include its environmental attributes, for instance, use of sustainable materials and control of environmental impacts during the manufacturing processes, etc. Therefore, both quality and environmental management have become important focuses for today's fashion and textiles manufacturers. International buyers of major brands often use quality management system (QMS) and environmental management systems (EMS) as a major tool to select capable fashion and textiles suppliers (Boiral, 2003; Boiral & Sala, 1998), to ensure their products and raw materials could meet customers' expectations on quality and environmental aspects.

To respond to the call for management systems in various industries, International Organization

for Standardization (ISO) has developed ISO 9000 in 1987 and ISO 14000 in 1996, which are generic QMS and EMS for worldwide applications. The number of ISO 9000 certified firms has been increasing persistently since its introduction some 20 years ago. According to recent statistics (ISO, 2009), almost one million of firms or business divisions in 175 countries have adopted ISO 9000. In the past five years, almost 800,000 firms or business units have adopted ISO 9000, representing an increase of almost 570%. For ISO 14000, it has been adopted by 188,815 firms or business divisions in 155 countries (ISO, 2009). From 2006 to 2008, almost 60,000 firms or business units have adopted ISO 14000, representing an increase of about 47% (ISO, 2009). Multi-national enterprises (MNEs) with operations in more than one country are widely recognized as key agents in the diffusion of ISO certifications across national borders.

The diffusion of ISO 9000 in the fashion and textiles industries is particularly pronounced. In the early 1990s, European Committee for Standardization (Committee European pour Normalization - CEN) developed importing regulations for use by the European Union (EU) countries. CEN requires manufacturing firms that are importing products into the European market to comply with ISO 9000 standard. Import of fashion and textiles products to EU countries are under this regulation. The requirement of ISO 9000 was then followed by major MNEs, which use the ISO-based criteria to certify their own suppliers and have developed their internal quality management systems according to the ISO guidelines (Guler, Guillen, & Macpherson, 2002). Many suppliers to MNEs subsequently required their upstream suppliers or business partners to be ISO certified, leading to the widespread diffusion of the standard in global supply chain.

ISO 14000 follows the global diffusion pattern of ISO 9000, and it has become the most widely adopted EMS in the world (Corbett & Kirsch, 2001). It is a set of management processes and

procedures requiring firms to identify, measure, and control their environmental impacts (Bansal & Hunter, 2003). With the aim of improving the environmental performance of a firm, compliance with the standard is audited and certified by an independent, third-party certification body (Jiang & Bansal, 2003). The initial version of ISO 14000 was a consolidation of various elements in BS 7750, a British environmental management standard, and European's Environmental Management and Audit Scheme (EMAS).

Regulations of different countries towards the adoption of ISO 14000 also affect the diffusion of this standard. European countries and some Asian countries, such as Japan (Bansal & Roth, 2000) and Singapore (Quazi, Khoo, Tan, & Wong, 2001), provide favourable legislative environment for firms to adopt EMS, while the U.S. comparatively provides less favourable legislative environment (Kollman & Prakash, 2001, 2002). The regulatory environment within a country affect the costs and perceived benefits of ISO 14000 adoption (Delmas, 2002). Jennings and Zandbergen (1995) maintained that the larger the pressure from the environment, the faster the diffusion of EMS.

Due to globalization, the environmental law and regulations are not just affecting the firms within a particular country, but also affecting firms which import and export goods to other countries. Christmann and Taylor (2001) found that if the polluting firms in developing countries export a large proportion of their output to developed countries, they would be more likely to adopt ISO 14000, despite they may be tempted by lax environmental regulations in developing countries.

Although the original objective of ISO 14000 is quite different from ISO 9000's, they shared the same management framework and both diffuse along the global supply chain. In the literature, some scholars investigated on the interactions between ISO 9000 and ISO 14000. Corbett & Kirsch (2001) found that ISO 9000 appears as an important factor explaining diffusion of ISO

14000, suggesting that the motivation, such as attracting potential customers, behind the two have significantly overlap. Pan (2003) also found that there is a strong linkage between the motivations of implementing ISO 9000 and ISO 14000 and their perceived benefits of adoption. Albuquerque, Bronnenberg, & Corbett (2007) further investigated the global diffusion patterns of ISO 9000 and ISO 14000, and they found that both certifications diffuse across countries primarily by geography. In addition, the adoption experience of ISO 9000 could also help certified firms to effectively implement ISO 14000, as the two systems are very similar in terms of implementation requirements (Poksinska, Dahlgard, & Eklund, 2003).

## **LITERATURE REVIEW OF QMS AND EMS ADOPTION IN THE FASHION SUPPLY CHAIN**

In fashion and textiles literature, researchers mainly focus on the usefulness of QMS and EMS in supplier selection process. Buyers use management certification (e.g., ISO 9000 and ISO 14000) as an instrument to determine whether the supplier is capable to follow industry's standards (Motwani, Youssef, Kathawala, & Futch, 1999; Teng & Jaramillo, 2005; Thaver & Wilcock, 2006). Teng and Jaramillo (2005) developed a model for evaluation of supplier in the fashion supply chain. They proposed five performance clusters to evaluate textiles supplier performance, which are delivery, flexibility, cost, reliability, and quality. They suggested using QMS certifications as the evidence for quality performance evaluation. The suppliers would receive a higher score in the evaluation model, if they are ISO 9000 certified.

There are only a few anecdote cases that discussed the impact of QMS on the fashion supply chain. Sarkar (1998) found that a textiles mill in India obtained higher customer satisfaction through increased employee involvement and

product quality improvement due to ISO 9000 adoption. Romano and Vinelli (2001) conducted a case study of the Marzotto Group, one of the most important Italian textiles and apparel manufactures, about its relationships with both upstream and downstream suppliers. They found that quality management system is the “glue” that makes the supply network to operate as a “whole system”. Adanur and Allen (1995) conducted the first industry survey of ISO 9000 in the U.S. textiles industry, and they found that the certified firms experienced decrease in production time and product returns. The certified firms also reported fewer raw material rejections from ISO 9000 certified suppliers. A recent study shows that the adoption of ISO 9000 can improve the adopting firms’ supply chain efficiency in the general manufacturing industries in the U.S. (Lo, Yeung, & Cheng, 2009), suggesting that the adoption of QMS might help the certified firms to become a more efficient node in their supply chain.

The implementation of QMS are often under the pressure of major customers, thus small- and medium-sized textiles manufacturers have no choice but to comply with customer requirements on these certification. They might pursue ISO 9000 without genius knowledge about QMS. Allen and Oakland (1988, 1991a, 1991b) found that small textiles firms lack correct knowledge about QMS compared to large firms, in three survey studies of 183 textiles firms. They concluded that there is a distinct lack of good quality management practices within in the British textiles industry. Fatima and Ahmed (2010) studied the ISO 9000 certified firms in Pakistan’s bedwear textiles industry. They found that 60% of the firms offered poor training, 70% had poorly defined quality policy and objectives, and 70% had ineffective internal audit. Their findings show that despite the high adoption rate of ISO 9000 in the industry, there is lack of real implementation of QMS, and ISO 9000 is merely a passport into export markets. Fashion and textiles manufacturers in developing countries have self-regulation pressures to adopt

QMS for gaining legitimacy from the MNEs of developed countries (Christmann & Taylor, 2001).

In the operation management (OM) literature, there are some critics on EMS’s benefits in firm operations. The critics believe that environmental initiatives often transfer the cost previously bore by the society back to the firms (McGuire, Sundgren, & Schneeweis, 1988). The increased liability and environmental obligations would also lead to a negative impact on firms’ operational performance and its flexibility in production (i.e. limited choices of environmental friendly dyes and fabrics, which are often more expensive). Therefore, textiles firms’ operations managers would hesitate to adopt EMS in their production. On the other hand, the advocate of EMS believe that the ISO 14000 could improve environmental performance, which eventually improved firms’ performance through cost-saving and revenue gain pathways (Klassen & McLaughlin, 1996).

In fact, the perceived benefits of EMS in fashion supply chain are quite direct. The dying process in textiles processing could produce huge amount of emissions that would lead to fine and high restoration cost. The impact of EMS is especially important for the wet processing of natural fibres, which are water, energy and pollution intensive (Ren, 2000). Managing the environmental impact through a systematic process would help the firms to reduce water and energy consumption, as well as to avoid serious pollution incidents. Therefore, EMS adoption is particularly relevant to fashion and textiles related firms. However, compared to ISO 9000, the number of empirical works that focused on the EMS adoption in the fashion supply chain is very limited. There are only a few survey studies discussed about the sustainability of the fashion supply chain.. For example, Fresner (1998) conducted a case study of an Austrian textiles mill and found that the adoption of ISO 9000 helped to reduce solid waste and then pursue ISO 14000 for further improvement in productivity. Brito et al. (2008) found that the adoption of ISO 14000 in Europe fashion and textiles industries would

improve customer services and cost optimization for the adopting firms, and eventually improve the overall performance of the whole supply chain. However, both studies mentioned above did not provide objective evidence of such impact. To explore how QMS and EMS affect fashion and textiles firms' supply chain efficiency, more empirical evidence is needed.

## **HYPOTHESIS DEVELOPMENT**

Supply chain efficiency could refer to lead-time performance, delivery promptness and inventory level (Kojima, Nakashima, & Ohno, 2008). If the members of a fashion supply chain could deliver their products to their down stream customers in shorter period, the performance of the overall supply chain performance is improved. The well-known Supply Chain Operations Reference (SCOR) model suggested that firms' operating cycle time is an important indicator to measure supply chain efficiency (Stewart, 1995, 1997). To measure supply chain efficiency for a particular firm, accounting-based performance indicators, namely 1) inventory days, 2) accounts receivable days, and 3) operating cycle time can be used (Lo, et al., 2009). We discuss how ISO 9000 and ISO14000 could possibly affect the supply chain efficiency of adopting firms as follows.

ISO 9000 requires the adopting firm to ensure that product quality is constantly measured and appropriate corrective actions are taken whenever defects occur. These actions must be undertaken through a well-defined management system that monitors the potential quality problems continuously. Therefore, the defect rate of the fashion products should decrease and defects should be detected and corrected early in the production processes, and less scrap and rework need to be handled in the manufacturing processes (Naveh & Marcus, 2005). Therefore, the overall time required turning raw material into fashion and

textiles products that fulfil customer order should be shortened (i.e. lower inventory days).

ISO 14000 adoption could also lead to lower inventory days, as it requires organizations to implement pollution prevention procedures to avoid environmental spills, crises, and liabilities that might incur huge effort in restoration (Bansal & Hunter, 2003; Brio, Fernandez, Junquera, & Vazquez, 2001). Therefore, ISO 14000 certified firms could face less frequent mandatory pollution restoration that could seriously disrupt their operations. ISO 14000 certified firms are also perceived as less risky than their non-certified counterparts, less frequent environmental inspections from customers and regulators are required (Potoski & Prakash, 2005), leading to further shortening of inventory days. Therefore, we hypothesize that the time required to convert raw materials into textiles products (i.e., inventory days) is shorter after ISO 9000 or ISO 14000 implementation. As the initial objectives and its impact on supply chain are different between ISO 9000 and ISO 14000, we develop two parallel hypotheses to estimate their impact on supply chain performance independently.

*H1a: The adoption of QMS leads to lower inventory days.*

*H1b: The adoption of EMS leads to lower inventory days.*

The perceived benefits of ISO 9000 are not just confined to improving product quality, but also enhancing customer services (Buttle, 1997). If ISO 9000 implementation can improve product quality and customer services, the customer orders fulfilment time should be shorter. Moreover, if there were any quality problem of the fashion products, payment would be postponed as defective fashion products are returned to rework. Customers may not pay for the products until the reworked products being delivered and met their quality requirements. As a result, the time between product delivery and customer payment

(i.e. accounts receivable days) should be shorter for firms with higher product and service quality for the ISO 9000 certified firms (Lo, et al., 2009).

By taking proactive measures to prevent environmental crises, an ISO 14000 certified firm are able to prevent mistaken use of hazardous materials, and violation of environmental regulatory requirements in the customer's market, which might results in large-scale product recall. Once a product recall is needed, the accounts receivable days will be significantly affected (i.e. longer). Besides, as customers are more favourable toward environmentally friendly products and organizations, ISO 14000 adoption can establish a positive corporate image and trust from customers in the long run (Bansal & Hunter, 2003). Therefore, such firms have the potential to bargain for more favourable payment terms from customers who trusted and loyal to them (i.e., customers are willing to pay earlier). This hypothesis can be tested by measuring the accounts receivable days.

*H2a: The adoption of QMS leads to lower accounts receivable days.*

*H2b: The adoption of EMS leads to lower accounts receivable days.*

In the fashion supply chain, operating cycle time consists of manufacturing time (the time required to turn raw materials into products), delivery time (the time required to deliver products from the manufacturer to customers), and payment fulfilment time (the time required for customers to pay for their accepted products). The total time incurred in the above processes is known as operating cycle or "cash-to-cash cycle" (Eskew & Jensen, 1996). Therefore, we hypothesize that operating cycle time should be shorter after the implementation of ISO 9000 and ISO 14000.

*H3a: The adoption of QMS leads to a shorter operating cycle.*

*H3b: The adoption of EMS leads to a shorter operating cycle.*

## **METHODOLOGY AND DATA COLLECTION**

In this research, we focus on fashion and textiles related firms in the manufacturing industry (SIC code 2000-3999). All firms under the industry that contains keywords such as "Fashion", "Textiles", "Dye", "Apparels" and "Fabrics", were included in our sample. To generate our sample, we identified ISO 9000 and ISO 14000 certified firms and their years of certification from registration data of *Quality Digest* and *Who's Registered*, which are online registration databases. Since each firm could have multiple plants/sites certified, we follow the practice of previous research (e.g., Corbett, Montes-Sancho, & Kirsch, 2005; Naveh & Marcus, 2005) by focusing on the first certification. It is because this is the only time period representing the change from a non-certified to a certified firm status. Additional certifications after the first certification only mean continuous improvements. After compiling the data from the online databases and from Standard and Poor's financial database - COMPUSTAT, we found that 284 ISO 9000 certified and 61 ISO 14000 certified publicly listed fashion or textiles manufacturing firms in the U.S.

We define the year of formal ISO certification as the certification year (year 0). To measure the abnormal change in performance over a long-term period (event window), we should start by defining the base year, when there is no prior impact from the preparation of ISO certification on the sample firms. To pass the certification audit, the average preparation time is 6-18 months prior to registration (Corbett, et al., 2005). Therefore, year -2 should be taken as the base year. As we only focus on the first certification, we can assume that there is no impact from ISO implementation on all the sample firms during the base year (year -2). ISO requires a third-party audit to verify that it has been effectively implemented, so a strong impact of ISO on performance should appear in the certification year when the firm passed the

audit. The performance of certified firms should also experience the impact years after ISO certification. Therefore, we set the event period in this research at year -2 as the base year and measure the changes over the next five years (year -1, year 0, year 1, year 2, and year 3).

To estimate the abnormal changes in supply chain performance within the event window, we compare the actual performance with the expected performance of the sample firms, which is based on the changes in performance of control firms (Barber & Lyon, 1996). The selection of control firms should be based on a combination of three criteria: pre-event performance, industry, and firm size (Barber and Lyon, 1996). First, matching on pre-event performance can avoid the mean reversion problem of accounting data and control the impact of other factors on firms' performance (Barber & Lyon, 1996). Second, industry economic status could account for up to 20% of the changes in financial performance (McGahan & Porter, 1997). Moreover, environmental issues and the impact of EMS are industry-specific (Russo & Fouts, 1997), so we must control industry type in matching sample and control firms. Third, previous studies have suggested that operating performance varies by size (e.g., Fama & French, 1995). We thus match sample and control pairs based on the three matching criteria.

We generate the sample-control pairs and regard these pairs as the *performance-industry-matched* group. The first step is to match each sample firm to a portfolio of control firms based on at least a two-digit SIC code and 90%-110% of performance in year -2. In Step 2, if there are some firms have no control firm is matched in step 1, we use at least a one-digit SIC code and 90%-110% of performance to match for control firms. If no control firm is matched in the Step 2, we use only the 90%-110% of performance as the matching criterion.

In our sample, there are 248 ISO 9000 certified firms, of which 58 are ISO 14000 certified. We discard 57 firms that did not have financial

information (Operating cycle) in year -2. In the remaining 191 fashion and textiles related firms, 154 firms are matched in Step 1 (80.6%). five firms are matched in Step 2. No firm is matched in Step 3. We matched 159 sample firms with at least one control firm in year -2. The financial information presented in table 1, the number of sample and control matched pairs gradually decrease from the ending period year 1 to year 3, due to lack of financial information in either sample firms or control firms.

For another group of matching, i.e., *performance-industry-size-matched*, we further control the firm size. We use the 50%-200% range of total assets for controlling the firm size. In other words, we match the sample and control firms with at least a two-digit SIC code, 50-200% firm size (in terms of total assets), and 90%-110% prior certification performance in year -2 (Step 1). In the case where a sample firm cannot match any control firm in Step 1, we relax the industry-matching criterion to at least a one-digit SIC code, while keeping the other matching criteria unchanged (Step 2). If no control firm is matched in Step 2, we use only the 50%-200% of firm size and 90%-110% of performance as the criteria (Step 3). The reason for taking the prescribed steps to create two control groups is to try to match most of the firms without compromising on the tightness of the matches on performance (Hendricks & Singhal, 2008).

## **Measurements of Indicators**

We measure the fashion and textiles firms' supply chain efficiency by measuring the inventory days, accounts receivable days, and operating cycle time. For the calculation of inventory days, we first divide the cost of goods sold by average inventory. We then divide the 365 days by inventory turnover ratio for the Inventory days. The unit of inventory days is in terms of day (see formula 1). For accounts receivable days, similarly, we first calculate the accounts receivable turnover

Table 1. Abnormal operating cycles of sample firms for the ISO 9000 adoption in three-year period (year -2 to year 1), four-year period (year -2 to year 2), and five-year period (year -2 to year 3), based on performance-industry-matched and performance-industry-size-matched matching.  $p < 0.1^*$ ;  $p < 0.05^{**}$ ;  $p < 0.01^{***}$  for one-tailed tests; <sup>a</sup> in percentage

Performance measures	year -2 to year 1				year -2 to year 2				year -2 to year 3			
	N	Mean	Median	% negative	N	Mean	Median	% negative	N	Mean	Median	% negative
Operating Cycle	149	-18.44	-13.24	63.00	142	-11.59	-14.13	63.00	139	-17.24	-15.12	67.00
<i>t/z statistics</i>		-2.19	-3.46	***		-2.51	-3.64	***		-3.34	-4.15	***
Inventory Days	149	-14.00	-10.31	62.00	142	-11.00	-9.69	63.00	139	-14.48	-9.47	65.00
<i>t/z statistics</i>		-2.28	-3.05	***		-2.83	-3.26	***		-3.10	-3.46	***
Accounts Receivable Days	149	-9.95	-1.05	51.00	142	-1.78	-1.56	54.00	139	-7.56	-4.32	61.00
<i>t/z statistics</i>		-1.86	-1.71	**		-0.80	-1.40	*		-2.48	-2.76	***
<b>Performance-industry-size-matched</b>												
Performance measures	year -2 to year 1				year -2 to year 2				year -2 to year 3			
	N	Mean	Median	% negative	N	Mean	Median	% negative	N	Mean	Median	% negative
Operating Cycle	144	-12.43	-5.51	57.00	137	-9.07	-3.92	59.00	131	-14.22	-7.18	60.00
<i>t/z statistics</i>		-1.44	-1.68	*		-1.74	-1.51	*		-1.65	-1.44	*
Inventory Days	144	-9.57	-1.89	55.00	137	-11.28	-3.50	55.00	131	-12.54	-5.46	59.00
<i>t/z statistics</i>		-1.58	-1.57	*		-2.39	-1.68	***		-1.86	-1.52	*
Accounts Receivable Days	144	-2.86	0.20	50.00	137	2.32	0.61	47.00	131	-2.41	0.38	48.00
<i>t/z statistics</i>		-0.88	-0.53	0.00		1.06	1.69	0.68		-0.77	-0.20	-0.35

by dividing the credit sales by average accounts receivable. We then use 365 days over accounts receivable turnover to estimate the number of accounts receivable days (see formula 2). The overall operating cycle is the summation of inventory days and accounts receivable days, and it represents the time required to turn the raw materials to cash from customers. The corresponding formulas as follows:

Letting  $IT$  be inventory turnover ratio, given by

$$IT = \frac{COGS}{Avg.Inv.},$$

Where

$COGS$  = cost of goods sold,  
 $Avg.Inv.$  = average inventory balance,

We have

$$I = \frac{365}{IT}. \quad (1)$$

Similarly, letting  $ART$  be the accounts receivable turnover ratio, given by

$$ART = \frac{CS}{Avg.AR},$$

Where

$CS$  = credit sales,  
 $Avg. AR$  = average accounts receivable balance,

We have

$$AR = \frac{365}{ART}. \quad (2)$$

$$OC = I + AR \quad (3)$$

Where

$OC$  = operating cycle,  
 $I$  = number of inventory days,  
 $AR$  = number of accounts receivable days.

We estimate abnormal supply chain efficiency (i.e., inventory days, accounts receivable days, and operating cycle time) within the event window as the difference between sample post-event performance (i.e., actual performance in year 1, year 2 and year 3) and expected performance (in year 1, year 2 and year 3). We estimate expected performance as the sum of sample pre-event performance (i.e., in year -2) and change in the median performance of control firms in that period (i.e., from year -2 to year 1, year 2 and year 3). The formulas are as follows:

$$AP_{(t+j)} = PS_{(t+j)} - EP_{(t+j)},$$

$$EP_{(t+j)} = PS_{(t+i)} + (PC_{(t+j)} - PC_{(t+i)}),$$

Where

$AP$  – abnormal performance,  
 $EP$  – expected performance,  
 $PS$  – performance of sample firms,  
 $PC$  – median performance of control firms,  
 $t$  – year of ISO 9000 / ISO 14000 certification,  
 $i$  – starting year of comparison ( $i = -2$ ),  
 $j$  – ending year of comparison ( $j = 1, 2, \text{ or } 3$ ).

We obtain the performance data from the COMPUSTAT database. Since the first ISO 9000 (ISO 14000) certification was awarded in 1990 (1996) and we need performance data at least two years before certification (year -2) and three years after certification (year 3) for analysis, we obtain performance data covering the period 1988 to 2008.

We conduct the Wilcoxon signed-rank (WSR) test to examine the median abnormal performance. We also carry out the Sign test to determine if the



percentage of positive abnormal performance is significantly higher (i.e., higher than 50%). To check for consistency, we further conduct the parametric *t*-test on the mean abnormal performance to ensure that our findings are robust. Table 1 and Table 2 present the results of ISO 9000 and ISO 14000 on supply chain efficiency respectively.

## RESULTS

We begin our discussion by examining abnormal supply chain efficiency on ISO 9000 certified textiles and textiles related firms. The cumulative results of three-year to five-year (from year -2 to year 1, year 2 and year 3) changes provide a clearer picture on the long term impact of ISO 9000 adoption on firms' supply chain efficiency in the fashion supply chain. For the results of the *performance-industry-matched* group from the year prior to ISO 9000 implementation (year -2) to the year of post-certification (year 1), the median (mean) cumulative changes in operating cycle is -13.24 days (-18.44 days), which is significant at the 1% (1%) level. More than half of the sample firms (63%) experience a shorter operating cycle, which is significantly higher than 50% ( $p < 0.01$ ). The median (mean) abnormal change in inventory days is -10.31 days (-14.00 days), which is significant at the 1% (1%) level, with over 62% of the sample firms shortened their inventory days. The median (mean) abnormal change in accounts receivable days is -1.05 days (-9.95 days), which is significant at the 5% (5%) level. More than half of the sample firms (51%) experiencing a shorter accounts receivable days.

For the results of *performance-industry-matched* group from year -2 to year 2, the median (mean) cumulative changes in operating cycle is -14.13 days (-11.59 days), which is significant at the 1% (1%) level. About 63% of sample firms experience a shorter operating cycle, which is significantly higher than 50% ( $p < 0.01$ ). The median (mean) abnormal change in inventory days

is -9.69 days (-11.00 days), which is significant at the 1% (1%) level, with over 63% of the sample firms shortened their inventory days. The median (mean) abnormal change in accounts receivable days is -1.56 days (-1.78 days). More than half of the sample firms (54%) experiencing a shorter accounts receivable days.

For the results of *performance-industry-matched* group from year -2 to year 3, the median (mean) cumulative changes in operating cycle is -15.12 days (-17.24 days), which is significant at the 1% (1%) level. About 67% of sample firms experience a shorter operating cycle, which is significantly higher than 50% ( $p < 0.01$ ). The median (mean) abnormal change in inventory days is -9.47 days (-14.48 days), which is significant at the 1% (1%) level, with over 65% of the sample firms shortened their inventory days. The median (mean) abnormal change in accounts receivable days is -4.32 days (-7.56 days). More than half of the sample firms (61%) experiencing a shorter accounts receivable days.

The results of abnormal supply chain performance are similar between the *performance-industry-matched* group and the *performance-industry-size-matched* group, except for the accounts receivable days results. In both matching groups, the impacts of ISO 9000 on operating cycle and inventory days are statistically significant. Hypotheses H1a and H3a are supported. However, the abnormal impact of ISO 9000 on accounts receivable days is not statistically significant in the *performance-industry-size-matched* group. This mixed results suggest that accounts receivable days is sensitive to firm size; hypothesis H2a is only partially supported.

The overall results are robust between the three-year, four-year and five-year cumulative results, revealing that the impact of ISO 9000 on supply chain performance is long lasting in fashion and textiles industries. The length of shorten operating cycle is longer in the period from year -2 to year +3, which means the impact of ISO 9000 is long lasting. The certified textiles related firms improve

Table 2. Abnormal operating cycles of sample firms for the ISO 14000 adoption in three-year period (year -2 to year 1), four-year period (year -2 to year 2), and five-year period (year -2 to year 3), based on performance-industry-matched and performance-industry-size-matched matching;  $p < 0.1^*$ ;  $p < 0.05^{**}$  for one-tailed tests; <sup>a</sup> in percentage

Performance-industry-matched												
year -2 to year 1			year -2 to year 2			year -2 to year 3						
Performance measures	N	Mean	Median	% negative	N	Mean	Median	% negative	N	Mean	Median	% negative
<b>Operating Cycle</b>	45	-13.36	-11.15	64.00	41	0.30	-3.93	59.00	33	-5.49	-4.37	55.00
<i>t/z statistics</i>		-1.79 **	-2.13 **	-1.79 **		0.04	-0.93	-0.94		-0.82	-0.87	-0.35
<b>Inventory Days</b>	45	-6.36	-4.86	64.00	41	-3.76	-6.96	61.00	33	-6.22	-4.17	58.00
<i>t/z statistics</i>		-1.45 *	-1.93 **	-1.79 **		-0.63	-1.29	-1.25		-1.10	-1.39 *	-0.70
<b>Accounts Receivable Days</b>	45	-15.45	-2.54	62.00	41	-2.84	-0.14	51.00	33	-3.90	-2.33	58.00
<i>t/z statistics</i>		-2.05 **	-1.95 **	-1.49 *		-0.54	-0.16	0.00		-0.95	-0.78	-0.70
Performance-industry-size-matched												
year -2 to year 1			year -2 to year 2			year -2 to year 3						
Performance measures	N	Mean	Median	% negative	N	Mean	Median	% negative	N	Mean	Median	% negative
<b>Operating Cycle</b>	40	-3.21	-2.99	55.00	37	2.71	-4.66	59.00	32	-4.66	-3.03	53.00
<i>t/z statistics</i>		-0.68	-0.91	-0.47		0.37	-0.46	-0.99		-0.68	-0.64	-0.18
<b>Inventory Days</b>	40	-4.78	-2.01	55.00	37	-2.26	-2.64	59.00	32	-5.08	-3.51	56.00
<i>t/z statistics</i>		-1.15	-1.25	-0.47		-0.33	-1.12	-0.99		-0.89	-1.18	-0.53
<b>Accounts Receivable Days</b>	40	1.63	3.74	40.00	37	5.03	3.99	43.00	32	-1.01	-1.92	56.00
<i>t/z statistics</i>		0.45	-0.90	1.11		1.87	1.49	0.66		-0.34	-0.51	-0.53

their supply chain efficiency continuously in the five-year period.

Table 2 presents the results of ISO 14000 matching groups. The *performance-industry-matched* group from the year -2 to year 1, the median (mean) cumulative changes in operating cycle is -11.15 days (-13.36 days), which is significant at the 5% (5%) level. More than half of the sample firms (64%) experience a shorter operating cycle, which is significantly higher than 50% ( $p < 0.05$ ). The median (mean) abnormal change in inventory days is -4.86 days (-6.36 days), which is significant at the 5% (5%) level, with over 64% of the sample firms shortened their inventory days. The median (mean) abnormal change in accounts receivable days is -2.54 days (-15.45 days), which is significant at the 5% (5%) level. More than half of the sample firms (62%) experiencing a shorter accounts receivable days.

The abnormal median changes of all three supply chain performance indicators are negative in the four-year (from year -2 to year 2) and five-year periods (from year -2 to year 3). However, they are not statistically significant in nearly all the statistical tests. Such results suggest that the impact of ISO 14000 on fashion and textiles related firms' supply chain efficiency is temporary. This impact diminished after year 1. We could not found significant impact of ISO 14000 on the three indicators in the *performance-industry-size-matched* group. These mixed results suggest that hypotheses 1b, 2b and 3b are not supported. The adoption of ISO 14000 only has some short-term impact on supply chain efficiency but it is not enduring. We will discuss these findings in the discussion section.

## **MODERATING FACTORS OF ISO 9000 ADOPTION IN THE FASHION SUPPLY CHAIN**

We try to provide a deeper understanding on the association between ISO 9000 adoption and the

improvement in operating cycle. We only focus on ISO 9000 because we reveal no significant change on operating cycle from ISO 14000 adoption in the previous section. We construct a regression model to study how firm-level characteristics affect the impact of ISO 9000 on abnormal operating cycle over the five-year event period (from year -2 to year 3). We use firm size, and original financial performance of the ISO 9000 certified firms as the control factors. The abnormal performance in operating cycle of ISO 9000 certified firms could be more positive for larger firms. Larger firms normally have more resources for hiring external consultants, providing additional training, and dedicating additional manpower to facilitate the implementation process of ISO 9000. We use firms' total assets to represent the firm size.

We also control the financial performance of the firm because firms that are more profitable are more efficient in operations. As ISO 9000 adoption calls for improvement in a firm's operational efficiency, firms that are more efficient may be able to implement the system more effectively than less efficient firms. Firms that are more profitable could also have more resources for ISO 9000 implementation. We estimate the financial performance of a firm as the firm's ROA in year 3.

We include three independent variables into the regression model, which are labour intensity, R&D intensity, and time of ISO 9000 adoption. The arguments and predictions of the three indicators are as follows:

Independent variables:

1. *Labour intensity*: The abnormal changes in operating cycle could be more positive (shortened length of operating cycle) in more labour intensive firms. It is because these firms might have higher need in standardizing their operation procedure to ensure the production processes is smooth. The calculation of labour intensity is the number of employee over firm's total assets.

2. *R&D intensity*: Industries with higher R&D intensity would normally mean that they face more rapid technological and product changes. There are thus more opportunities for new product development for high-technology textiles firms. This allows them to implement efficient process designs to a greater extent. Therefore, the positive impact of ISO 9000 on abnormal operating cycle could be higher in firms with higher levels of R&D intensity. We measure R&D intensity as R&D expenses over sales.
3. *Time of ISO 9000 adoption*: According to the institutional theory, early adoptions of organizational innovations are motivated by technical and economic needs (DiMaggio & Powell, 1983), while later adopters respond to the growing social legitimacy of the innovations as taken-for-granted organizational structure improvements (Westphal, Gulati, & Shortell, 1997). ISO 9000 is a well-recognized example of institutionalized management practice (Guler, et al., 2002). Therefore, we predict that early adopter of ISO 9000 could have larger improvement in operating cycle than the later ones, as the

formers are motivated by technical benefits of ISO 9000.

Table 3 presents the cross-sectional regression results. We use the abnormal performance in operating cycle of the *performance-industry-matched* group for analysis. For this model, the *F*-value is 2.89, which is significant at the 1% level. The adjusted *R*<sup>2</sup> values is 8.0%, which is comparable to those observed in previous studies that attempted to use cross-sectional regression models to explain abnormal performance (e.g., Hendricks & Singhal, 2008).

We find that firm size and firm labour intensity do not moderate the association between ISO 9000 adoption and abnormal operating cycle. Fashion and textiles firms' ROA is negatively related ( $p < 0.01$ ) to abnormal operating cycle. It means textiles firms that are more profitable can further shortened their operating cycle time from ISO 9000 adoption. The coefficient of R&D intensity is negatively and statistically significant at the 1% level ( $p < 0.01$ ). It means that high technology fashion and textiles firms could benefit more from the reduction of operating cycle time after ISO 9000 adoption. The coefficient of time of adoption is positive and statistically sig-

*Table 3. Estimated coefficients (t-statistics in parentheses) from regression of abnormal operating cycle change from year -2 to year 3*

<b>Independent Variables</b>			
<i>Intercept</i>	-5879	(-1.684)	**
<i>Firm size +</i>	0.001	(0.663)	
<i>ROA +</i>	-108.259	(-2.911)	***
<i>Labour intensity</i>	200.802	(0.939)	
<i>R&amp;D intensity +</i>	-61.501	(-2.463)	***
<i>Year of ISO 9000 adoption +</i>	2.940	(1.683)	**
<b>Number of observations</b>		109	
<b>Model F value</b>		2.89	***
<b>R squared (%)</b>		12.2	
<b>Adjusted R squared (%)</b>		8.0	
Note: Significance levels (One-tailed tests) of independent variables: $p < 0.05 < **$ ; $p < 0.01 < ***$			

nificant at the 5% level. Late adopters of ISO 9000 obtain less abnormal benefit from ISO 9000 adoption (i.e. they have longer abnormal operating cycle compared to early adopters). It shows that the institutionalization of ISO 9000 in general manufacturing industries also appear in the fashion supply chain.

## **DISCUSSION AND SUMMARY**

This study provides empirical evidence on the impact of QMS and EMS adoption on firms' supply chain performance in the fashion supply chain. Based on the 248 ISO 9000 and 61 14000 certified publicly-listed fashion or textiles related firms in the U.S., we find that ISO 9000 adoption has a statistically significant positive impact on operating cycle, inventory days and accounts receivable days. Depending on the methods used to estimate abnormal performance, the median abnormal improvement in operating cycle ranges from 7.18 days to 15.12 days shorter than non-certified firms over a five-year period. In other words, the certified firms save up to 15.12 days to turn raw materials into cash payment from their customers. This suggests that the certified fashions or textiles firms become a more efficient node in the fashion supply chain.

The median improvement in inventory days ranges from 5.46 days to 7.18 days over a five-year period. The results show that the improvement in inventory days is the major reason of the overall improvement in operating cycle. QMS certified firms in the fashion supply chain are more efficient in their production process and inventory management, resulting a shorter inventory days compared to non-certified competitors.

The median improvement in accounts receivable days of *performance-industry-matched* group is 4.32 days. The magnitudes of abnormal changes in accounts receivable days are generally smaller than the changes in inventory days. There are also mixed results of abnormal changes in accounts

receivable days between the two matching groups, which mean the impact of ISO 9000 is less significant on this indicator. The possible reason is that accounts receivable days is sensitive to firm size, therefore, the impact of ISO 9000 on it was taken away after firm size had been controlled.

In the cross-sectional analysis, we find that high-tech firms could achieve better supply chain performance than low-tech firms in the fashion supply chain. These high-tech firms in the fashion supply chain are the firms with advanced manufacturing techniques and technology. The results show that the adoption of ISO 9000 could help these firms to further improve their utilization of technological resources and thus improve their supply chain operations. The late adopters of ISO 9000 in the fashion supply chain obtain much less supply chain benefits than the early adopters do. The coefficient is about 2.9, which means the abnormal operating cycle is 2.9 days longer for every one-year delay in adoption. This result supports the institutional explanation of ISO 9000 adoption in the operation management literature, suggesting that the late adopters are not driven by the technical efficiency of a management practice. Another possible explanation is that there are less inefficient non-certified firms in the industry in the later years, therefore the comparative improvement in supply chain efficiency become much less significant.

### **Why EMS has Just Limited Impact on Firms' Supply Chain Efficiency?**

We also investigated that the abnormal changes in operating cycle, inventory days, and accounts receivable days in ISO 14000 certified firms in the fashion supply chain. However, such change is not long lasting (only in year -2 to year 1 period) and only appears in the *performance-industry-matched* group. One possible reason is that some ISO 14000 certified firms sample have already ISO 9000 certified prior the adoption of ISO 14000. Therefore, the incremental benefits

from ISO 14000 are smaller than their first ISO 9000 certification. It is also possible that there are only limited number of ISO 14000 firms in our sample to reveal any statistical significance of ISO 14000 impact. In addition, a previous study showed that ISO 9000 is partly driven by bilateral trade relationships in the supply chain, while ISO 14000 is by culture (Albuquerque, et al., 2007), it could be the reason why ISO 9000 could show more benefits in supply chain efficiency comparatively. Although both certifications are being used as supplier selection tools, only ISO 9000 shows strong and significant impact on firms' supply chain performance. The results suggested that the adoption of QMS is likely to be the primary "glue" that makes the nodes in the fashion supply chain works more closely with each other and thus the whole supply chain could become more efficient.

### **Managerial Implications to Fashion and Textiles Manufacturers**

Fashion and textiles firms, which have not obtained ISO 9000, should consider such adoption. It is obvious that ISO 9000 adoption is necessary for improving firms' supply chain efficiency. Our cross-sectional analysis results further suggest that labour intensity is not a moderating factor of ISO 9000 impact on supply chain efficiency. It means that it works not only labour intensive textiles firms (which are very common in textiles industry), but also highly automated textiles firms. For textiles firms with higher R&D intensity, which often have faster new product development and shorter product life cycles, could benefit more from being certified by ISO 9000. In other words, firms that have already adopted ISO 9000 can further improve their supply chain efficiency, by implementing a corporate strategy with higher R&D investment for new products. The late adopters of ISO 9000 should also pay attention to the motivation in obtaining this certification. If the motivation is largely institutional (i.e. by responding to customer requirement), instead

of improving firms' operational efficiency, such firms received much less supply chain benefits.

Although we could not reveal a consistent and long-term impact from the ISO 14000 adoption on supply chain performance in this study, we could not rule out the possibility that there are other potential benefits for being certified by ISO 14000. Given the large amount of pollutant emissions and high level of energy and water consumptions during textiles manufacturing processes, the benefits of ISO 14000 might be more on firms' cost efficiency. Therefore, the results should not be interpreted as the lack of usefulness of ISO 14000. Besides, the impact of ISO 14000 on firms' supply chain efficiency on other manufacturing industries might be exists. The mixed results of ISO 14000 in this study should not be implied that ISO 14000 has no impact to general manufacturing industries.

### **LIMITATIONS AND FUTURE RESEARCH**

This study is the first exploratory empirical work focuses on the QMS and EMS adoption in the fashion supply chain and its impact of supply chain performance. There are some limitations should be addressed in future research. First, this study has only included the fashion and textiles related firms in manufacturing industries. However, fashion retailers are also key players in the fashion supply chain. They might have dominating negotiation power over their suppliers in the supply chain. The power between the buyer-supplier relationships may have strong moderating effects on the abnormal performance. Second, we only included all the publicly listed textiles related firms in the fashion supply chain of the U.S. However, most fashion supply chains involve significant number of suppliers from developing countries (e.g., China and India). The impact of ISO 9000 on the textiles firms from developing countries might not be the same as the firms in the U.S.

The textiles firms in developing countries might adopt the standard not because of its technical efficiency, but for the legitimacy from its customers in developed countries. Therefore, a replication of the current study under developing countries context could provide the complete picture of the impact of QMS and EMS in the fashion supply chain. Finally, this study only explored the impact of QMS and EMS on supply chain performance. Further studies should be made with the focus on firms' profitability and cost efficiency, to provide additional evidence of the usefulness of these certifications in the fashion supply chain.

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## **KEY TERMS AND DEFINITIONS**

**ISO 9000:** A quality management system developed by ISO in 1987, and its latest version is ISO 9000:2008.

**ISO 14000:** An environmental management system developed by ISO in 1996, and its latest version is ISO 14000:2004.

**Operating Cycle:** It is the time required from turning raw materials into products to customers pay for their accepted products, it is also called cash-to-cash cycle.

**Inventory Turnover:** It is the ratio showing how many times a firm's inventory is sold and replaced in one year.

**Inventory Days:** It is the average number of days goods remain in inventory before being sold to customers.

**Accounts Receivable Turnover:** It is the ratio of the number of times that accounts receivable is collected in one year.

**Accounts Receivable Days:** It is an average number of days a firms needed to receive payments from their customers.

## Chapter 7

# Strategic Partnerships in the U.S. Textile and Apparel Industry: Exploring Value and Fairness

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### **ABSTRACT**

*This chapter provides a comprehensive investigation of strategic partnership social value, economic value, relational distance and fairness. Application of social exchange, transactional cost analysis, and distributive justice theories provides the theoretical basis for this research. Results from qualitative interviews with U.S. textile industry executives, a national quantitative questionnaire and case study research with a successful company that engages in strategic partnerships provide a multi-faceted understanding of strategic partnerships. While social and economic value were reported to occur in strategic partnerships, the relationship between social value and fairness was the only relationship found to be statistically significant ( $r = .68$ ,  $P < .001$ ). Implications for industry and future research possibilities are discussed.*

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## **INTRODUCTION**

Many members of the textile complex use strategic partnerships with other textile complex members as a way of improving performance. A strategic partnership is an alliance between two or more firms in which resources, capabilities, and core competencies are combined to pursue mutual benefits (Hitt, Ireland & Hoskisson, 1997). The goals of these partnerships are for both members to become more focused, flexible, and market driven (Corey, 1999). Strategic partners can be suppliers, customers, complementors, competitors or companies outside the industry. Such arrangements have resulted in increased commonality of partners as both competitors and complementors to each other. Over 50 percent of organizations surveyed in one multi-industry study indicated they partnered with their competitors. (Parise & Henderson, 2001). A strategic partnership is more comprehensive than programs such as quick response or vendor-managed inventory; it encompasses the production and distribution functions of these programs and broadens the spectrum of shared responsibility by including joint pre-production functions such as research and development, and post-production functions such as combined sales and marketing, and shared risk on new or failed products. Strategic partnerships are also viewed by some channel members as preferable to consolidations because they provide the benefits of added industry expertise and resources to members without the financial and legal complexities involved with corporate mergers or acquisition (Gassenheimer & Houston, 1998).

If conducted correctly, strategic partnerships can be extremely beneficial to participants: companies with successful partnerships receive a 50 percent higher return on investments on those partnerships than the average ROI from the top 2,000 companies in the world; however a drawback is the high risk involved. Failure rates for strategic partnerships are in the 60-70 percent range (Ertel, 2001). If companies know what factors contribute

to successful strategic partnerships, such factors can be emphasized in the development stages, thus reducing the number of failed partnerships and increasing the benefits to all parties involved.

Research in the field of strategic partnerships has been ongoing for decades in a wide variety of industries. Mallen (1963) was one of the first theorists to describe the relationships between distribution channel members in his theory of retailer-supplier conflict, control, and cooperation. In this theory he posited that the various members of a distribution channel operated under a constantly changing set of conflicting and cooperating objectives, and if the conflicting objectives outweighed the cooperating objectives, channel effectiveness was diminished. An example of conflicting objectives is an ordinary sales transaction between members: the seller benefits from obtaining the highest sales price possible, while the buyer benefits from the lowest sales price. These conflicting objectives provide the basic source of conflict between channel members. As a means of overcoming this inherent conflict, the author advocates cooperation between a supplier and its retailers. This can be achieved by having the supplier do things for the retailers that it already does for itself, such as selling, advertising, training sales associates, planning and promoting for retailers. Another method to achieve cooperation is to avoid associations with potentially uncooperative channel members. Mallen (1963) states that by viewing the distribution channel as one vertically integrated firm and having optimum cooperation among members, channel members will experience consumer and profit satisfaction.

Strategic partnerships may vary in their degree of partner collaboration and added value. Maynard (1996) depicts the entire spectrum of business relationships on a diagonal scale, from external, tactical transactions such as traditional "arm's-length transactions" requiring low collaboration and providing low added value to partners at one extreme to internal growth relationships, such as those in corporate subsidiaries requiring high col-

laboration and providing high added value on the other extreme. Strategic partnerships are located in the middle of the spectrum, between regular selling and licensing arrangements on the lower end and the fusion of two companies at the higher end. Such partnerships require a moderate degree of collaboration between partners and provide moderate added value. Larson (1992) examined social control in dyadic strategic partnerships organized by high-growth entrepreneurial firms using an inductive field study method. Findings indicated that the observed firms had relatively stable, sustained relationships that were characterized by multiple transactions and a high degree of cooperation and collaboration among partners. The partnerships were controlled by social controls that evolved from norms of partner trust and reciprocity.

Graham, Daugherty, and Dudley (1994) investigated the relationship between the length of time partnerships had been in existence and the degree of success in implementing specific purchasing strategies and achieving desired outcomes. In five of six instances, a significant positive relationship was found between length of time the partnership had existed and success in purchasing strategy implementation. Partnership duration was also found to have an effect on success in achieving desired outcomes. Morgan and Hunt (1994) found in their empirical survey that relationship commitment and trust development are integral to the overall network performance, and develop a commitment-trust theory which suggests that relationship commitment and trust develop when firms care for their relationships by 1) providing resources, opportunities and benefits that are superior to the offerings of alternative partners, 2) maintaining high standards of corporate values and allying oneself with exchange partners having similar values, 3) communicating valuable information, and 4) avoiding taking advantage of their exchange partners. The relationships that are formed based on commitment-trust will have

a sustainable competitive advantage over firms without similar relationships.

Based on their analysis of 80 partnerships, Ellram and Hendrick (1995) developed five conclusions on the subject of partnerships: 1) partnering arrangements between buyers and suppliers are generally viewed positively by both members, 2) buyers and supplier had similar perception of their partnership for a number of key factors, including having a futuristic orientation, a win/risk sharing approach, and excellent communication, 3) both parties wanted to continue to improve the partnership in many ways, even though the partnership was viewed very favorable, 4) those aspects of the partnership that could be improved were widely agreed upon by both partners, and 5) there was agreement between partners regarding the level of desired improvement. Sigaw and Simpson (1998) examined the effects of a supplier's market orientation on its dyadic relationship with its distributor. Results suggested that supplier's market orientation affected its distributor's market orientation and commitment to the relationship. In addition, the distributor's market orientation was found to have a direct effect on its trust and perception of cooperative norms. Relationship variables such as trust, cooperative norms and commitment were also found to have a direct effect on the distributor's satisfaction with its financial performance.

The purpose of this study was to examine the structure and nature of strategic partnerships in the U.S. textile industry, with specific objectives to 1) to obtain information about textile companies who were engaged in strategic partnerships using qualitative and quantitative methods; 2) to create a descriptive profile of these strategic partnerships, and 3) to investigate the relationship between social value, economic value, relational distance and fairness, each of which is discussed in greater detail in the following section.

## **Theoretical Frameworks**

Social Exchange Theory. In order to examine social value in strategic partnerships, it is important to understand its basis through an examination of social exchange theory. Thibaut and Kelley's (1959) social exchange theory was originally developed as a theory for the social psychological field, but has numerous practical business applications. Social exchange is particularly useful because it can be used to explain the nature of group relationships in dyads such as the ones that we are discussing in this chapter, or it can be expanded to more complex groups such as entire networks. The primary principle of social exchange theory is that "...the existence of the group is based solely upon the participation and satisfaction of the individuals comprising it..." (Thibaut & Kelley, 1959). The theory states that the value of a relationship between two members is characterized by each party's satisfaction with the exchange situation, using a behavioral context. Members base their level of satisfaction with a) the cooperative nature of the relationship, b) the compatibility of goals, and c) a comparative evaluation of relational value against available alternative relationships. When member satisfaction declines below acceptable levels and viable alternative relationships exist, parties reassess their dependence in the declining relationship before they express their concerns and/or determine whether to retain the relationship (Gassenheimer & Houston, 1998).

Many other researchers have used social exchange theory as a guide for their research projects. Bagozzi (1974) incorporated elements of social exchange theory into a marketing exchange environment. Building on previous definitions of exchange that had not yet been developed into formal theory, he created a theory of the exchange system, in which he defined the exchange system as "...a set of social actors, their relationships to each other, and the endogenous (e.g., one actor's persuasiveness or social influence) and endogenous (e.g., social norms, availability of

alternatives) variables affecting the behaviors of the social actors in those relationships." Examples of social actors include sales associates, advertisers and consumers. Relationships are the roles each social actor has. Endogenous and exogenous variables are causal concepts attached to both of the actors and their relationships that influence the decisions of the actors to respond.

The use of social exchange theory in business research experienced a period of decline after the early 1970s, only to have a resurgence of popularity beginning in the early 1980s by a core group of researchers that has refined the theory to better reflect the current competitive business environment. In their article, Dwyer, Schurr and Oh (1987) outlined a framework for developing buyer-seller relationships. They separated transactions between buyers and sellers into two categories: discrete transactions and relational exchange. In discrete transactions, no contact occurs between the participants other than the exchange of money for goods or services. By contrast, in relational exchange, transactions occur over time and each transaction is viewed in terms of its history and potential future. The future relationship is supported by statements and assumptions in combination with mutual trust and planning. A non-economic satisfaction and social exchange develops between the members. The authors characterize such relationships as moving through five general phases, including 1) awareness, 2) exploration, 3) expansion, 4) commitment, and 5) dissolution. The authors propose an untested model that illustrates the relationship development process, including relationship phases, subprocesses for deepening dependence and phase characteristics.

Anderson and Narus (1984) used social exchange theory to develop a model of distributor-manufacturer working relationships based on the distributor perspective. Their model included constructs of working relationships including manufacturer control, conflict, satisfaction, communication, outcomes given available alternatives

and outcomes given previous experience. The first four behavioral constructs had been taken from the channels of distribution literature, while the last two constructs were adapted directly from the first writings from Thibaut and Kelley (1959) about social exchange theory. Their limited initial test showed support for the model and that the two constructs adapted from social exchange literature gave significant explanation for the behavioral constructs of the model. Anderson and Narus (1990) were able to draw upon their previous theoretical development and use it as a guide for an empirical study based on social exchange principles. The researchers again incorporated a construct of social exchange theory known as the “outcomes given comparison level” in their study of distributor and manufacturer firms. The outcomes given comparison level construct is a firm’s calculation of the results (rewards minus costs incurred) from a strategic partnership compared to expectations based on present and past experience with similar partnerships, and knowledge of the partnerships among other companies. Their results indicated that outcomes given comparison and relative dependence (also a construct of social exchange theory) together with communication emerge as key constructs in the explanation of manufacturer and distributor working partnerships.

Hallen and Johanson (1991) used social exchange theory to investigate interfirm adaption in business relationships (e.g., suppliers adapting to the needs of specific important customers, or customers adapting to the capabilities of specific suppliers). Their results supported the hypothesis that interfirm adaptations are elements in a social exchange process. These adaptations are made in part unilaterally, to compensate for an imbalance in the interfirm power relationship, and partly as reciprocal demonstrations of commitment and trust in the relationship. Nam and Kim (1999) conducted a study that used partnership quality as a key predictor for the success of information systems (IS) outsourcing partnerships, using a

social exchange perspective on partnership quality. Their findings indicated that partnership quality was not only necessary to assure high-quality partnerships, but also functioned as a key predictor for managing IS outsourcing partnership satisfaction for users and businesses. In a series of articles (Miller, 1998; Miller & Kean, 1999) Miller has used social exchange theory to effectively examine consumer and retailer exchange in rural communities. In the first study, Miller (1998) found that reciprocity (i.e. the degree to which individuals expect cooperative action in exchange transactions) was significantly higher in rural communities that had a higher level of consumer spending within the community marketplace. In a second article, Miller and Kean (1999) suggested that triangulation (use of complimentary research methods such as qualitative and quantitative for validation purposes) was important for obtaining a credible assessment of the importance of perceived reciprocity in rural marketplace exchange. Results further indicated that there was an inverse relationship between reciprocity in the marketplace and with retailers’ level of satisfaction with operating a business in the rural community.

Transactional Cost Analysis. While social exchange examines the non-tangible aspects of organizational relationships, transactional cost analysis (TCA) describes the economic component of a strategic partnership. Transaction costs take the form of direct or opportunity costs that occur as a result of doing business with a particular exchange partner. The unit of analysis is the individual exchange transaction, which is evaluated with the understanding that previous transactions and the anticipation of future transactions may affect the way the individual transaction is structured (Rindfleisch & Heide, 1997). TCA has been applied to several different marketing areas, including vertical integration decisions, strategy for foreign market entry, industrial purchasing strategy and distribution channel management. TCA is rooted in the writings of the economist

Commons, whose writings date back to 1924 and state that transaction is the basic unit of analysis. The theory places great importance on identifying those critical dimensions that differ between different types of transactions. The critical dimensions include, but are not limited to: 1) transaction frequency, 2) transaction uncertainty, and 3) the type and degree of “asset specificity” involved in supplying the good or service in the transaction. Asset specificity refers to the extent to which an asset may be redistributed for other uses by other individuals without losing any of its productive value. This last dimension is given the most significance in TCA (Williamson, 1991).

In a study of Canadian export firms, Klein and Frazier (1990) used a transaction cost analysis model to explain channel degree decisions, or what degree of forward integration firms should choose when entering foreign markets. Strong support was found for their model, indicating that the ability of the market to limit opportunistic tendencies of outside intermediaries is a major factor in determining level of forward integration into a foreign market- when contract enforcement cannot be relied upon in the new market; different levels of forward integration are more likely alternatives. Adler and Scherer (1998) used a sample of contractors drawn from a population of contracts granted by the United States Air Force Material Command and public sales data for each sample contractor to examine whether transaction cost dimensions (asset specificity, uncertainty and contract incompleteness) could reliably predict the type of contract (cost-plus fixed fee, firm fixed price or incentive) used in an economic exchange. Results indicated that two transaction cost dimensions, Contract Impediments and Contract Knowledge are critical dimensions for selecting a contract alternative. Contract Impediments illustrates the difficulty in adequately developing contractual requirements, while Contract Knowledge represents the relationships between buyer and seller necessary to determine what is required to carry out the

contract. The more contact time between buyer and seller, the more likely the contract conditions show new work design, development or testing.

Distributive Justice. The concept of fairness can best be understood through the theory of distributive justice. Distributive justice describes strategic partnership members’ perceptions of partnership fairness. Distributive justice is defined as an evaluation of the channel members’ relative rewards or losses, compared to its contributions and inputs (Kumar & Scheer, 1995). Distributive justice theory was first developed in the sociological and psychological literature in the early 1970s, and its use in business-to-business applications is still evolving. An early researcher in the field of distributive justice, Deutsch (1975) defined the concept as being “concerned with the distribution of the conditions and good which affect individual well-being”. Distributive justice consists of the treatment of all people so that all receive outcomes that are proportional to the inputs they provided as equals, according to their needs, ability, efforts, accomplishments, so that they have equal competitive opportunity free from favoritism and discrimination, according to the supply and demand of the marketplace, requirements of the common good, principles of reciprocity and so that no individual falls below a certain level (Deutsch, 1975).

According to Cook and Hegtvedt (1983), distributive justice has two main components: fair allocation and just compensation, and is closely related to the concepts of equity (fair exchange) and procedural justice (fair procedures). In their research the authors cite Eckhoff’s work which makes a distinction between the mutually beneficial, two-way transfer of valued resources (also known as reciprocity) and the one-way distribution of resources across a category of recipients (also known as allocation). It is this second type of distribution, allocation, which is the focus of distributive justice. Cook and Hegtvedt (1983) consider allocation to occur when an allocator distributes valued rewards, resources, rights,



obligations, etc. to an array of recipients; either directly via an exchange relationship with the distributor or indirectly with each other. A combination of exchange and allocation activities may be combined within the exchange framework. The just compensation portion of distributive justice is concerned with issues such as the fairness of the allocation of benefits together with the allocation of negatives for a more complete theory of allocation within the exchange framework. Kumar and Scheer (1995) studied the role of supplier fairness (justice) in developing long-term relationships between large automotive suppliers and small resellers (dealers) in the United States and Holland. Their study examined two types of fairness: distributive fairness and procedural fairness. The first type is the reseller's perception of the fairness of earnings and other outcomes that it receives from its relationship with the supplier. The authors conceptualized distributive fairness as a firm's comparison of actual outcomes to perceived deserved outcomes. Procedural fairness is fairness of a supplier's procedures and processes in relation to its resellers. Results indicated strong support that resellers' perceptions of both distributive and procedural fairness enhanced relationship quality.

### **Qualitative Research**

Qualitative interviews of seven textile and apparel executives provided an in-depth understanding of how strategic partnerships in the U.S. textile and apparel complex function. The textile complex is defined as "the industry chain from fiber to fabric, through end uses of apparel, interior furnishing and industrial products" (Dickerson, 1999). Seven interviews were conducted with domestic textile complex executives (director, vice president or president) from companies with headquarters in the southeastern United States that conducted business in the global marketplace. The companies in the sample included a fiber manufacturer, textile manufacturers, and apparel (sock, childrenswear and jeanswear) manufacturers.

Using a structured questionnaire developed from an extensive literature review, topics included the existence and frequency of partnerships, the nature of strategic partnerships based on the Lorange and Roos model (1992) asking about sharing of people, capital, private company information, office space, risk, exclusivity in products or prices, and also about economic and social benefits, the role of the retailer and the future of strategic partnerships in each firm's future. Table 1 lists the interview questions used during each of the interviews.

Partnerships may occur at different stages of the production process. The upstream stage or early phases of production chains includes activities such as engaging in joint research and development. The goals of this type of partnership are to gain scale advantage for purchasing power or to best utilize human resources through collaboration. A second type of partnership occurs in the downstream stage or final stages of the partners' production and distribution chains. These activities include distribution and marketing. Strategic partnership benefits in this stage are from the combined strength of each partner's offerings resulting in a stronger ability to serve customer needs. A third type of partnership occurred when one partner would combine its upstream strengths with its partner's downstream strengths, resulting in complementary strengths. For example, a textile manufacturer might handle all of the research and development for a new fabric that is then used as a component in an apparel manufacturer's product. The apparel manufacturer then assumes all marketing and promotional expenses for the product. The apparel manufacturer benefits from exclusive access to a new product and the textile manufacturer benefits from increased visibility through marketing and promotions to a wider audience.

Results. The average number of strategic partnerships each respondent company was engaged in was four, while respondents indicated that they were willing to consider entering into

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Table 1. Qualitative Interview Questionnaire

Topic 1: Existence and Frequency	
	1. Does your firm engage in strategic partnerships as a means of maintaining corporate competitiveness?
	2. Does your firm engage in multiple strategic partnerships simultaneously? How many? Why that particular number?
Topic 2: Nature of Strategic Partnerships; Testing of Lorange and Roos (1992) Model	
	1. What elements of a strategic partnership does your company share with its partners? Describe how you employ these elements: a) people, b) capital for R&D or marketing, c) private company information, d) office space, e) risk, f) exclusivity in products or prices, g) others that were not mentioned?
	2. Which of the previous elements would your company never share with a strategic partnership and why?
	3. Do your strategic partnerships only take place with vendors in different areas of the supply chain, or do you partner with companies at the same point in the chain as yourself also? Why?
	4. When creating a strategic partnership, does your firm anticipate the partnership will exist only for the life of the project, or will it be ongoing?
	5. Has your firm had any of its strategic partnerships come to a close? If yes, were the partnerships considered to be successes or failures, or some of each?
	6. If the partnership was considered a success, what steps were taken during the strategic partnership process that were responsible for its success?
Topic 3: Economic and Social Benefits	
	What are the 1) economic and 2) social benefits your company has experienced as a result of its strategic partnerships?
Topic 4: Role of the Retailer in the Supply Chain	
	1. What is the role of the retailer in the textile complex supply chain?
	2. What is the role of the retailer in your firm's strategic partnerships?
Topic 5: Future	
	1. Do you intend to undertake more strategic partnerships in the future?
	2. What role do you see strategic partners and partnerships playing in your business in the future?

additional partnerships if the fit was right. There were several factors that were common among partnerships. The first was partnership structure. Upstream (early phases of the production chain) did occur between respondents. One example of this type of partnership was the fiber manufacturer and its textile manufacturer partner. In this partnership, the textile manufacturer produced samples for a new product the fiber manufacturer was developing at no cost in exchange for exclusive use of the product for a specified period of time once it was perfected. Partnerships were more common in the downstream phases of the production phase through joint marketing. An example of this came from a textile manufacturer respondent who jointly marketed apparel products made by their apparel manufacturer partner using both company's names. Partnerships that had a

combination of upstream and downstream were reported when the childrenswear manufacturer relied on its textile manufacturer partner's technical expertise for innovations in childrenswear fabrics. The responsibility of promoting these innovations to retailers and the public then fell to the childrenswear manufacturer, who used its name recognition and marketing skills to both partners' advantage.

Among partners, sharing of human resources occurred primarily in the form of formal meetings of management and from regular communication between employees of partnering companies. However, at the most integrated partnership, employees of one apparel manufacturer and their fabric manufacturing partner each had designated offices at both partners' buildings. Furthermore, that manufacturer paid for an analyst to work on

their account exclusively at an office located in the headquarters of a major retail partner. Sharing expenses occurred for joint media advertising, in-store fixtures, and signage. Private company information was shared among partners, including sales data, forecasts and expenditures. Shared risk was also a factor, usually in the form of sharing responsibility for products with defective quality or fashion risk. Exclusivity of goods, such as unique colors or patterns for partners, was also a common element of partnerships among those surveyed.

Aspects of social value were important factors in strategic partnerships. One respondent referred to the importance of partnership trust, a component of social value when they said:

*Communication, if it's not honest, is worthless. And honest communication means more than just telling the truth; it means telling the truth or being open about things that aren't being asked. Trust is the key, absolutely the key. Trust comes from honest communication. We have some clients where the trust is there, and as long as you don't miscommunicate, the trust is there forever.*

The importance of partnership fairness was another theme in the interview process. One respondent who was an executive at a childrenswear manufacturer stated this:

*What happened in most cases was the retail community came back to the wholesale community and said, 'Here's what I want now: I want you to ticket our goods, I want you to ship our goods. Before, I would pay freight, and now I want you to pay freight, and before I'd ticket my goods, now I want you to ticket our goods, so here's the things that I no longer want to do and I want to put on you, plus I want to raise my price.' That's not a good deal. Every time I walked into a partnership meeting, I felt like I was walking out with less clothes and money! If it isn't mutually beneficial, it isn't strategic.*

Members of strategic partnerships received economic benefits from partnership participation such as increased access to complementary resources. Members also received faster access to goods and services from their partners. All respondents agreed that strategic partnerships would grow in importance for their own companies and for the industry as a whole:

*We would like to have all of our key clients on a strategic partnership on the retail side, and more of our suppliers be strategic partners. The reason is because as the market adjusts and changes, with less people in the marketplace, the more strategic partnerships you have the more business you're going to do.*

**Implications.** Results from these seven interviews indicated that the elements of strategic partnerships include 1) the potential for mutual benefits (social and economic) for partners; 2) a common interest in products and markets; 3) corresponding business ethics as a foundation for trust; and 4) an environment for sharing resources and benefits. By understanding these elements and working to cultivate them in their own strategic partnerships, textile complex members may improve their chances of maintaining healthy strategic partnerships.

## **Quantitative Research**

Building on the information taken from the qualitative interviews, a quantitative survey was designed to distribute to the industry at large. The purpose of the quantitative portion of this research project was to develop a profile and examine the nature of strategic partnerships in the textile industry. The survey sample was selected from two national textile industry directories and all companies that met predetermined criteria set by the researchers (which included only manufacturers of apparel fabrics and companies which employed a minimum number of 25 workers) were

included in the sample. Only corporate headquarters were contacted. Because all companies that fit the criteria received a survey, no sampling procedures were used, the entire population was contacted. Of the 510 companies contacted, 93 surveys (18.2%) were returned. Of the returned surveys, 39 respondents (7.6% of the population) indicated that they had strategic partnerships in place. Three surveys were rejected because of incomplete responses, so the sample used in the study was N=36.

Three research hypotheses were tested in this study:

- H1.** There is a negative relationship between economic value and relational distance.
- H2.** There is a negative relationship between social value and relational distance.
- H3.** There is a positive relationship between economic value, social value and fairness, combined with a negative relationship with relational distance and fairness (i.e., as economic value and social value go up and relational distance goes down, fairness goes up).

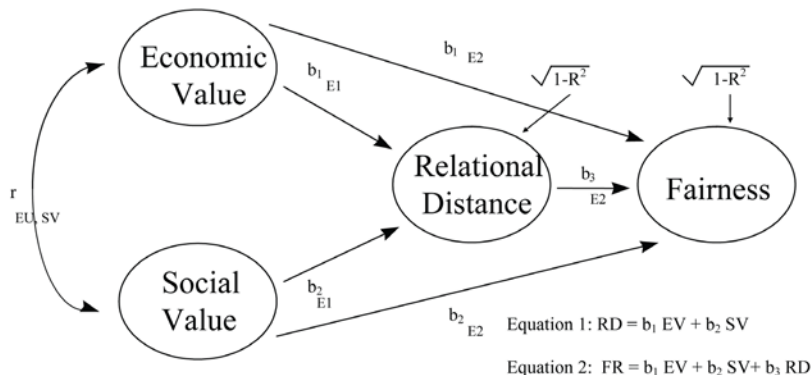
Assumptions included that textile companies engaged in strategic partnerships as a means of

improving their industry competitiveness, that social value and fairness were present in these partnerships, as well as that the criteria used in the study for selecting the population (minimum number of employees, U.S. headquarters, listed as a manufacturer of textiles for apparel products) was representative of the general population of manufacturers of textiles for apparel products.

The path model for this equation was adapted from a theoretical model developed by Gassenheimer and Houston (1998) and is shown in Figure 1. The model combines the importance of the behavioral component of a strategic partnership by using principles adapted from social exchange theory together with an economic component, using principles adapted from transactional cost analysis (TCA), and a fairness component, using principles adapted from distributive justice theory, during the assessment process. Four interrelated variables are present in strategic partnerships: 1) economic value, 2) social value, 3) relational distance and 4) fairness. An explanation of the variables is provided below.

**Economic Value.** Based on principles used in transactional cost analysis (TCA), the economic value of a strategic partnership to a member is determined by calculating expected financial returns and gains to themselves relative to other

*Figure 1. Path Model. Adapted (but different) from: Gassenheimer, J.B. & Houston, F.S. (1998). The role of economic value, social value and perceptions of fairness in interorganizational relationship retention decisions. Journal of the Academy of Marketing Science, 26(4), 322-338*



options. These calculations include comparing the efficiency of transactional options, the cost of exiting the current partnership, and the cost of protecting specific asset investments against potentially opportunistic partners (Gassenheimer & Houston, 1998).

**Relational Distance.** Relational distance is expressed on a continuum of relational characteristics based on the economic and social intent of the exchange. At one extreme lies economic interest. Here exchange transactions are made using market pricing, and the transaction is viewed as a one-time event, so future rewards or obligations are not taken into account. The interest is completely self-serving and there is no concern for the exchange partner, as the transaction is considered to be the economic end of the contact. There is no effort made to develop any social value. At the opposite extreme, social interests take precedence, and the continuance of the relationship is determined by whether group well-being and group goals are being met. The interest is completely group based, rather than focused on individual members' costs and rewards (Gassenheimer and Houston, 1998). Relational distance involves the difference between partners that each member places on the economic and social importance of the partnership.

**Social Value.** Based on the principles of social exchange theory, social value is the extent to which members receive satisfaction from their strategic partnership based on a comparative evaluation of their alternative options for accomplishing the goals of the relationship. In a purely social exchange situation, members of a partnership base their decision whether or not to maintain their relationship based on their satisfaction with the cooperative nature of the partnership, the compatibility of goals and a comparison of the expected social value from alternative partnerships (Gassenheimer & Houston, 1998).

**Fairness.** Based on principles from distributive justice theory, members' perceptions of strategic partnership fairness are a result of each member's

original intent for participating in the strategic partnership, and the value that each member receives from the partnership. Members' perceptions of fairness can be determined by three distribution rules – equity, equality and needs – that illustrate the interdependence in a strategic partnership. The equity rule provides the economic exchange perspective, positing that member outcomes should reflect inputs, and members should strive for equity in order to ensure they give no more to the partnership than they receive. The equality rule provides the social exchange perspective, by giving importance to the harmony and solidarity within the partnership. The need rule illustrates the group-value rationale, and states that the well-being of individuals takes precedence when individuals' needs are perceived to be closely linked to group success (Gassenheimer & Houston, 1998). Not all members of strategic partnerships define and calculate fairness in the same manner, and in order to remain successful, some members may have to compromise their standards somewhat.

The path model in Figure 1 illustrates the two regression equations that were created for this research experiment. The two regression equations tested in this research were:

$$\text{Equation 1: } RD = b_1 EV + b_2 SV$$

$$\text{Equation 2: } FR = b_1 EV + b_2 SV + b_3 RD$$

In the first equation, the exogenous variables EV and SV represent the independent variables economic value and social value, and the endogenous variable RD represents the dependent variable relational distance. All three of these variables are included in the second equation's exogenous variables with the addition to the model of the endogenous variable FR with represents the dependent variable fairness.

A quantitative questionnaire was designed to investigate the relationship between social value, economic value, relational distance and fairness in existing strategic partnerships based on both

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Table 2. Components of Strategic Partnerships

Rank	Partnership Component	Frequency
1 (tie)	Exclusivity in Products and Prices	27
1 (tie)	Shared Technology Between Partners	27
2	Shared Private Company Information	26
3	Sharing of People in Cross-Company Teams	17
4	Shared Financial Risk	16
5	Shared Capital for Research and Development	11
6	Shared Capital for Advertising Expenses	4
7	Shared Office Space in Both Partners' Offices	1

a preliminary qualitative study of textile and apparel industry executives and on key concepts from an extensive literature review. Descriptive data pertaining to strategic partnerships also was collected. The frequency of the components of strategic partnership is provided in Table 2. The content of the variables used in the path model follows. Social exchange literature (Anderson & Narus, 1990; Scheuing, 1994; Shankar, 1994) lists several non-economically derived benefits that should occur in relationships with high social value. These benefits include: feelings of trust, feelings of commitment, sharing of work-related advice/support, empathy/concern for the other's well-being, interest in partners' family or personal life, sharing of humor, looking out for partners'

best interest, interacting with someone you like, feelings of belonging or acceptance, and improved open communications. Each individual benefit was formatted as a seven-point Likert scale, of which respondents were asked to indicate to what degree each social benefit had been added to their business as a result of their strategic partnership. The scores the respondents gave for each social benefit was then summed for a total social value score that was used in data analysis. The social value score had a possible range of ten (no social value) to seventy (high social value). Mean scores for each social benefit are provided in Table 3.

The transactional cost analysis literature (Adler and Scherer, 1998; Klein and Frazier, 1990, and Rindfleisch and Heide, 1997) lists several eco-

Table 3. Social Benefits Received From Strategic Partnership Participation

Rank	Social Benefit Received	Mean Score
1	Sharing of Work-related Advice/Support	5.67
2	Partnership Commitment	5.56
3 (tie)	Concern for Partners' Personal Well-being	5.42
3 (tie)	Partnership Trust	5.42
4 (tie)	Feelings of Organizational Belonging/Acceptance	5.39
4 (tie)	Improved Communication	5.39
5	Interacting With Someone Partner Likes	5.36
6	Concern for Partners' Best Interest	5.11
7	Sharing of Humor or General Conversation	5.03
8	Interest in Partners' Family or Personal Life	4.19

conomic benefits that should occur in relationships with high economic value. These benefits include: increased market share, shortened turnaround time, increased profit, reduced inventory level, reduced work-in-progress, decreased product costs, improved product quality, reduced administrative costs, reduced purchasing costs, and reduced uncertainty of number of orders received. Each individual benefit was formatted as a seven-point Likert scale, of which respondents were asked to indicate to what degree each economic benefit had been added to their business as a result of their strategic partnership. The scores the respondents gave for each economic benefit was then summed for a total economic value score that was used in data analysis. The economic value score had a possible range from nine (no economic value) to sixty-three (high economic value). Mean scores for each economic benefit are provided in Table 4.

The distributive justice literature (Kumar & Scheer, 1995) lists several elements that should occur in fair business relationships. These elements include: fair support of partners, fair receiving of rewards, fair distribution of roles and responsibilities, fair treatment relative to other partner firms, fair contributions to joint marketing efforts. Each element was formatted as a seven-point Likert scale, of which respondents were asked to indicate to what degree their partnership was fair.

The scores the respondents gave for each element was then summed for a total fairness score that was used in data analysis. The fairness score had a possible range of five (no economic value) to thirty-five (high-fairness).

The relational distance variable indicated how differently the respondent viewed the importance their own company placed on social value and economic value from the importance their partner placed on these same issues. Four items were created that asked the respondent to indicate the priority which: 1) their firm placed on the economic benefits of the partnership; 2) their firm placed on the social benefits of the partnership; 3) they believed their partner placed on the economic benefits of the partnership; and 4) they believed their partner placed on the social benefits of the partnership. Each item was formatted as a seven-point Likert scale, the respondent scores and partner scores were each summed individually, and then the partner scores for economic and social priority were subtracted from the respondent scores for economic and social. Any score other than zero indicated that there was relational distance in the partnership, and was recoded as a dichotomous variable that indicated only whether or not relational distance was present in the partnership. The relational distance score had a possible range from zero (no relational distance) to one (relational distance).

*Table 4. Economic Benefits Received From Strategic Partnership Participation*

<b>Rank</b>	<b>Economic Benefit Received</b>	<b>Mean Score</b>
1	Improved Market Share	4.92
2	Improved Product Quality	4.75
3	Increased Profit	4.28
4	Improved Turnaround Time	4.25
5	Reduced Inventory Level	4.08
6	Reduced Product Costs	4.03
7 (tie)	Reduced Purchasing Costs	3.92
7 (tie)	Reduced Work-in-progress Time	3.92
8	Reduced Administrative Costs	3.36

*Table 5. Descriptive Statistics for Continuous-Level Model Variables*

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
Economic Value <sup>a</sup>	37.50	11.99	13	56
Social Value <sup>b</sup>	52.53	11.57	24	70
Fairness <sup>c</sup>	25.94	5.35	14	35

<sup>a</sup>Individual scores consisted of summed responses to nine 7-point Likert-scale questions (Min score =9, Max score = 63).

<sup>b</sup>Individual scores consisted of summed responses to ten 7-point Likert-scale questions (Min score = 10, Max score = 70).

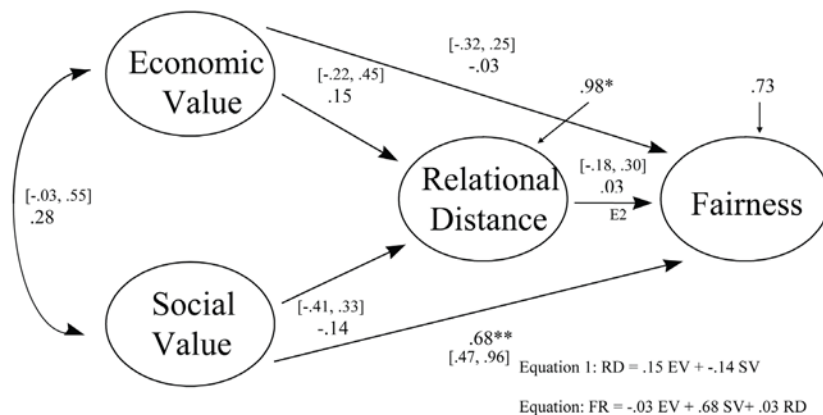
<sup>c</sup>Individual scores consisted of summed responses to five 7-point Likert-scale questions (Min score = 5, Max score = 35).

Table 5 provides the descriptive statistics for each of the continuous variables. For relational distance, which was dichotomized, 41.7% of the companies indicated there was relational distance between them and their strategic partner.

The relationship between the variables used in the path model was analyzed using the Ordinary Least Squares form of regression analysis. Ordinary Least Squares is a common statistical method of determining path coefficients (i.e., standardized regression weights) that best represents the relationship among variables in a recursive path model. To confirm the results of the regression analysis through additional statistical tests, bootstrap analysis was used to estimate the standard errors of the resulting path coefficients and their subsequent 95% confidence intervals. Bootstrap methods use computer-intensive meth-

ods to determine the sampling variation of the parameter estimates by repeated resamplings with replacement from the original sample (Vogt, 1993). Results from bootstrap estimation have proven to be as reliable as those found through normal approximation methods (Peterson, 1991). The benefit in estimating variation via the bootstrap is that the variation in the actual data is used to estimate sampling error rather than estimation based on normal parametric assumptions. The results of the bootstrapping estimation of the 95% confidence intervals are shown on the path model in Figure 2. The path model shows the path coefficients along with each path coefficient's 95% bootstrapped confidence interval. Across the complete path model, the only path found to be statistically significant was the relationship between social value and fairness which had a p-

*Figure 2. Completed Path Model. \*NOTE: Adjusted R<sup>2</sup> was negative. \*\*All coefficients p > .40 except b<sub>2</sub> of Equation #2, p < .0001*





value of less than .0001. To further investigate the observed relationship between social value and fairness found in the full path model, a reduced model estimating only the direct effect of social value on fairness was run. The reduced model indicated that the relationship between social value and fairness was unchanged when relational distance was ignored ( $r=.68$ ).

**Results and Implications.** A statistically significant relationship was found between the social value and fairness variables which indicates that as respondents' perceptions of social value increases, so does their perception of fairness in their strategic partnerships. This may indicate that partners who like doing business with each other feel that they are treated more fairly by their partners despite what their contributions are or what they receive from the partnership. This finding is consistent with the model proposed by Gassenheimer and Houston, but it is interesting to note that the economic value variable did not have a statistically significant relationship with the fairness variable, which they did predict. This may be due to the fact that economic value is a prerequisite to the formation of any strategic partnership. If a company would not enter into a strategic partnership unless economic value was present, the economic value would be constant among all respondents, so it would not appear statistically significant. However, the fact that social value has a positive impact on perceptions of fairness should encourage industry professionals to make non-economic factors a priority of any strategic partnership to ensure its success.

**Limitations and Challenges.** Limitations included replicating concepts of social value, economic value, relational distance and fairness with a new and/or multiple instruments. The lower-than anticipated response rate was also a limitation, although as previously stated, since the number of firms with strategic partnerships in place was unknown, an attempt was made to sample all known partnerships. Also, this model was originally proposed over 10 years ago, so any

future studies must be amended to interpret any significant changes that have occurred during this time period.

## **Case Study**

Finally, a case study of a firm which engages in strategic partnerships provides an applied example of how one successful corporation uses strategic partnerships. Glen Raven Mills is one of the most successful privately-owned textile companies in the U.S., and its owners recognize the importance that strategic partnerships have played in their success over the past 125 years. Once famous for its reputation as the company that invented panty hose in 1953, Glen Raven Mills today is a premier provider of protective fabrics for both outdoor and apparel uses, with such well-known brands as Sunbrella®. Since its founding as the company Altamahaw Mills (Bornemen, 2005), two of the company's manufacturing partnerships have been in existence for 100 and 75 years respectively, (Allen E. Gant, personal communication, January 5, 2006). They have also had the same bank for over 80 years.

Participation in strategic partnerships has enabled the company to create some of its most successful products, which are examples of upstream partnerships discussed by respondents in the qualitative portion of this research project. For example, a partnership that had a research and development component with an automobile manufacturer resulted in a new interior headliner for automobiles that is colorfast and recyclable. Also, the Sunbrella® Graphics System, the industry's first warranty-backed system for faster, more efficient application of graphics to Sunbrella® fabric was developed because of a partnership with some national retail and restaurant chains. Finally, GlenGuard®, a comfortable lightweight fabric that is durable and meets industry standards for flame resistant materials was developed as a result of a partnership with a protective apparel manufacturer ("Case Studies", 2006).

Glen Raven Mills has received economic value from engaging in strategic partnerships. As CEO Allen E. Gant, Jr. said, “Market access needs to be the primary reason for a partnership”, which supports the possibility from the quantitative study that since economic value may be a prerequisite to the formation of any strategic partnership, it is a given and does not have a significant relationship with fairness. Gant expands on the economic value of partnerships:

*Certainly there are opportunities, such as intellectual property, market access, those kinds of things in which you are able to gain a position in the marketplace much quicker if you do it through a partnership than if you try to go in and do it by yourself.*

Social value components such as trust are also present in the partnerships that Glen Raven Mills has:

*Our perspective is, the less we can be partners, then we really can't do business together, and the reason is, if we can't trust each other to take advantage of the marketplace in such a way that it would be good for both parties.*

Gant further credits the social aspects of strategic partnerships when he states:

*You treat customers differently if you think of them in terms of being a partner in your business. That's the way we handle our business (personal communication, 2006).*

**Results and Implications.** Based on their past successes, Glen Raven Mills has seen the benefits of strategic partnerships and been able to capitalize on their relationships for the mutual benefit of both parties. Other companies would be well-advised to follow Glen Raven Mills' lead and work to forge strong ties with partners based on

mutual trust which result in sustained relationships which go beyond normal business transactions.

## **SUMMARY OF RESULTS AND FUTURE RESEARCH DIRECTIONS**

For textile complex industry professionals, these studies underscore the importance of the non-economic aspects of strategic partnerships. Business practitioners will need to include the concepts of trust, communication and shared information and consider whether they are present when determining the economic benefits of entering into a strategic partnership in order to heighten the chances of its success. A major challenge for firms that are interested in forming effective strategic partnerships is that social value and fairness do not seem to be a priority for business transactions today. With many businesses adopting Wal-Mart's adversarial pricing tactics the idea of trusting and enjoying the working relationship with one's business partner seems quaintly outdated. Lynn (2006) states that of Wal-Mart's top ten suppliers in 1994, four have sought bankruptcy protection in the following years, so clearly the economic benefits they believed they'd have from doing business with Wal-Mart did not translate into financial success. If companies begin to place a priority on social value, fairness and the satisfaction of both partners, perhaps a more even business playing field will result, rather than one with few winners and more losers.

For academics, the study of strategic partnerships in the textile and apparel complex has many avenues to expand on the current body of literature. While it is notoriously difficult to get members of the textile and apparel complex to share information, if dyadic research that took the perspective of both sides of a partnership (or more, if there were multiple partnerships involved) into account, a more comprehensive view of strategic partnerships would be possible. Similarly, a longitudinal study that investigated partnerships over the duration of

the alliance would provide valuable information about the stages that partnerships encounter.

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## KEY TERMS AND DEFINITIONS

**Economic Value:** The extent to which a strategic partnership minimized transaction costs between two partners by fulfilling basic economic needs at a minimum of cost to each (e.g.,

transaction speed, efficiency) (Gassenheimer & Houston, 1998).

**Fairness:** Each party's evaluation of economic and social value in terms of benefits and costs to themselves and to their partner (Gassenheimer & Houston, 1998).

**Social Value:** The extent to which the strategic partnership brings members non-economically-

derived satisfaction with the exchange situation (e.g., cooperation, compatibility of goals) (Gassenheimer & Houston, 1998).

**Strategic Partnership:** An alliance between two or more firms in which resources, capabilities, and core competencies are combined to pursue mutual benefits (Hitt, Ireland & Hoskisson, 1997).

## Chapter 8

# Strategic Sourcing and Supplier Selection: A Review of Survey-Based Empirical Research

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### **ABSTRACT**

*Increasingly, supply chain integration and supply chain management are receiving a great deal of attention from researchers and practitioners alike. Supply chain management has been viewed as a viable initiative to enhance sustainable competitive advantage under increased national and international competition. The use of survey-based empirical research has been perceived as a desirable way in supply chain management research, because the use of empirical data helps support the understanding of supply chain management practices within industries. Strategic sourcing and supplier selection play vital role in managing the supply chain due to their contributions to the success of the company. This chapter surveys the current state-of-the art of the survey-based empirical research on strategic sourcing and supplier selection. The findings based on an in-depth analysis of thirty-eight articles are discussed, which will help both the academicians and the practitioners in textile/apparel/fashion industries to understand more about the latest development and trends in survey-based empirical research on strategic sourcing and supplier selection. An agenda for future research is also presented.*

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## **INTRODUCTION**

Supply chain management (SCM) is a central and important area for academic research due to its impact on firms competing in today's global economy, and supply chain management is recognized as a contemporary concept that leads to achieving benefits of both operational and strategic nature (Al-Mudimigh, Zairi, & Ahmed, 2004). According to Gunasekaran, Patel and McGaughey (2004), at the strategic level, SCM is a relatively new and rapidly expanding discipline that is transforming the way for improving organizational competitiveness both in manufacturing and services.

The short-term objective of SCM is to increase productivity and reduce inventory and cycle time, while the long-term strategic goal is to increase customer satisfaction, market share and profits for all members of the virtual organization (Tan, 2002; Wisner & Tan, 2000). To realize these objectives, all strategic partners must recognize that purchasing function, with its boundary-spanning activities, is a crucial link between the sources of supply and the organization itself (Wisner & Tan, 2000). Purchasing/sourcing connects suppliers and buyers closely, which are two of the driving forces of competitiveness in an industry (Porter, 1980).

The importance of empirical research has been stressed for some time. Based on Flynn, Sakakibara, Schroeder, Bates, and Flynn (1990) and Scudder and Hill (1998), empirical research refers to research based on real world observations or experiments; it uses data gathered from naturally occurring situations or experiments, in contrast to research that is conducted via laboratory or simulation studies, where the researchers have more control over the events being studied. Meredith, Raturi, Amoako-Gyampah and Kaplan (1989) argued that Production and Operations Management (P/OM) research should recognize the applied nature of P/OM. Amoako-Gyampah and Meredith (1989) concluded the use of research methodologies associated with empirical research had not been proceeding along the path that was

perceived to be important by industry before 1989. Flynn et al. (1990) discussed the need for more research on operations management which is based on data from the real world. Since then P/OM research field has witnessed the increased deployment of empirical research designs, particularly survey research, to understand better such issues as quality management and manufacturing strategy. P/OM researchers have demonstrated remarkable progress in comprehending the complexities of designing and executing empirical research (Rungtusanatham, Choi, Hollingworth, Wu, & Forza, 2003). This progress is evidenced not only by the quantity, but also the quality and sophistication of the research endeavors that have been completed (Rungtusanatham et al., 2003).

There are many advantages of using survey research. For example, surveys are useful in describing the characteristics of a large population while no other method of observation can provide this general capability; they can be administered from remote locations using mail, email or telephone; consequently, very large samples are feasible, making the results statistically significant even when analyzing multiple variables (Nardi, 2006). There are some disadvantages of survey research at the same time; for example, it may be hard for participants to recall information or to tell the truth about a controversial question; and as opposed to direct observation, survey research (excluding some interview approaches) can seldom deal with "context" (Nardi, 2006). However, the benefits of conducting survey research outweigh its disadvantages. Survey is the most commonly used empirical research design in operations management research (Flynn et al., 1990; Rungtusanatham et al., 2003).

There is an increasing interest in the survey-based empirical research in the field of SCM (Rungtusanatham et al., 2003). The current state and the direction of movement of topics studied and research methodologies used are of interest to many researchers in the operations management field (Scudder & Hill, 1998). SCM continues to

receive a great deal of attention from researchers and practitioners alike. A recent growing body of SCM literature is concerning strategic sourcing/purchasing and supplier selection and their importance to the success of a company. There is an increasing interest in the survey-based empirical research in the field of strategic sourcing/purchasing and supplier selection. However there is a lack of review paper on the state of the survey-based empirical research in specific supply chain management issues. This chapter seeks to provide a comprehensive assessment of the survey-based empirical work on strategic sourcing and supplier selection. The chapter updates the literature with an extensive seventeen-year (April, 1993 – July, 2010) review of the state of the art survey-based empirical research on strategic sourcing/purchasing and supplier selection issues in SCM published in some major operations management journals and major textile/apparel/fashion research journals. Since the textile and apparel supply chain is dynamic, global and complex, SCM is an important topic in modern textile/apparel/fashion business. Strategic sourcing and supplier selection are crucial for firms in modern textile/apparel/fashion business to gain sustainable competitive advantage and enhance business performance. Therefore, we believe the concepts and the research methodologies we reviewed in this chapter are very applicable to the fashion business and can provide theoretical and applied perspectives for further research and development of fashion supply chain management. We seek to propel survey-based empirical research in fashion industry and business analysis because of the benefits of survey-based empirical research which were demonstrated in other industries.

In the next section, the paper presents the issues related to strategic sourcing and supplier selection that contribute to our improved understanding of SCM and SCM in the textile and apparel/fashion industries. Then, the paper surveys the recent state-of-the art of the survey-based empirical research on strategic sourcing and supplier selec-

tion. Following the detailed and comprehensive review, the analytical results of thirty-eight articles and the insights based on our in-depth survey are discussed. An agenda for future research in SCM in textile/apparel/fashion business is presented in the concluding section.

## **BACKGROUND**

### **Strategic Sourcing and Supplier Selection**

In Mentzer, DeWitt, Keebler, Min, Nix, Smith, and Zacharia (2001), supply chain management is defined as “the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole.” A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. A typical supply chain may involve a variety of stages including customers, retailers, wholesalers/distributors, manufacturers, component/raw material suppliers (Chopra & Meindl, 2010).

Since 1990s, both academics and managers have given unprecedented attention to strategic purchasing (Freeman & Cavinato, 1990; Ellram & Carr, 1994). The ability of purchasing to influence strategic planning has increased in a number of firms due to the rapidly changing competitive environment (Carr & Pearson, 2002; Carter & Narasimhan, 1996a), and evidence reveals that purchasing is increasingly seen as a strategic weapon to establish cooperative buyer-supplier relationships to enhance a firm’s competitive stance (Carr & Pearson, 1999). Thus, contemporary purchasing/sourcing is now best recognized as a fundamental unit of SCM (Chopra & Meindl, 2010), and the theoretical construct of strategic purchasing is conceptualized by its proactive



as well as long-term focus, its contributions to the firm's success, and strategically managed buyer-supplier relationships (Carr & Pearson, 1999; Carter & Narasimhan, 1994; Reck & Long, 1988). One of the most important objectives of the purchasing/sourcing function is the development of a network of competent suppliers. Supplier assessment and selection is one of the most fundamental responsibilities of supplier management. Therefore, strategic sourcing and supplier selection are two important themes of supply chain management.

Strategic purchasing/sourcing is defined as the process of planning, implementing, controlling, and evaluating highly important purchasing in an effort to meet a firm's goals (Carr & Pearson, 1999, 2002; Carr & Smeltzer, 2000). A number of articles address the need for purchasing to assume a more strategic role (Carr & Smeltzer, 2000; Carter & Narasimhan, 1994, 1996a, 1996b; Ellram & Carr, 1994; Narasimhan & Das, 1999; Pearson & Gritzmacher, 1990; Paulraj & Chen, 2007) in this age of ever-increasing world competition. Factors such as the dynamic supply environment of the firm, the level of competition, and changes in the purchasing function have created the opportunity and necessity for an increase in integrating suppliers and purchasing/sourcing into the strategic decision-making process. Carter and Narasimhan (1996a) identified five basic principles for achieving the strategic role of purchasing/sourcing: clearly linking specific purchasing management goals with firm-level strategies, emphasizing human resource management effectiveness, fostering a close relationship with key suppliers, actively integrating purchasing with other functions, and creating the proper atmosphere within purchasing.

From a theoretical perspective, a firm's resources can be used to support its capabilities so the firm can achieve a competitive advantage (Barney & Hesterly, 2010; Carr & Pearson, 2002; Chen, Paulraj, & Lado, 2004; Reck & Long, 1988). Strategic sourcing/purchasing is viewed by top management as an important resource of

the firm. It is involved in the firm's strategic planning process and purchasing is treated as equal to other major functions in the firm (Freeman & Cavinato, 1990; Kocabasoglu & Suresh, 2006). At a macro level, a strategic use of purchasing requires a purchasing manager to monitor the company's environment, forecast changes in that environment, share relevant information with suppliers and colleagues in other functions, and identify the company's competitive advantages and disadvantages relative to its suppliers. At a micro level, strategic purchasing involves the identification of critical materials, the evaluation of possible supply disruptions for each of them, and the development of contingency plans for all identifiable supply problems (Burt & Soukup, 1985).

Supplier selection is an important strategic decision and serves as a source of competitive advantage (Lao, Hong, & Rao, 2010; Simpson, Siguaw, & White, 2002). In order to compete effectively in the world market, a company must have a network of competent suppliers. Supplier assessment and selection is designed to create and maintain such a network and to improve various supplier capabilities that are necessary for the buying organization to meet its increasing competitive challenges. A firm's ability to produce a quality product at a reasonable cost and in a timely manner is heavily influenced by its suppliers' capabilities, and supplier performance is considered one of the determining factors for the company's success (Choi & Hartley, 1996; Krause, Scannell, & Calantone, 2000; Lao, Hong, & Rao, 2010; Monczka, Trent, & Callahan, 1993; Tan, Lyman, & Wisner, 2002).

Supplier selection becomes a central concern as the buyers look to form strategic partnerships (Mabert & Venkataramanan, 1998; Spekman, 1988). A growing emphasis on establishing long-term channel relationships, driven by competitive pressures and business complexity, has encouraged many firms to become highly selective in their choice of supplier. Effective evaluation and

selection of suppliers is considered to be one of the critical responsibilities of purchasing/sourcing managers. The evaluation process often involves the simultaneous consideration of several important supplier performance attributes that include price, delivery lead time, and quality (Kannan & Tan, 2002; Krause, Scannell, & Calantone, 2000; Narasimhan & Jayaram, 1998).

There are several key reasons why sourcing and suppliers are becoming increasingly critical to the competitive success of a firm. First, manufacturers are beginning to focus on their core competences (Prahalad & Hamel, 1990) and areas of technical expertise (i.e. firms concentrating on what they do best). An emphasis on internal competences requires greater reliance on sourcing activities and external suppliers to support directly non-core requirements. Second, developing effective supply base management strategies can help counter the competitive pressures brought about by intense worldwide competition. To remain globally competitive, firms must receive competitive performance advantages from their suppliers that match or exceed the advantages that suppliers provide to leading foreign competitors. Third, suppliers can support directly a firm's ability to innovate in the critical areas of product and process technology. As organizations continue to seek performance improvements, they are reorganizing their supplier base and managing it as an extension of the firm's business system (Chen, Paulraj, & Lado, 2004; Lao, Hong, & Rao, 2010; Morgan & Monczka, 1996; Paulraj & Chen, 2007; Vonderembse & Tracey, 1999).

### **Supply Chain Management in the Textile/Apparel/Fashion Industries**

Traditionally in the textile-apparel-retail supply chain, each chain member runs its business based upon separate concerns and interests, sometimes causing conflicts in the relationships with chain partners. Apparel manufacturing is labor intensive with companies historically competing on

price. In the apparel industry, the upper end of the supply chain contains an abundant supply of available manufacturers and low-wage workers from various countries (Abernathy, Volpe, & Weil, 2006). Manufacturers compete for retail business, and retailers select vendors, primarily on a cost basis. However, over the last ten years, the multiple criteria of cost, quality, delivery speed, and delivery reliability, are becoming critical for the textile and apparel industries (Thaver & Wilcock, 2006; Su, Dyer, & Gargeya, 2009).

The textile-apparel-retail supply chain is global and complex (Dickerson, 1999). The intricate nature of these industrial sectors is reflected in the numerous steps in the chain, the diversity of activities, the fragmentation of the market, and the varying product and quality specifications being managed. Customization demands and the need for "quick response" in rapidly changing markets are causing firms to recognize the strategic role that suppliers and supply management can play in achieving sustainable competitive advantage (Su, Dyer, & Gargeya, 2009).

The world marketplace for textile/apparel/fashion is dynamic, considering continual changes in product availability, prices, and competition. Sourcing/purchasing decisions go far beyond cost considerations to influence the manufacturing, marketing, and financial strategies that a firm can execute. When sourcing/purchasing is elevated in status with other major factors that define a firm's competitive strategy, a more proactive strategy can be developed by the firm to deal with environmental change. The sourcing/purchasing department's knowledge of supplier networks and capabilities can provide top management with the kind of information that enables a firm to define its future, rather than react or adapt to a future that is defined by the competition. Thus, sourcing/purchasing has the potential to supply critical information (e.g. information regarding supply market or environmental uncertainties) that enables a firm to develop an effective strategy to actively prepare for the future competition (Carr

& Pearson, 1999; Paulraj & Chen, 2007). Therefore, the textile/apparel/fashion companies need to strategically acquire the materials and services that will enhance their ability to meet their customer's needs and improve financial performance (Su, Dyer, & Gargeya, 2009).

## **RECENT SURVEY-BASED EMPIRICAL RESEARCH ADDRESSING STRATEGIC SOURCING AND SUPPLIER SELECTION**

We thus turn our attention to recently completed survey-based empirical research studies that contribute to our improved understanding of the SCM issues, especially strategic sourcing and supplier selection, and their relationship with firm's performance. According to Rungtusanatham et al. (2003), SCM is a research focus that stood out as showing fastest ascendancy to prominence, and sourcing strategies and supplier selection are two topics which have shown an increase of publications.

We chose to anchor our assessment period between 1993 and 2010, a 17-year time horizon. We included six operations management journals that have been known to publish empirical studies, in particular survey papers. We selected *Decision Sciences (DS)*, *International Journal of Operations & Production Management (IJOPM)*, *International Journal of Purchasing and Materials Management (IJPMM)*, *Journal of Operations Management (JOM)*, *Journal of Supply Chain Management (JSCM)*, and *Supply Chain Management: An International Journal (SCM)*. In order to address the status of survey-based empirical research in textile/apparel/fashion supply chain management, we also included two research journals in textile/apparel/fashion management field – *Clothing and Textiles Research Journal (CTRJ)*, and *Journal of Fashion Marketing and Management (JFMM)*.

We reviewed articles published in the eight journals noted above. Thirty-eight articles address strategic sourcing and/or supplier selection using survey-based empirical research methodology from April 1993 to July 2010. Each of the articles was reviewed by the researchers. The detailed and comprehensive summarization of the literature related to the current state-of-the art of the survey-based empirical research on strategic sourcing and supplier selection is shown in Table 1 and Table 2.

## **ANALYTICAL RESULTS OF RECENT SURVEY-BASED EMPIRICAL RESEARCH**

In this chapter, we engaged in trend and pattern analyses in order to gain greater understanding of the survey-based empirical research on strategic sourcing and supplier selection.

Of the 38 articles reviewed between April 1993 and July 2010, thirty-four of survey-based empirical research studies were published in operations management field research journals – 3 from *Decision Sciences (DS)*, 5 from *International Journal of Operations & Production Management (IJOPM)*, 6 from *International Journal of Purchasing and Materials Management (IJPMM)*, 7 from *Journal of Operations Management (JOM)*, 12 from *Journal of Supply Chain Management (JSCM)*, and 1 from *Supply Chain Management: An International Journal*. As seen in Table 3, only 4 survey-based empirical research studies were published in textile/apparel field research journals, namely, *Clothing and Textiles Research Journal (CTRJ)*, and *Journal of Fashion Marketing and Management (JFMM)*.

As shown in Table 1, of the 38 articles reviewed, thirty-four studies (89.5%) adopted mail survey as data collection methodology; one study used web-based survey (Lao, Hong & Rao, 2010); while the other 3 studies conducted in-person survey including face-to-face interview (Milling-

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Table 1. Summary of Research Method, Types of Industries Surveyed, Sample, and Response Rate of Survey-Based Empirical Research Addressing Strategic Sourcing and Supplier Selection Issues (38 Articles)

No.	Author(s)	Method	Industries	Sample Frame	Response Rate
#1	Watts & Hahn (1993)	Mail survey	A wide range of industries (no SIC information)	Random sample from members of the Sixth District of the National Association of Purchasing Management (NAPM). 81 usable responses.	16%
#2	Carter & Narasimhan (1994)	Mail survey	Firms spanning several classification of industry groups	A random sample from the NAPM membership database. 300 completed responses.	10%
#3	Carter & Narasimhan (1996a)	Mail survey	Firms spanning several classification of industry groups (no SIC information)	A random sample from the NAPM membership database. 302 completed responses.	10%
#4	Carter & Narasimhan (1996b)	Mail survey	Firms spanning several classification of industry groups	A random sample from NAPM and Center for Advanced Purchasing Studies (CAPS) members. 369 completed responses.	14.8%
#5	Choi & Hartley (1996)	Mail survey	Automotive companies in the US	A random sample from NAPM, the Ohio Manufacturing list, and the Japanese Automotive Supplier Directory. 156 surveys were usable.	21%
#6	Narasimhan & Jayaram (1998)	Mail survey	Two industries—small machine tools and non-fashion textile manufacturing	A random sample from directories of trade association members from these two industries in US and Mexico. 127 complete returned responses.	N/A
#7	Tan, Kannan, & Handfield (1998)	Mail survey	A broad spectrum of industries, including automotive, defense, chemical, computer, consumer products, electronics, and etc.	A random sample of quality directors and vice-presidents from members of the American Society for Quality Control (ASQC). 313 returned surveys.	21.3%
#8	Trent & Monczka (1998)	Data collected annually from annual seminar at Michigan State University	A broad range of industries (no SIC information)	Executive managers participating a five-day seminar at Michigan State University.	N/A
#9	Carr & Pearson (1999)	Mail survey	A variety of industry	A random sample from members of the National Association of Purchasing Management (NAPM). 739 respondents.	34.6%
#10	Narasimhan & Das (1999)	Mail survey	A variety of industry, including mechanical subassembly manufacturers, chemicals, automotive, electronics, and etc.	A random sample from the NAPM senior management Title 1 list. 68 utilizable cases.	11.3%
#11	Tan, Kannan, Handfield, & Ghosh (1999)	Mail survey	A broad spectrum of industries, including automotive, defense, chemical, computer, consumer products, electronics, and etc.	A random sample of quality directors and vice-president from the American Society of Quality Control. 313 returned survey.	21.3%
#12	Vonderembse & Tracey (1999)	Mail survey	A variety of discrete part manufacturing industries (no SIC information)	A random sample of the Midwest Region of NAPM members. 268 usable responses received.	13.4%
#13	Carr & Smeltzer (2000)	Mail survey	A variety of industry	A random sample from the MAPM membership. 163 surveys received. Split whole sample into two subsamples.	22%
#14	Das & Narasimhan (2000)	Mail survey	The range of industries included SIC codes from 34 to 38.	A random sample from the NAPM Title 1 member list. 322 usable responses were received.	19%

continued on following page

*Table 1. continued*

No.	Author(s)	Method	Industries	Sample Frame	Response Rate
#15	Krause, Scannell, & Calantone (2000)	Mail survey	Wide range of industries, including apparel and textile, chemical, electrical, food, misc. manufacturing, and etc.	A random sample of purchasing executives from NAPM members list. 527 usable responses (322 from manufacturing firms, and 205 from service firms).	35%
#16	Shin, Collier, & Wilson (2000)	Mail survey	A wide range of industries such as steel, rubber, electronics, plastics, mechanical and etc.	A random sample from 1995 American Society for Quality Automotive Division membership directory. 176 effective usable responses.	24.4%
#17	Wisner & Tan (2000)	Mail survey	Firms from SIC codes 20 to 39 (manufacturing firms)	A random sample from NAPM member listing. 101 usable returned surveys.	6.7%
#18	Narasimhan & Das (2001)	Mail survey	A wide cross-section of US industry, including SIC codes 34, 35, 36, 37 and 38.	A random sample of senior purchasing professionals from the 'Title I' membership list of the NAPM. 322 usable responses.	19%
#19	Tracey & Tan (2001)	Mail survey	A variety of industry (no SIC information)	A random sample from subscribers of the publication <i>Industry Week</i> from across the USA who characterized themselves as higher level executives at manufacturing firms. 180 effective usable responses.	9%
#20	Carr & Pearson (2002)	Mail survey	Various industries from misc. manufacturing, food, financial, electronics, health care, and etc.	A random sample of purchasing executives from NAPM membership database. 175 usable responses.	22%
#21	Ellram, Zsidisin, Siferd, & Stanly (2002)	Mail survey	A wide range of industries from manufacturing, high technology, service, energy, and healthcare	A random sample from the Institute for Supply Management (formerly NAPM). 246 surveys returned.	26.8%
#22	Kannan & Tan (2002)	Main survey	A variety of industries, including raw materials and component manufacturers, final product manufacturers, and wholesalers and retailers.	A random sample of senior materials and purchasing managers in the US who were members of either ISM or APICS-The Educational Society for Resource Management. 411 usable surveys were returned.	9.1%
#23	Simpson, Siguaw, & White (2002)	Mail survey	A wide cross-section industries (no SIC information)	A random sample of purchasing managers from Institute of Supply Management (formerly NAPM). 299 responded surveys.	14.3%
#24	Tan (2002)	Mail survey	Firms from SIC 20 to 39, including food, miscellaneous manufacturing industries, and etc.	A random sample from the Institute for Supply Management (ISM) and the American Production and Inventory Control Society (APICS) membership lists. 411 usable returned surveys.	9.1%
#25	Tan, Lyman, & Wisner (2002)	Mail survey	A variety of industry, including raw material, component and final product manufacturers.	A random sample of senior managers of manufacturing firms identified from NAPM membership list. 101 useable returned surveys.	6.73%
#26	Rozemeijer, Weele, & Wegge-man (2003)	Mail survey	A variety of companies, including industry, retail and services.	A random selected companies from the official Amsterdam Stock Exchange list. 46 completed surveys.	30%
#27	Chen, Paulraj, & Lado (2004)	Mail survey	A variety of US manufacturing companies with SIC codes 34, 35, 36, 37, 38, and 39	A sample of US manufacturing companies drawn from the ISM membership directory. 221 usable responses were received.	23.2%

*continued on following page*

## Strategic Sourcing and Supplier Selection

Table 1. continued

No.	Author(s)	Method	Industries	Sample Frame	Response Rate
#28	Kim & Rucker (2005)	Mail survey	US apparel industry	A list of firms selected from Fairchild's Textiles and Apparel Financial Directory for 1990/1991 and Directory of Members and Associate Members of the American Apparel Manufacturers Association (AAMA) for 1991. 83 returned responses.	31.4%
#29	Kocabasoglu & Suresh (2006)	Mail survey	A variety of industry with SIC codes between 34 and 38	Respondents were selected from supply management executives of manufacturing firms in the US, who are members of ISM. 140 complete and usable responses were received.	7.1%
#30	Millington, Eberhardt, & Wilkinson (2006)	Survey (face-to-face interviews)	A variety of industry	A survey of 75 UK and US manufacturing operations in the eastern seaboard region of China	100%
#31	Thaver & Wilcock (2006)	Mail survey	Canadian textile and apparel industry	A sample of firms that were importing apparel, fabric, or accessories for apparel was selected from (1) Canadian Apparel Federation, STYLE: Buyers' Guide, (2) Canadian Apparel Manufacturers, Apparel – Buyers' Guide, (3) Retail Council of Canada, 1999 Retail Chains in Canada; and (4) Canadian catalogue firms. 56 returned surveys.	11.2%
#32	Gonza'lez-Benito (2007)	Mail survey	Three industries in Spain: SIC35, SIC36, and SIC37	A sample of Spanish firms that employ 100 or more employees from these three industries. 180 firms returned completed questionnaires.	43.2%
#33	Modi & Mabert (2007)	Mail survey	A variety of US manufacturing industry with SIC codes, 34, 35, 36 and 37	A random sample from members of the Institute of Supply Management (ISM). 161 responses were received.	8.47%
#34	Paulraj & Chen (2007)	Mail survey	A variety of industry with SIC codes between 34 and 39	A random sample from members of the Institute of Supply Management (ISM). 232 responses were received.	24.3%
#35	Tam, Moon, Ng, & Hui (2007)	A survey administered by face-to-face interviews.	Hong Kong clothing industry	The respondents include part-time evening students studying for a Master's degree in Textiles and Clothing at Hong Kong Polytechnic University and exhibitors during Hong Kong Fashion Week, Fall/Winter 2004. 120 usable surveys were received.	40%
#36	Su, Dyer, & Gargeya (2009)	Mail survey	US textile and apparel industry	A random sample of firms selected from Dun & Bradstreet (D&B) database and two directory books. 181 returned responses.	38.2%
#37	Gonza'lez-Benito (2010)	Mail survey	Three industries in Spain: SIC35, SIC36, and SIC37	A sample of Spanish firms that employ 100 or more employees from these three industries. 180 firms returned completed questionnaires.	43.2%
#38	Lao, Hong, & Rao (2010)	Web-based survey	Participants represent six industries: SIC23 "Apparel and other textile products", and other five industries – SIC30, SIC34, SIC35, SIC36, and SIC37.	An email list was obtained from two providers of an executive contact database: RSA Teleservices and Lead411. 201 usable responses were received.	3.9%

*Table 2. Summary of Major Data Analysis Methods, Research Focuses and Major Findings of Survey-Based Empirical Research Addressing Strategic Sourcing and Supplier Selection Issues (38 Articles)*

No.	Author(s)	Major Data Analysis Methods Used	Research Focuses	Major Findings
#1	Watts & Hahn (1993)	Descriptive statistics including frequency, mean, and rank; Chi-square analysis	An exploratory study to gain a better understanding of current activity and involvement in supplier development.	Supplier development programs are more prevalent than expected and that large companies are more likely to be involved. The results also show the importance of formal supplier evaluation to the supplier development process.
#2	Carter & Narasimhan (1994)	Descriptive statistics; ANOVA	An exploratory study to document the central role that the purchasing function can play in ensuring a high level of quality and customer satisfaction.	Efforts to improve TQM can be successful if top management commitment and acceptance of the importance of purchasing to the attainment of corporate goals are developed.
#3	Carter & Narasimhan (1996a)	Descriptive analysis; Factor analysis; Multiple linear regression	An exploratory study to document purchasing's role and the impact purchasing decisions have on corporate performance.	Any firm can successfully develop and implement purchasing strategies. A firm's efforts at purchasing strategy development can be successful. Purchasing is indeed strategic.
#4	Carter & Narasimhan (1996b)	Descriptive analysis; Factor analysis; Bi-variate correlation	An exploratory study to identify various purchasing and business market trends.	Various purchasing and business market trends are identified and are synthesized into strategic organizational propositions, including the strategic importance of purchasing and supplier management will increase and emerge as a key element of business strategy.
#5	Choi & Hartley (1996)	Descriptive analysis; Chi-square analysis; Factor analysis; MANOVA; Post hoc-Tukey's test.	An exploration of supplier selection practices across the supply chain.	No differences among the auto assemblers, direct suppliers, and indirect suppliers were found for the importance placed on consistency (quality and delivery), reliability, relationship, flexibility, price, and service.
#6	Narasimhan & Jayaram (1998)	Descriptive statistics; Factor analysis; Structural equation modeling	A study that verifies a conceptual model that relates to sourcing decision, manufacturing goals, customer responsiveness, and manufacturing performance.	This study examines the relationship among sourcing decisions, manufacturing goals, customer responsiveness, and manufacturing performance. An integrated supply chain involves aligning sourcing decisions to achieve manufacturing goals that are set to respond favorably to the needs of customers.
#7	Tan, Kannan, & Handfield (1998)	Descriptive analysis; Bonferroni Test; Multiple linear regression; Bi-variate correlation	A study that identifies selected purchasing practices and customer relation practices which are strongly associated with the firm success.	This research examines the relationship between SCM practices, supplier performance, and company performance. The results of this research provide empirical evidence that selected purchasing practices and customer relation practices are strongly associated with the perceived financial and market success of firms.
#8	Trent & Monczka (1998)	Descriptive statistics	An exploratory study to detail the real and projected changes and trends in purchasing and supply management.	The article details the real and projected changes and trends that have affected and will continue to affect purchasing and sourcing professionals, including supplier and sourcing importance, and performance measurement.
#9	Carr & Pearson (1999)	Descriptive analysis; Correlation analysis; Exploratory factor analysis; Structural equation modeling (using n=168)	This study examines a structural model of strategic purchasing and its influence on supplier evaluation systems, buyer-supplier relationships, and firm performance.	Strategic purchasing is important to the success of the firm. Firms that have strategic purchasing are more likely to implement a supplier evaluation system. Increased emphasis on strategic purchasing and supplier evaluation systems are critical for firms seeking to establish long-term relationships with their suppliers. Strategically managed long-term relationships with key suppliers can have a positive impact on the firm's financial performance.
#10	Narasimhan & Das (1999)	Descriptive analysis; Structural equation modeling; ANOVA	The study presents a structural equation analysis of the conceptual model that investigates the influence of strategic sourcing and advanced manufacturing technologies on specific manufacturing flexibilities.	Strategic sourcing can be used to target specific manufacturing flexibilities and that interflexibility synergies need to be considered while formulating flexibility-based manufacturing strategies.

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## Strategic Sourcing and Supplier Selection

Table 2. continued

No.	Author(s)	Major Data Analysis Methods Used	Research Focuses	Major Findings
#11	Tan, Kannan, Handfield, & Ghosh (1999)	Descriptive analysis; Bonferroni multiple comparisons; Factor analysis; Multiple linear regression	The study identifies factors of SCM that impact corporate performance.	A firm's competitive environment and management's responsiveness to it affects its performance. The use of TQM and effective management of supply base, and a customer relation focus positively affects performance.
#12	Vonderembse & Tracey (1999)	Descriptive statistics; Bi-variate correlation	An exploratory study examining the extent to which supplier selection criteria and supplier involvement are used by manufacturers.	Implementing supplier selection criteria and involving suppliers has a positive impact on performance.
#13	Carr & Smeltzer (2000)	Subsample of 78 surveys for MANOVA and Correlation analysis; the remaining 85 for multiple regression	The study examines a regression model of the relationship among purchasing skills and strategic purchasing, firm performance, and supplier responsiveness.	There is no statistical significance difference for type (manufacturing compared to non-manufacturing firms) and size (large compared to small firms) with respect to purchasing skills. Purchasing skills are related to strategic purchasing, a firm's financial performance, and supplier responsiveness.
#14	Das & Narasimhan (2000)	Descriptive analysis; Confirmatory factor analysis; Multiple linear regression analysis	The study explores the relationship between purchasing competence and manufacturing performance.	Purchasing competence is found to have a positive impact on manufacturing cost, quality, and delivery, as well as new product introduction and customization performance. Purchasing integration, a component of purchasing competence, is found to relate to all dimensions of manufacturing performance.
#15	Krause, Scannell, & Calantone (2000)	Descriptive analysis; Structural equation modeling	The study presents a structural equation analysis of two conceptual models that examine the impact of supplier development strategies on performance.	Direct involvement activities, where the buying firm internalizes a significant amount of the supplier development effort, play a critical role in performance improvement.
#16	Shin, Collier, & Wilson (2000)	Descriptive analysis; Structural equation modeling	The study tests three research hypotheses associated with supply management orientation, supplier performance, and buyer performance using a confirmatory structural equation modeling approach.	An improvement in the supply management orientation (SMO) improves both the suppliers' and buyers' performance. In addition, the influence of SMO on delivery and quality related performance is more statistically significant than on cost or flexibility performance.
#17	Wisner & Tan (2000)	Descriptive statistics; Bonferroni multiple comparison test	An exploratory study on supply chain management and its impact on purchasing.	This study identified current supply chain management issues and practices for manufacturing firms operating in US, including strategic elements of supply chain management, problems and concerns in supply chain management, supplier issues in supply chain management, strategic alliance and supplier certification programs.
#18	Narasimhan & Das (2001)	Descriptive analysis ANOVA; Confirmatory factor analysis; Regression analysis	The study tests the impact of purchasing integration and practices on manufacturing performance.	Purchasing integration was found to moderate the relationship between purchasing practices and manufacturing performance. Increased investments in purchasing integration were observed to lead to higher performance returns from investments in purchasing practices.
#19	Tracey & Tan (2001)	Descriptive analysis; NOVA; Tukey pairwise comparison; Structural equation modeling	The study presents a structural equation analysis of a conceptual model that examines the relationships among supplier selection, supplier involvement, customer satisfaction, and firm performance.	Effective purchasing is an important element of supply chain management and a source of superior firm performance. Selecting and evaluating suppliers grounded in the criteria of quality, delivery reliability, and product performance enhances the four dimensions of customer satisfaction (price, quality, variety, and delivery) and firm performance.
#20	Carr & Pearson (2002)	Descriptive analysis; Structural equation modeling	A model of the relationships among purchasing/supplier involvement, strategic purchasing, and firm performance is offered and tested using structural equation modeling.	Purchasing/supplier involvement has a positive impact on strategic purchasing, and strategic purchasing has a positive impact on firm's financial performance.

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*Table 2. continued*

No.	Author(s)	Major Data Analysis Methods Used	Research Focuses	Major Findings
#21	Ellram, Zsidisin, Siferd, & Stanly (2002)	Descriptive analysis; ANOVA; Exploratory factor analysis; Bonferroni post-hoc test	An exploratory study that identifies purchasing and supply management best practices.	This research examines purchasing and supply management best practices, and the linkage to organizational success. Organizational success was measured by the total return to shareholders of an individual firm compared to the industry average TRS.
#22	Kannan & Tan (2002)	Descriptive analysis; Factor analysis; Tukey multiple comparisons; Correlation analysis	An exploratory study that identifies supplier selection and assessment criteria and the relationships between criteria and business performance.	Soft, non-quantifiable selection criteria, such as a supplier's strategic commitment to a buyer, have a greater impact on performance than hard, more quantifiable criteria such as supplier capability, yet are considered to be less important. Assessment of supplier's willingness and ability to share information also has a significant impact on the buying firm's performance, yet is again considered to be relatively unimportant.
#23	Simpson, Siguaw, & White (2002)	Descriptive statistics	An exploratory study that identifies the factors used in measuring the performance of suppliers.	Less than half of the responding firms have a formal supplier evaluation process in place, and that quality, supplier certification, facilities, continuous improvements, physical distribution factors, and channel relationship factors were the factors most commonly included in supplier evaluation programs.
#24	Tan (2002)	Descriptive analysis; Bi-variate correlation; Factor analysis; Multiple linear regression analysis	An exploratory study that identifies the practices and the concerns associated with successful supply chains.	This study investigates the contemporary practices and concerns of supply chain management, also relates the practices and concerns to firms' performance. A general conclusion is that all of the significant supply chain management practices positively impact performance.
#25	Tan, Lyman, & Wisner (2002)	Descriptive analysis; Scheffe multiple range test; Factor analysis; Bivariate correlation	An exploratory study of the prevalent supply chain management and supplier evaluation practices.	This study revealed that supply chain management practices could be categorized into six constructs and supplier evaluation practices could be categorized into three constructs. Some of the constructs identified in this study correlated positively with firm performance.
#26	Rozemeijer, Weele, & Wegge-man (2003)	Descriptive statistics; Bi-variate correlation	An exploratory study of creating corporate advantage through purchasing.	Corporate purchasing initiatives should be congruent with the overall level of corporate coherence and the level of maturity of the purchasing function.
#27	Chen, Paulraj, & Lado (2004)	Descriptive analysis; Factor analysis, Structural equation modeling	The study presents a structural equation analysis of a conceptual model that examines the relationships among strategic purchasing, supply management, and firm performance.	The results provide robust support for the links between strategic purchasing, supply management, customer responsiveness, and financial performance of the buying firm. Strategic purchasing can engender sustainable competitive advantage by enabling firms to: (a) foster close working relationships with a limited number of suppliers; (b) promote open communication among supply-chain partners; and (c) develop long-term strategic relationship orientation to achieve mutual gains.
#28	Kim & Rucker (2005)	Descriptive analysis; T-test; Logistic Regression	The study examines a broad range of potential predictors of location and ownership decisions by U.S. apparel manufacturers.	Significant predictors of a company's decision to engage in domestic production only versus domestic and off shore production were the size of the company and perceived flexibility of U.S. production. Significant predictors of the proportion of a company's off shore production were the company's foreign business experience, the perception that the company's products are sensitive to fashion change, and perceived flexibility of off shore production. The only significant predictor of decisions to make (use inside production), buy (use outside production), or both was the perceived fashionability of the products.

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## Strategic Sourcing and Supplier Selection

Table 2. continued

No.	Author(s)	Major Data Analysis Methods Used	Research Focuses	Major Findings
#29	Kocabasoglu & Suresh (2006)	Descriptive analysis; Structural equation modeling	The study is to identify the key, characterizing elements of strategic sourcing. A framework of strategic sourcing based on past research was developed and tested using data from manufacturing firms.	The results indicate that strategic sourcing is based on the status of purchasing function with the firm, the level of internal coordination of purchasing with other functions within the firm, information sharing with key suppliers and development of key suppliers.
#30	Millington, Eberhardt, & Wilkinson (2006)	Descriptive analysis; ANOVA, Qualitative analysis	An exploratory study to investigate the availability and performance of different types of supplier in China.	The results suggest that, while the availability of indigenous suppliers is limited, private Chinese enterprises have the flexibility and potential to perform well if both the supplier and buyer are willing to make significant investments, especially in the areas of workforce training and quality procedures.
#31	Thaver & Wilcock (2006)	Descriptive analysis; T-test	An exploratory study to determine the criteria used by members of the textile and apparel chain to select overseas vendors.	Criteria relating to a vendor's flexibility and responsiveness were most important. Registration to a quality program such as ISO 9000 was not considered important nor did it seem to give an overseas vendor a business advantage over its domestic non-registered counterpart. Two factors, category of apparel firm and the firm's use of quality programs, were potential determinants of favorable responses to registration.
#32	Gonzalez-Benito (2007)	Descriptive analysis; Factor analysis; Regression analysis; Structural equation modeling	The study proposes that purchasing's contribution to business performance depends on the degree to which purchasing capabilities fit with and support the business strategy. The research model was tested using structural equation modeling.	This study distinguishes two levels of fit: between purchasing strategic objectives and purchasing capabilities, defined as "purchasing efficacy," and between business strategy and purchasing strategic objectives, which is viewed as an immediate consequence of the strategic integration of purchasing. The interaction between both levels of fit influences business commercial and financial performance
#33	Modi & Mabert (2007)	Descriptive analysis; Structural equation modeling	A conceptual model of an organization's efforts to improve supplier performance is developed and tested using structural equation analysis.	The results suggest that evaluation and certification efforts are the most important supplier development prerequisites before undertaking operational knowledge transfer activities such as site visits and supplier training. Furthermore, collaborative inter-organizational communication is identified as important supporting factor in transforming an organization's efforts to develop suppliers into supplier performance improvements.
#34	Paulraj & Chen (2007)	Descriptive analysis; Structural equation modeling	The study presents a structural equation analysis of a conceptual model that examines the linkages among environmental uncertainties, strategic supply management, supplier performance, and buyer performance.	The study results provide empirical support that there is a positive link between environmental uncertainties and strategic supply management initiatives (strategic sourcing is a key ingredient of strategic supply management). It further demonstrates that strategic supply management can lead to collaborative advantage and ultimately create a "win-win" situation for supplier and buyer firms.
#35	Tam, Moon, Ng, & Hui (2007)	Descriptive analysis; Chi-square test	This study is to explore the differences between the small and medium-sized enterprises (SMEs) and the large enterprises (Les) of the Hong Kong clothing industry in terms of the adoption of production sourcing strategies and buyer-supplier relationships.	The results show that there were certain differences between the small and medium-sized enterprises (SMEs) and the large enterprises (Les) with regard to production sourcing: Les are more able to disperse production globally; Les are more likely to adopt single sourcing, while SMEs prefer multiple sourcing; SMEs tend to use a combined strategy of in- and outsourcing, whereas Les select either insourcing or outsourcing; and Les are more likely to develop a formal strategic alliance with their trading partners.
#36	Su, Dyer, & Gargaya (2009)	Descriptive analysis; Multivariate analysis of variance; Structural equation modeling	The study presents a structural equation analysis of a conceptual model that examines the linkages among strategic sourcing, supplier selection, competitive advantage, and business performance.	The research findings support that strategic sourcing has a significant and positive effect on business performance, and supplier selection has a significant and positive effect on the firm's ability to gain competitive advantages.

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Table 2. continued

No.	Author(s)	Major Data Analysis Methods Used	Research Focuses	Major Findings
#37	Gonzalez-Benito (2010)	Descriptive analysis; Factor analysis; Multiple regression analysis	The study examines the exploratory hypothesis: Business performance is affected by the relative importance that the purchasing function assigns to the different generic competitive objectives (i.e. quality, cost, dependability, and flexibility).	An organization's commercial and financial performance increases when it increases the relative importance of flexibility and decreases the relative importance of reductions in stock levels and purchasing prices in its supply strategy. The best performing firms are those that combine quality, dependability, and flexibility as priority objectives and relegate cost reductions to secondary importance.
#38	Lao, Hong, & Rao (2010)	Descriptive analysis; Structural equation modeling	The study presents a structural equation analysis of a conceptual model that examines the relationships among supply management, supply flexibility, and supply chain performance.	The results indicate strong, positive and direct relationships between supply management practices (including supplier selection, supplier development, and strategic supplier alliance) and supply flexibility, and between supply flexibility and supply chain performance.

ton, Eberhardt, & Wilkinson, 2006; Tam, Moon, Ng, & Hui, 2007) or collected from annual seminar (Trent & Monczka, 1998).

Table 4 summarizes the industries represented and the sample frame of the 38 survey-based empirical research studies presented in Table 1 and Table 2. One striking result was that 34 out of the 38 articles drew their samples from a wide range of cross-industries. Of the 38 articles reviewed, only 4 articles including Kim and Rucker (2005), Thaver and Wilcock (2006), Tam, Moon, Ng, and Hui (2007), and Su, Dyer, and Gargeya (2009) specifically surveyed sectors in textile/apparel/fashion industries. Another 5 articles, including

Narasimhan and Jayaram (1998), Krause, Scannel, and Calantone (2000), Wisner and Tan (2000), Tan (2002), and Lao, Hong, and Rao (2010), explicitly stated that they included textile and/or apparel firms in their survey samples (see Table 4).

With respect to sampling strategies, all 38 articles provided sufficient information about the sampling process to help readers understand how the final sample was constructed. As shown in Table 4, of the 38 articles, 3 articles (Millington, Eberhardt, & Wilkinson, 2006; Tam, Moon, Ng, & Hui, 2007; Trent & Monczka, 1998) collected data using the convenient samples; one article (Lao, Hong & Rao, 2010) collected data from the

Table 3. Summary of Appearance of the 38 Articles on Various Journals

Journal	Number of Articles	Article No. (#)
Decision Sciences (DS)	3	#6, #10, #15
International Journal of Operations & Production Management (IJOPM)	5	#11, #20, #25, #30, #37
International Journal of Purchasing and Materials Management (IJPMM)	6	#1, #2, #3, #4, #7, #8
Journal of Operations Management (JOM)	7	#5, #9, #16, #18, #27, #32, #33
Journal of Supply Chain Management (JSCM)	12	#12, #13, #14, #17, #21, #22, #23, #24, #26, #29, #34, #38
Supply Chain Management: An International Journal (SCM)	1	#19
Clothing and Textiles Research Journal (CTRJ)	2	#28, #36
Journal of Fashion Marketing and Management (JFMM)	2	#31, #35
Total Number of Articles Reviewed: 38		

## Strategic Sourcing and Supplier Selection

Table 4. Summary of the Sample Frame and the Industries (According to Standard Industrial Classification Scheme) Represented in the 38 Articles

Article No. (#)	Author(s)	Industries Surveyed	Sample Frame	Response Rate
#6	Narasimhan and Jayaram (1998)	Non-fashion textile manufacturing and small machine tools	A random sample Sample size n = 127	N/A
#8	Trent and Monczka (1998)	A broad range of industries (no SIC information)	A convenient sample Sample size n = N/A	N/A
#15	Krause, Scannell, and Calantone (2000)	Wide range of industries including apparel and textile, etc.	A random sample Sample size n = 527	35%
#17	Wisner and Tan (2000)	Firms from SIC codes 20-39 (SIC22-textile mill products, SIC23-apparel and textile products)	A random sample Sample size n = 101	6.7%
#24	Tan (2002)	Firms from SIC codes 20-39 (SIC22-textile mill products, SIC23-apparel and textile products)	A random sample Sample size n = 411	9.1%
#28	Kim and Rucker (2005)	US apparel industry	A random sample Sample size n = 83	31.4%
#30	Millington, Eberhardt, and Wilkinson (2006)	UK and US manufacturing firms in the eastern seaboard region of China (no SIC information)	A convenient sample (face-to-face interview survey) Sample size n = 75	100%
#31	Thaver and Wilcock (2006)	Canadian textile and apparel industry	A random sample Sample size n = 56	11.2%
#35	Tam, Moon, Ng, and Hui (2007)	Hong Kong clothing industry	A convenient sample Sample size n = 120	40%
#36	Su, Dyer, and Gargeya (2009)	US textile and apparel industry	A random sample Sample size n = 181	38.2%
#38	Lao, Hong, and Rao (2010)	Participants represent six industries: SIC23 (apparel and textile products), SIC30, SIC34, SIC35, SIC36, SIC37	Entire sample population Sample size n = 201	3.9%
Other 27 articles		A variety of industries (no information about whether textile and apparel firms were included in the samples)	Random samples	6.73%-43.2%

entire sample population; while the rest of 34 articles gathered data using random sampling frame.

The response rates for the reviewed articles are between 43.2% (González-Benito, 2007, 2010) and 3.9% (Lao, Hong, & Rao, 2010) for mail survey and web-based survey. Millington, Eberhardt and Wilkinson (2006) achieved a 100% response rate for their face-to-face interviews of 75 UK and US manufacturing operations in eastern seaboard region of China. In 10 articles, the response rates are or below 10%. In 9 articles, the response rates are or above 30% (see Table 1).

Table 5, which tabulates the 38 articles presented in Table 1 and Table 2 according to primary research purpose, reveals that SCM researchers have been increasingly designing relational studies using survey methodology for data collection. Out of 38 articles reviewed, 29 articles (76.3%) use relational empirical research to investigate the relationships among two or more constructs or variables, either in an exploratory or a confirmatory manner (see Table 5).

The data analysis methods used in the survey-based empirical research on strategic sourcing and supplier selection are presented in Table 6. A

*Table 5. Classifying the 38 Survey-Based Empirical Research Articles by Primary Research Purpose and by Year*

Year	Descriptive Research (Article No.)	Relational Research (Article No.)		Both Descriptive and Relational (Article No.)
		Exploratory	Confirmatory	
1993	#1	–	–	–
1994	#2	–	–	–
1996	#5	#3, #4	–	–
1998	#8	#7	#6	–
1999	–	#12	#9, #10,	#11
2000	#17	–	#14, #15, #16	#13
2001	–	–	–	#18, #19
2002	#23	#24	#20	#21, #22, #25
2003	–	#26	–	–
2004	–	–	#27	–
2005	–	–	–	#28
2006	#30, #31	–	#29	–
2007	#35	–	#32, #33, #34	–
2009	–	–	#36	–
2010	–	#37	#38	–
Total Count	9	7	14	8

variety of data analysis methods are used to analyze the data and/or to examine the relationships in the proposed research models, including descriptive statistics, Bi-variate correlation analysis, multiple comparison test, analysis of variance (ANOVA), multivariate analysis of variance (MANOVA), multiple linear regression (MLR), factor analysis, and structural equation modeling (SEM).

**CONCLUSION AND DISCUSSIONS**

Based on an in-depth survey of the 38 articles and the summary tables (Tables 1, 2, 3, 4, 5, and 6) in the previous section, several insights can be drawn to enhance our understanding of the current survey-based empirical research on strategic sourcing and supplier selection.

First, from our review of the 38 articles in the past 17 years on strategic sourcing and supplier selection, there is a deficiency of survey-based empirical research on strategic sourcing and supplier selection in textile/apparel/fashion industries. Table 1 and Table 2 summarize the recent articles in the area of strategic sourcing and supplier selection regarding the research method, industries surveyed, sample frame, response rate, data analysis tools, research focus, major findings, etc. As show in Table 4, there are only 4 articles specifically surveyed sectors in textile/apparel/fashion industries and another 5 articles explicitly stated they included textile and/or apparel firms in their survey samples. The research studies which surveyed other industries would provide researchers in the textile/apparel/fashion supply chain management field with a clearer picture of the trend of survey-based research in the area; this may also help researchers in the textile/ap-

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Table 6. Summary of Data Analysis Techniques Used in the 38 Survey-Based Empirical Research Articles

Data Analysis Methods	Article No. (#)	Number of Articles	Percentage
Qualitative Analysis	#30	1	2.6%
Logistic Regression	#28	1	2.6%
T-test	#28, #31	2	5.3%
Chi-Square Analysis	#1, #5, #35	3	7.9%
MANOVA	#5, #13, #36	3	7.9%
ANOVA	#2, #5, #10, #18, #19, #21,	6	15.8%
Multiple Comparison	#7, #11, #17, #19, #21, #22, #25,	7	18.4%
Correlation Analysis	#4, #7, #9, #12, #13, #22, #24, #25, #26	9	23.7%
Multiple Linear Regression	#3, #7, #11, #13, #14, #18, #24, #32, #37	9	23.7%
Structural Equation Modeling (since 1998)	#6, #9, #10, #15, #16, #19, #20, #27, #29, #32, #33, #34, #36, #38	14 (3 articles before 2000, and 11 articles since 2000)	36.8%
Factor Analysis	#3, #4, #5, #6, #9, #11, #14, #18, #21, #22, #24, #25, #27, #32, #37	15	39.5%
Descriptive Statistics	#1 – #38	38	100%

parel/fashion industries to better plan their own research or arouse their interests in conducting survey-based empirical research in the topic.

Second, from the research design perspective, mail survey is selected as the method for data collection for most of survey-based empirical research reviewed (34 articles used mail survey). Mail survey appeared to be a strong preference to collect data for supply chain management quantitative research (see Table 1). It allows the researchers to sample the broadest number of respondents over a wide geographic area. However, how to achieve a satisfactory response rate is a challenge for survey-based empirical research. In an effort to increase the response rate a modified version of the methodology of Dillman's (1978) was followed in most of the articles.

Third, in terms of research methodology, recent articles are interested in using survey-based relational empirical research on supply chain management (see Table 5). The survey articles in supply chain management generally fall into one of the two categories, descriptive or relational, in terms of why the survey research was being conducted

(Rungtusanatham et al., 2003). The descriptive studies are designed to provide a "snapshot" of the current state of events related to a supply chain management phenomenon, and generally they do not conduct formal tests of hypotheses, other than tests of differences between groups for descriptive purposes. Relational studies are designed to empirically examine relationships among two or more constructs or variables, either in an exploratory or a confirmatory manner. Studies that fall into this category specify propositions or hypotheses a priori to guide subsequent empirical analyses (Rungtusanatham et al., 2003). Out of the 38 articles reviewed, 29 articles are relational empirical research (see Table 5). This is encouraging especially for textile and apparel field because textile and apparel discipline needs to keep up with the latest development in research theories and methodologies. Relational survey research offers the foundation for building and testing theories and for growth of scientific knowledge in SCM field for textile/apparel/fashion industries.

Fourth, we have witnessed that quantitative analysis methods seem to be very popular in supply

chain management research. Most of the articles typically combine two or more different statistical analysis methods. It is noted that structural equation modeling has steadily gained popularity in empirical survey-based research since 1998. One of the unique features of structural equation modeling is the ability to provide parameter estimates for relationships among unobserved variables (latent variables). It simultaneously measures multiple relationships among independent and dependent variables in one model (Bollen, 1989). Because of these features of structural equation modeling, this comprehensive data analysis method is promising in supply chain management research. Out of the 38 reviewed articles, 14 articles (36.8%) (3 articles before 2000 and 11 articles since 2000) use structural equation modeling to investigate the relationships in the proposed conceptual models (see Table 6).

Fifth, the research reviewed clearly indicates that many organizations upgraded their purchasing/sourcing function to be an integral part of the corporate planning process. Carr and Pearson (1999) indicated that emphasizing strategic purchasing means that the firm recognizes the importance of reviewing and adjusting purchasing's plan to match the company's strategic plans on a regular basis. It will be necessary to develop purchasing strategies according to a long-range plan. The strategic purchasing/sourcing is involved in the firm's strategic planning process and purchasing/sourcing is treated as an equal to other major functions in the firm (Freeman & Cavinato, 1990). Once a firm adopts strategic goals, it can then begin the process of developing purchasing strategies, and sourcing function has active interaction with other functions such as manufacturing, marketing, and customer services. When sourcing/purchasing is elevated to a strategic level, it can better contribute to the firm's business performance (Carr & Pearson, 1999, 2002; Reck & Long, 1988).

The organizations emphasizing strategic sourcing recognize the benefits and competitive

advantages associated with integrating sourcing/purchasing into strategic planning (Tan, Kannan, & Handfield, 1998). Das and Narasimhan (2000) explored the relationship of purchasing competence with manufacturing priorities. In their study, purchasing integration, a component of purchasing competence, is found to relate to all dimensions of manufacturing performance. Empirical studies validate the fact that strategic sourcing can impact a firm's competitiveness of low cost, high quality, reliable delivery, flexibility, and quick response time, and also improve firm's financial performance (Narasimhan & Das, 2001; Narasimhan & Jayaram, 1998; Su, Dyer, & Gargeya, 2009). Strategic sourcing is recognized as a key contributor to firm's success (Carr & Pearson, 1999; Carr & Pearson, 2002; Narasimhan & Jayaram, 1998; Su, Dyer, & Gargeya, 2009). Paulraj and Chen (2007) demonstrated that strategic supply management which includes strategic sourcing as a key element can lead to collaborative advantage and ultimately create a "win-win" situation for supplier and buyer firms.

Sixth, buyer-firms adopt strategic approaches to search for suppliers whose expertise and competence can be leveraged. A study by Lao, Hong, and Rao (2010) presented a model of supply management, supply flexibility, and supply chain performance. Supply management, which includes supplier selection, supplier development, and strategic supplier alliance, has become increasingly integrated with company strategic plans in order to maximize firm responsiveness. The study results indicated strong, positive, and direct relationship between supply management practices, and supply flexibility, and between supply flexibility and supply chain performance. Regardless of how the relationship is structured, many companies must rely on their suppliers to contribute to their ability to be viable competitors. In a supply chain environment, evaluating the capabilities of suppliers has a special role in that shared responsibility for the achievement of corporate targets is emphasized. The supplier se-

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lection criteria help a firm identify vendors that can provide excellent product quality, performance, availability, and consistent delivery. Many studies' results (Lao, Hong, & Rao, 2010; Paulraj & Chen, 2007; Shin, Collier, & Wilson, 2000; Tan, Kannan, & Handfield, 1998; Tracey & Tan, 2001; Vonderembse & Tracey, 1999) reveal that when suppliers are selected with these capabilities, both supplier performance and the buying firm's performance are expected to increase. A number of studies (Gonza'lez-Benito, 2010; Kannan & Tan, 2002; Simpson, Siguaw, & White, 2002; Tan, Lyman, & Wisner, 2002; Thaver & Wilcock, 2006) have examined the criteria used by buying firms to assess supplier performance. The evidence suggests that although cost is still the primary criterion, quality, delivery, and service are also commonly used. This trend marks a shift away from traditional price-based evaluation of suppliers to multiple evaluation criteria.

### **FUTURE RESEARCH DIRECTIONS**

We believe that this comprehensive review of survey-based empirical research on strategic sourcing and supplier selection was necessary to provide a historical perspective and an introspective reflection for future SCM survey research in textile/apparel/fashion industries. It is our observation from reviewing previous published empirical research that strategic sourcing and supplier selection have been recognized as key decisions in firm's decision making process. Strategic sourcing and supplier selection are two key drivers of buying firm's competitive priorities and further lead to firm's financial performance in textile/apparel/fashion business. With changing dynamics due to global competition and new technological advances in numerous areas, future researchers interested in strategic sourcing and supplier selection will have many opportunities to explore critical supply chain management issues. We suggest an agenda for future SCM research

in textile/apparel/fashion industries as per the following paragraphs.

First, most current survey-based empirical studies on strategic sourcing and supplier selection use data collected from a broad range of industries, in which automotive industry is a major industry for sample frame. More future survey research should be encouraged to investigate SCM issues (e.g. strategic sourcing and supplier selection) in one unique industry such as fashion/apparel retailing industry, in order to get a better understanding of the supply chain management in that specific industry. And thus, focusing on an industry supply chain will provide effective information exact to that industry and will benefit producers, marketers, and managers in that specific industry. It would be interesting to see if there are patterns by industry in terms of supply chain management practices or size of firms. Apparel business especially fashion business exhibits very different characteristics from other industries. It is very necessary for apparel/fashion industry to investigate SCM issues from a scientific perspective by using survey-based empirical research.

Second, the survey-based empirical study using systematic data gathering efforts provides a baseline for longitudinal studies of supply chain management practices before some anticipated change in an industry or in general practices. Based on the dynamic nature of textile and apparel business, the longitudinal follow-up studies should be designed to examine changing strategy and practices in textile/apparel/fashion business.

Third, little research has been done on how to measure sourcing/purchasing performance in textile/apparel/fashion industries. It would be helpful to explore how sourcing/purchasing views itself, how it is viewed by top management, how it is viewed by other function areas within the firm, and how it is viewed by suppliers to the firm.

Last, international studies should be conducted by using survey-based empirical research methodology to examine the sourcing and supplier



selection strategies and practices across different countries. This is necessary with the more and more open economy around the world and sourcing has become a global activity for textile/apparel/fashion business.

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## **KEY TERMS AND DEFINITIONS**

**Competitive Advantage:** A firm creates more economic value than rival firms (Barney & Hesterly, 2010).

**Empirical Research:** Refers to research based on real world observations or experiments. It uses data gathered from naturally occurring situations or experiments, in contrast to research that is conducted via laboratory or simulation studies, where the researchers have more control over the events being studied (Flynn, Sakakibara, Schroeder, Bates, & Flynn, 1990; Scudder & Hill, 1998).

**Strategic Sourcing:** Defined as the process of planning, implementing, controlling, and evaluating highly important purchasing in an effort to meet a firm's goals (Carr & Smeltzer, 1999, 2000; Carr & Pearson, 2002).

**Supplier Selection:** Factors that an organization uses when selecting and evaluating key/preferred supplier's performance (Kannan & Tan, 2002).

**Supply Chain Management (SCM):** A process for designing, developing, optimizing, and managing the internal and external components of the supply system, including material supply, transforming materials and distributing finished products or services to customers, which is consistent with overall objectives and strategies (Mentzer, DeWitt, Keebler, Min, Nix, Smith, & Zacharia, 2001).

**Supply Chain:** A set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products and/or services from a source to a customer (Mentzer, DeWitt, Keebler, Min, Nix, Smith, & Zacharia, 2001).

**Survey:** A research design in which a sample of subjects is drawn from a population and studied (or interviewed) to make inferences about the population (Nardi, 2006).

**Textile-Apparel-Retail Supply Chain:** Refers to soft goods supply chain, which includes the manufacturing of textile or apparel products from the fiber stage through completion of end-use products, as well as the retailing or other distribution phases associated with making the products available to the consumer (Dickerson, 1999).

# Chapter 9

## A Three–Level Multiple–Agent Early Warning Mechanism for Preventing Loss of Customers in Fashion Supply Chains

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### ABSTRACT

*The fashion industry is experiencing rapid changes in many areas, including the supply chain. Typical quick response (QR) systems have been broadly used in the fashion industry to enable agile supply chain management (SCM). However, the original functions of QR systems cannot completely address the challenge of issuing early warnings to prevent customer loss. This article merges the typical MIS system development procedure with that of an e-SCM multiple-agent decision support system to confront this problem. The system has three levels: data mining, ontology, and decision support. These levels are interlinked in handling different databases. Different agents execute different tasks at each level to achieve integration and communication in a supply chain with less human intervention. The proposed framework emphasizes transparent connections among businesses and assists in information sharing, thereby preventing customer loss.*

### INTRODUCTION

Customers continually patronize businesses that provide excellent products or services. Moreover, businesses should build an early warning mechanism to prevent customer loss. Hence,

setting up an early warning mechanism in supply chain management (SCM) is important to ensure that business-to-customer (B2C) relations run smoothly.

In the fashion industry, the key to business survival is satisfying customer orders, regardless of

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the state of the economic environment. A business usually plays multiple tasks in the supply chain, including taking customer orders, processing these orders, and delivering the goods. In essence, the business collectively becomes a customer, retailer, wholesaler, distributor, manufacturer, and supplier.

One of the goals of SCM in the fashion industry is to manufacture products that adequately meet customer requirements, starting from the downstream supply chain (demand side) to the upstream supply chain (supply side). Another goal is to ensure that products can be efficiently produced and delivered from the upstream to the downstream. However, sometimes, an order has to move across different countries, creating an information gap between the demand and supply sides. This can have a negative impact on customers because they do not receive prior warning on the long-term distribution of the product they ordered.

The fashion industry features a very complex global supply chain (Lo, Hong, & Jeng, 2008). As such, SCM encounters some problems, particularly in information and logistics management.

### **Problems in Information Management**

The supply chain of the fashion industry faces a six-phase information management problem. The six phases are as follows:

- **Collecting information:** A data collection mechanism or an information system should be used to collect daily transaction data.
- **Storing information:** A software or a database management system should be adopted to store transaction data.
- **Integrating information:** Different data should be integrated together from different databases.
- **Analyzing information:** Analytical software is used to analyze data sets.

- **Explaining information:** Analytical results are explained to aid in decision making.
- **Delivering information:** Shared information is delivered to business partners based on their requirements.

For large enterprises, building an information system is relatively easy. However, most companies in the supply chain of the fashion industry are small and medium enterprises (SMEs), making any large-scale information system difficult to establish. Thus, they rarely use advanced information systems, such as enterprise resource planning (ERP), in their basic MIS infrastructure (Lo, Hong, & Hsu, 2006).

Building a complete information system usually requires large investment in purchasing information equipment, including software and hardware. Despite the prohibitive cost, some SMEs choose to invest in information systems to gain a competitive advantage.

In the same vein, any industry should improve its capability in information delivery and validity, as well as in efficiently handling quick response (QR) requirements and customer complaints. This explains why more and more retailers in the fashion industry use point of sales (POS) systems to obtain information on customer transactions automatically. Hence, having a robust information system has become an indicator of success, whether the business operates solely or connects with others in the upstream and downstream of the industry.

### **Problems in Logistics Management**

Logistics management also plays an important role in the supply chain of the fashion industry. It is divided into two categories based on the direction of objects: inbound logistics and outbound logistics. Inbound logistics represents the purchasing process of raw materials for a company. On the other hand, outbound logistics pertains to the distribution process of products from suppliers to

customers. In a supply chain, such as an integrated pipeline (Copacino, 1997), the three main activities are supply, operation, and distribution.

- **Supply:** It is concerned with the tasks of sourcing, purchasing, and transporting raw materials; handling parts inventory; and making effective deliveries. This part is called inbound logistics.
- **Operation:** It mainly conducts the processes of production with agile approaches. Its tasks include production planning, production scheduling, and process inventory.
- **Distribution:** It focuses on satisfying customer requirements. Among its tasks are forecasting, customer service, finished goods inventory, warehousing, and transportation. This part is also called outbound logistics.

As mentioned above, inbound logistics is the upstream of a supply chain. It provides raw materials for customers in the downstream for assembly, process, or manufacturing. In case raw materials are not delivered safely or on time, the downstream may run out of stock in emergency situations. Consequently, businesses consider ways to manage their suppliers effectively.

When inbound logistics has no problem with delivering raw materials for production, manufacturers can then control production planning and scheduling, and every production department can finish its tasks and check the quality of products. Finally, on the part of outbound logistics, a new product is produced by workers to be delivered to customers on time.

Thus, inbound and outbound logistics play different roles in SCM. Managing inbound logistics needs the understanding of suppliers, specifically on the production and delivery of raw materials. Sometimes the manager of suppliers needs to visit suppliers in the field to determine the consistency of processes.

In contrast, outbound logistics faces the pressure of dealing with customers directly. Consider this example. A wholesaler of fashion export products ships a container from Milan to a retailer in Hong Kong. However, a typhoon affects the scheduling, particularly the date of arrival. This creates two problems. First, the retailer in Hong Kong has to deal with an out-of-stock product situation. Its failure to replenish the stocks on time can ultimately result in customer loss. Second, the wholesaler's outbound logistics has failed to provide enough information on critical issues, such as the weather. This can lead to the loss of its own customer, the retailer.

Logistics should control detailed information from suppliers from the upstream to the downstream. If prompt and safe delivery cannot be guaranteed, then logistics will not be able to guarantee customer satisfaction. Only by continuously and consistently offering suitable services to customers can businesses survive, especially if they use IT in their SCM.

## **IT SOLUTIONS FOR PROBLEM OF SUPPLY CHAIN MANAGEMENT**

Businesses simultaneously deliver information to their upstream or downstream partners; they therefore approach the goal of reducing the bullwhip effect (Copacino, 1997). In practice, the bullwhip effect appears early in the textile, apparel, and fashion industries because information from the downstream is not delivered in real time to the upstream. Therefore, the dynamic requirements of customers are not captured at the same time. Consequently, customer loss increasingly occurs in unknown and uncertain situations, finally causing additional logistics cost and waste.

To resolve the problems associated with the bullwhip effect and uncertain information, the concept of SCM is implemented in the textile and apparel industries, and industrial partners use IT to make their supply chains more sustainable



(Sunhilde, 2008). However, the kind of IT that should be used in solving these problems in the long-term operations of the fashion industry is still debatable.

E-business technology in SCM provides businesses with strategic and tactical thinking directions (Vakharia, 2002). It allows businesses to achieve two major goals: ensure real-time information delivery and reduce paperwork cost. Ultimately, it enables businesses to make the right decisions at the right time.

Moreover, e-business technology plays an important role in the integration of heterogeneous information through different ways of communication to deliver correct information, enabling businesses to reduce both the time and cost of data processing and analysis. Numerous technologies are used in the design and development of information systems, and one of the most important of these is the application of agent or multiple agent systems in e-businesses (Huang, Chen, & Chen, 2006).

E-business technology can improve the speed of data processing and the sharing of real-time information with supply chain partners. However, traditional e-business technologies are focused on data processing; they rarely address customer behavior, such as customer interests and impressions. Hence, businesses that leave a poor impression on their customers after an unsatisfactory

purchase experience may consequently suffer from customer loss.

Therefore, we consider the use of IT as one of the solutions to SCM problems. Table 1 summarizes the key points.

## **AGENTS SYSTEM IN SUPPLY CHAIN MANAGEMENT**

A business in the fashion industry should not act like an isolated island in the supply chain. As mentioned earlier, the fashion industry has become global. In addition, the use of IT has become an important factor in enhancing competitive advantage in the global economy. In recent years, many studies have focused on efficiently handling information on SCM with the help of IT. Some have concentrated on applying artificial intelligence, such as agents, to solve problems in the supply chain. We briefly introduce these studies.

Recently, agent technology has been broadly used to assist business activities. An agent is an autonomous and computational entity. Agents can also work together (called multiple agents) to collect related knowledge and achieve a common goal (Weiss, 2000). They have different functions relevant to interactions designed for intelligent information systems. They are also widely used in many applications, such as e-commerce, real-time monitoring, modeling, information handling,

*Table 1. Information technology as a solution to problems in supply chain management*

<b>Side of supply chain</b>	<b>Function of supply chain</b>	<b>Solving early problems</b>
Supply	It is concerned with sourcing, purchasing, and transporting raw materials; handling parts inventory; and making effective deliveries. This part is called inbound logistics.	Early information on sourcing, purchasing, transporting, and inventory management
Operation	It mainly conducts the processes of production with agile approaches. Its tasks include production planning, production scheduling, and process inventory.	Early information on production planning, production scheduling, and process inventory
Distribution	It focuses on satisfying customer requirements. Among its tasks are forecasting, customer service, finished goods inventory, warehousing, and transportation. This part is also called outbound logistics.	Early information on forecasting, customer service, finished goods inventory, warehousing, and transportation

automated meeting scheduling, e-learning, electronic data interchange (EDI), extensible markup language (XML), and SCM.

For example, Turowski (2002) asserted that mass customization with a multi-agent system is supported by the Internet. He found that XML-based EDI can contain enough information, and through different agents, it can assist and achieve the goal of data interchange.

Other related works on agent systems are briefly reviewed as follows:

1. Researchers assert that agents have a great value in supply chains (Walsh & Wellman, 1999). For instance, functional agents, as well as the proposed negotiation-based multi-agents in framework-based SCM systems, are known to be playing crucial roles in supply chain management (Chen et al., 1999). There is a simulation-based framework (Swaminathan, Smith, & Sadeh, 1998) for developing customized supply chain agent models from a library of software components. In this framework, supply-chain agents are designed to play different roles as retailers, manufacturers, and transporters for effective inventory control. In addition, a re-configurable, multi-level, agent-based architecture, called MASCOT (multi-agent supply chain coordination tool), was developed and studied in the literature to coordinate supply chain planning and scheduling (Sadeh et al., 1999).
2. Researchers have designed a multi-resolution collaborative architecture, in which several kinds of agents—including interface agents, collaboration agents, knowledge management agents, domain agents, and resource agents—can communicate and collaborate (Wu et al., 2000). In fact, a collaborative agent system architecture was developed as the general architecture of web-based multi-agent systems for managing more and more complex supply chains (Shen et al.,

1999). In particular, agent-based e-markets for supply chain coordination, which follow a four-phase research approach, are now available. These four phases include multi-lateral negotiation protocol for e-markets, e-market ontology, protocol for multi-agent e-markets, and verification and evaluation (Kim, Paulson, & Petrie, 1999). An agent-based software system was proposed to assist in SCM decision making, as well as in the efficient and effective use of EDI (Pathak, Nordstrom, & Kurokawa, 2000). Hendler (2001) assert that web agents can widely be applied in Web services. Accordingly, these agents play an important role in SCM for B2B e-commerce. He and Leung (2002) conduct an in-depth literature review on studies of agents in e-commerce (B2B and B2C) and negotiation protocol. An e-supply chain model was developed for Web services (Singh, Iyer, & Salam, 2002). In their model, two kinds of agents, known as discovery agents and transaction agents, play different roles in the supply chain. The model also extends the kinds of agents from two to five, including discovery agents, transaction agents, buyer agents, supplier agents, and monitoring agents.

Despite having new advances in multi-agent systems for QR supply chains, the supply chain of the fashion industry changes very quickly which means the original functions of many QR systems cannot completely address the challenges of effective customer relations and service quality. It thus calls for further research.

Based on the literature review, we find that multiple agents can work together to achieve a common goal. Although most research studies emphasize applications of multiple agents to different sides of the supply chain, they rarely discuss the ways of building a mechanism for early and autonomous warning.

In this article, we focus on designing a system that combines the methods of ontology, agents, and data mining. The system efficiently integrates data and information on an early warning mechanism to prevent customer loss in fashion supply chains.

### MAIN FOCUS OF THE ARTICLE

As mentioned previously, problems exist in B2B and B2C supply chains. This section presents an e-SCM multiple-agent decision support system that focuses on solving B2C problems in supply chains. As an example, we concentrate on solving the early warning problem to prevent the possible loss of customers in the B2C supply chain.

Our proposed e-SCM multiple-agent decision support system considers the above issues, as it can automatically and effectively perform both electronic processes and information management at the same time. Most of these automatic units (agents) in the system can move quickly and compile information correctly. The detailed description of the proposed e-SCM multiple-agent

decision support system is presented in the following section.

### Goal of System Design

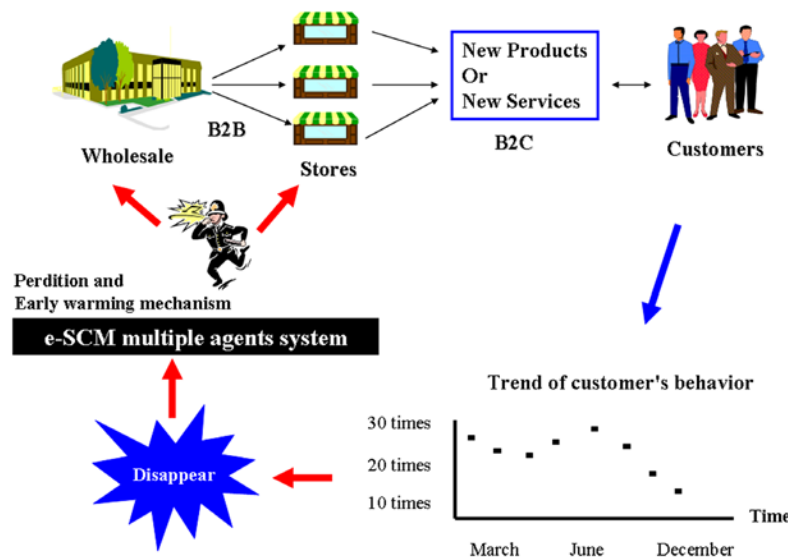
Business managers rarely think of building an early warning mechanism to understand the after sales behavior of customers. Hence, our goal is to design an e-SCM multiple-agent decision support system as an early warning mechanism in B2C supply chains.

Usually, when customers encounter negative experiences and impressions, they may choose to leave and not to return. Managers or decision makers have little knowledge of this situation. Thus, designing an e-SCM multiple-agent decision support system as an early warning mechanism can provide enough information for wholesalers (businesses) to become familiar with such situations.

With early warning information, wholesalers can make suitable decisions for salespeople in each store. In turn, salespeople can prepare good ideas and solutions to hold on to possibly lost customers before they leave.

An example is shown in Figure 1.

Figure 1. The designed goal of solving the early warning problem for possibly lost customers



In Figure 1, the prediction and early warning mechanism is based on an e-SCM multiple agent system. Why should wholesale and retail companies have an e-SCM multiple agent system? Clearly, in such a system, multiple agents work autonomously and collaboratively; they collect transaction data from customers, identify the trend of customer behavior, and determine whether such behavior will possibly change or disappear (in the figure, the customer visited 30 times until the number of visits decreased to 10).

Additionally, why do businesses need an early warning mechanism? This has to do with efficiency and promptness, which characterize the fashion industry, especially well-known fashion capitals, such as New York, Milan, and Paris. In the fashion industry, designing a practical early warning mechanism is essential to success.

**Design of System Functions**

The proposed design of the system functions for an early warning mechanism consists of three levels: data mining, ontology, and decision support (Lo et al., 2006). Each level is designed for approaching an early warning multiple agents system. The relationships of the three levels are shown in Figure 2. The functions of the three levels play different roles, as described below.

- **Data mining level:** At this level, data are collected from different transactions in shops, and they are stored in databases. All the transaction data in the databases are then delivered to the data warehouse. System managers then remove useless data or information before inputting all the data into the data mining mechanism to find rules or regularity. Our goal is to find the common features of possibly lost customers; hence, some classification or association-mining algorithms are adopted.

As an example, given a transaction database (Table 2), a concept hierarchy (Figure 3), and its corresponding customer sequences (Table 3), the problem of mining cross-level sequential patterns is to discover the following cross-level sequences:  $\langle(1^{**}), (11^*)\rangle$ ,  $\langle(11^*), (1^{**})\rangle$ ,  $\langle(11^*), (2^{**})\rangle$ ,  $\langle(11^*), (1^{**}, 2^{**})\rangle$ ,  $\langle(1^{**}), (111)\rangle$ ,  $\langle(11^*), (111)\rangle$ , and  $\langle(11^*), (21^*)\rangle$ . These sequences are in addition to the multiple-level sequences at the same concept level:  $\langle(1^{**})\rangle$ ,  $\langle(2^{**})\rangle$ ,  $\langle(1^{**}, 2^{**})\rangle$ ,  $\langle(11^*)\rangle$ ,  $\langle(21^*)\rangle$ ,  $\langle(11^*, 21^*)\rangle$ ,  $\langle(111)\rangle$ ,  $\langle(211)\rangle$ ,  $\langle(111, 211)\rangle$ ,  $\langle(1^{**}), (1^{**})\rangle$ ,  $\langle(1^{**}), (2^{**})\rangle$ ,  $\langle(1^{**}), (1^{**}, 2^{**})\rangle$ ,  $\langle(11^*), (11^*)\rangle$ , and  $\langle(11^*), (11^*)\rangle$ .

- **Ontology level:** When some classification or association rules have been learned, they can then be used to help determine possibly lost customers. However, determining possibly lost customers is not an easy job for system managers. In addition to the rules, sales experience and domain knowledge are also very important.

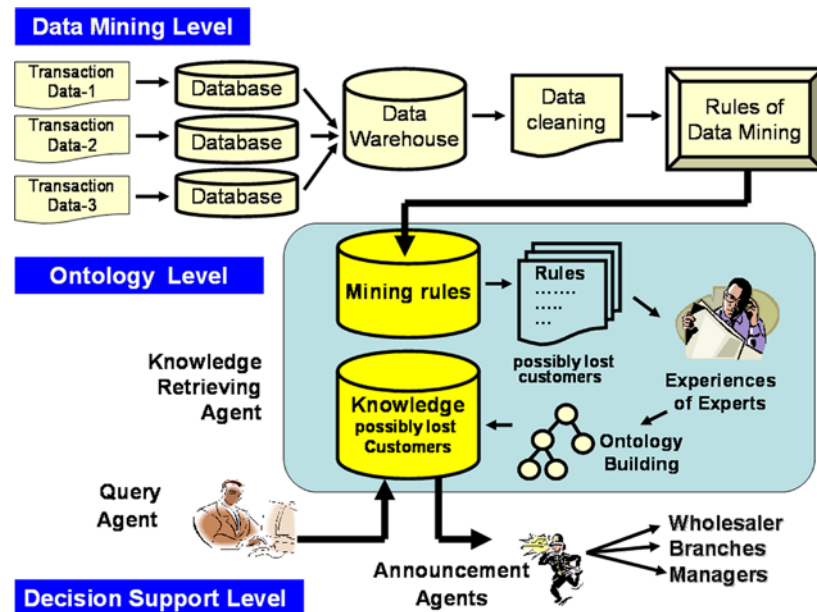
*Table 2. Original transaction database*

CID	Time	Item Bought
1	2002.03.01	111, 211
4	2002.03.11	211, 323
3	2002.03.13	111, 211, 313
4	2002.03.15	323, 421, 534
1	2002.03.17	111, 222
2	2002.03.21	112, 411
2	2002.03.31	111, 231

*Table 3. Customer sequences*

CID	Customer Sequences
1	(111, 211), (111, 222)
2	(111, 411), (111, 231)
3	(111, 211, 313)
4	(211, 323), (323, 421, 534)

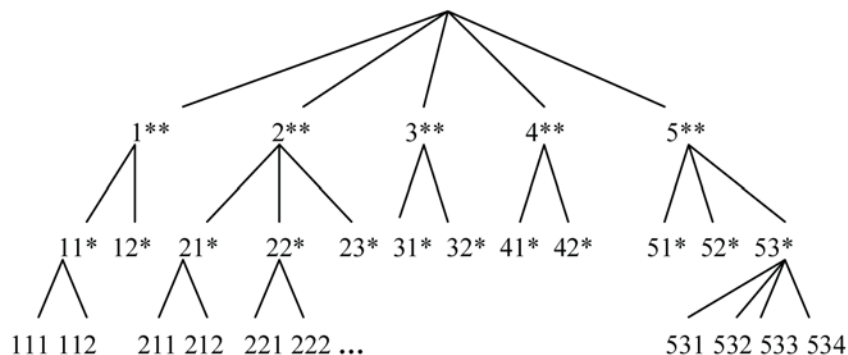
Figure 2. Three levels of function design for the e-SCM multiple-agent decision support system



Therefore, system managers may utilize suitable ontological knowledge to determine possibly lost customers based on the mined rules and experiences of domain experts. Thus, a knowledge retrieval agent functions according to this knowledge to retrieve some related features of customers when managers need to know which customers are most likely to leave or to be lost.

- Decision support level: Two kinds of agents are designed at this level: the announcement agent and the query agent. The announcement agent announces the warning, which includes the sales volume of each branch company, precise time of customers' leaving, and the features of customer loss (e.g., consumption of time and money). The query agent is different from

Figure 3. Concept Hierarchy



the announcement agent because it uses a knowledge base to answer user queries.

- Feedback: Although Figure 3 shows a one-way direction from data mining level to ontology level to decision support level, the function of feedback is needed when the running results are not accepted by wholesalers, branches, and managers.
- Evaluation: The proposed system should evaluate its functions at each level because a traditional system is rarely able to evaluate its functions after implementation. When only the daily operating system is considered and its performance is ignored, the system will easily become an island of information. What criteria should be used in the evaluation? We suggest that managers consider the criteria of the six phases of information management (collecting, storing, integrating, analyzing, explaining, and delivering information). The criteria are presented in Table 4.

**IMPACT AND FUTURE RESEARCH DIRECTIONS**

In recent years, the issue of improving the business performance of SCM in the fashion industry has been heavily discussed. Good supply chain

management not only effectively manages businesses, but also provides new solutions and opportunities (Lo, 2009).

With the aid of IT, businesses can have good opportunities to obtain a bigger market share and maintain good relations with suppliers in the upstream and with customers in the downstream of the supply chain. Therefore, SCM has become a methodology for improving the competitive advantage of large enterprises and SMEs (Lo, 2003).

In the United States, some apparel manufacturers and retailers use QR systems to improve the efficiency of the data delivery process. The system is broadly used in various sectors, such as health care (e.g., hospitals), tourism and hospitality (e.g., hotels), manufacturing, and public service (e.g., governments). In particular, an information system-enabled SCM creates a strong supply chain in the fashion industry.

In this article, we develop our own work based on previous research. In the future, we will continuously develop other multiple agent systems in addition to the early warning system.

Security and privacy have become very popular issues in recent years. If more researchers focus on related works, the functions of multiple agent systems will surely be discussed more thoroughly.

Kamaladevi (2010) believed that radio frequency identification (RFID) is the best technology for SCM, and the system supports various

*Table 4.*

Phases of information management	Criteria
1. Collecting information	How should we collect information, by POS or other IT tools?
2. Storing information	How should we store information, by databases (distribution or centric) or warehouse management system?
3. Integrating information	How should we integrate information, by CRM (customer relationship management system) or ERP?
4. Analyzing information	How should we analyze information, by data mining or OLAP (online analytical processing)?
5. Explaining information	How should we explain information, by system agents who will create the results or domain experts who will explain with their experiences?
6. Delivering information	How should we deliver information, by system agents through their achievements or information engineers who use e-mails to make announcements?

business processes, not all of which guarantee personal privacy.

Suresh and Kesavan (2010) indicated that RFID technology is currently used in many applications; including security and access control, transportation, and supply chain tracking. However, specific security risks, such as information leakage and data inconsistency, arise along the entire supply chain.

## **CONCLUSION**

Today, any economic activity is related to the global supply chain. Clearly, the global financial crisis affects not only the United States but also countries in Europe and Asia. Thus, the level of many economic activities has decreased recently, seriously affecting SCM. This decline in economic activities is causing remarkable changes in the structure of industries.

Many SMEs may not be able to survive the current financial crisis, and some suppliers, manufacturers, and retail companies may even disappear. These enterprises, however, play an important role in the economy, sometimes as suppliers and at other times as customers. Through the help of IT, these enterprises can improve their competitive advantage.

Our experience in designing an e-SCM multiple-agent decision support system can assist companies in solving SCM problems, such as those related to early warnings. This article has illustrated an e-SCM multiple-agent decision support system for early warning in a B2C supply chain.

The intelligent system can efficiently integrate data and autonomously deliver information in a supply chain. There are three levels in the design: data mining, ontology, and decision support. These levels are linked together to integrate access tools, data formats, management information systems, and databases. Different agents execute different tasks at each level to achieve integration and communication in a supply chain with less human intervention.

Our approach emphasizes the transparent connection between businesses and customers. Whereas traditional information exchange is unidirectional, our proposed approach allows different companies to exchange information simultaneously. These characteristics are useful to SCM in the fashion industry.

## **ACKNOWLEDGMENT**

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## KEY TERMS AND DEFINITIONS

**Supply Chain Management:** The management of the chain that connects from customers, stores, manufacturers to suppliers. Each role acts as a separate partner in the chain.

**e-SCM:** Electronic supply chain management that uses information technology in the management and easily connects suppliers and customers together through the technology.

**Multiple Agents:** A technology commonly used in building an intelligent system. An agent is an autonomous and computational entity, while multiple agents are identified as many single agents working together with different functions.

**Agents System:** The system with multiple agents working inside. The multiple agents work together to collect related knowledge and achieve a common goal.

**Customers Lost:** the customers who do not come to the store to purchase anything again.

**Data Mining:** A technique to automatically find implicit knowledge from a set of data.

**Ontology:** An approach for representing domain knowledge of an event. It has recently been widely applied to web service, semantic web, e-learning, and web mining.

**Decision Support System:** A computer system that contains confidential or useful information to assist managers in making good decisions.

# Chapter 10

## Time–Constrained Fashion Sales Forecasting by Extended Random Vector Functional Link Model

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### ABSTRACT

*Forecasting is about providing estimation of the future that cannot be observed at the moment. In this chapter, the random vector functional link (RVFL), which is a variation of the artificial neural networks (ANN) model, is used in establishing a fashion sales forecasting model. It is well-known that the RVFL inherits the learning and approximation capability of ANN, while running much faster than the traditional ANN. In order to develop a real world forecasting application, we propose a time-constrained forecasting model (TCFM), implemented by an extended RVFL, in which the user can define the time limit and a precision threshold for yielding the forecasting result. Real datasets collected from a fashion retail company are employed for the analysis. Our experiment has shown that the proposed TCFM can produce quality forecasting within the given time constraint. Future research directions are outlined.*

### INTRODUCTION

Forecasting is about predicting the future based on the past historical data. It is important in all kinds of applications. It is especially important in industries such as fashion retailing because of the

ever changing market needs and fashion trends. However, it is usually a tremendously difficult task as the future is truly unknown in many situations (Sztandera et al., 2004). Many statistical (Abraham & Ledolter, 1983) and mathematical (Frank et al., 2002) models are applicable for the purpose of

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forecasting. Techniques such as averaging over a horizon, moving average, Bayesian approach, and exponential smoothing (Hanke & Wichern, 2009) are all well-studied in the literature. Many of these statistical models are still being actively used in everyday's application and are proven to be useful and fast. The Artificial Neural Network (ANN) is originated from the mathematical model that simulates the structure and functions of biological neural networks. ANN has demonstrated superior performance in optical character recognition, speech recognition, signal filtering in communication networks and so on (Hansen & Nelson, 1997; Bhagat, 2005; Masters, 1994). ANN is also powerful in making prediction about future events or processes (Cortez et al., 1995; Zhang et al., 1998), including sales forecasting (Yu et al., 2010a). Essentially, ANN has been used as a non-linear data-modeling tool based on its capability of learning and finding sophisticated patterns from historical data. The typical ANN models apply gradient learning mechanisms and have to repeatedly run and fine-tune their parameters so as to learn the patterns from data well (Hertz, 1990). While the ANN models are capable of modeling both linear and non-linear models, they are often much slower compared to the traditional statistical models. There have been many efforts devoted to improving the efficiency of ANN, and many of them concentrate on the learning algorithm (MacKay, 2003). For instance, a new learning algorithm has been proposed recently based on neuron-by-neuron computation methods for the gradient vector and the Jacobian matrix (Wilamowski, 2008). The algorithm can handle ANN with arbitrarily neurons, and its training speed is much faster than the other algorithms. Although the neuron-by-neuron computation method is faster, it suffers a major limitation on its convergence ability. To be specific, there is a significant probability that the algorithm will fail to converge the global minima, so that the algorithm has to repeat from the very beginning. Although

there are solutions for this, the algorithm is not as fast as it can be.

In the literature, the single-hidden-layer feed-forward neural networks (SLFN) is one of the commonly used ANN tools in forecasting as it has been proven to be capable of approximating an arbitrary function. A novel learning algorithm for the SLFN, called extreme learning machine (ELM), has been proposed and explored recently (Huang et al., 2006; Sun et al. 2007). The ELM is originated from the method known as random vector functional link (RVFL) (Pau et al., 1994). In RVFL, an analytical approach is employed in finding the weights of the network in the learning process. The RVFL not only learns much faster than the traditional gradient-based learning algorithms but it also avoids many notorious problems faced by gradient-based learning methods such as stopping criteria, learning rate, learning epochs, local minima, and the over-tuned problems. Hence, the RVFL model significantly reduces learning time. Even though the RVFL has many advantages compared to those traditional gradient-based learning ANN algorithms, it suffers a disadvantage of having unstable outputs. To overcome this problem, in (Sun et al., 2008), an extended RVFL model, which repeatedly runs the RVFL, is proposed. The experimental findings in (Sun et al., 2008) indicate that this extension usually yields a smaller forecasting error. In this paper, an extended RVFL based time-constrained forecasting model (TCFM) is proposed. We specifically consider the case when the user can inputs two important parameters: (i) The time limit which governs the computation time for conducting forecasting, and (ii) the precision threshold. In this exploratory study of the TCFM for fashion sales forecasting, we employ real dataset from the industry to test the performance of the proposed algorithm. Our experiment has shown that the proposed system is effective and efficient for fast forecasting problems. Future research directions are outlined.

### The Time-Constrained Forecasting Model (TCFM)

In this section, we discuss the TCFM. In the following analysis, a daily sales time-series data collected from a fashion retail company is studied and seven weeks time-series data points are used. The forecasting problems are often closely related to time, in that forecasting is about foreseeing future, and therefore the forecasting work must be finished before the future time point have already passed. For example, forecasting for expected sales of the next week by the data of past weeks often have to be started after the data of past weeks are collected, and be finished before the next week begins, i.e. to be finished within hours or days. Another example is forecasting for control problems, where forecasting is used as indicator for control actions, and such forecasting must be finished within very short time in terms of seconds. Consequently, the time constraint is the key factor of TCFM. In the TCFM, we need to determine the number of repeated running the RVFL (with given number of hidden neuron and the size of training data) for forecasting. With respect to the literature (Yu et al., 2010c), it is known that the total forecasting time  $t$  required by running the RVFL  $P$  times is a linear function of  $P$ . In order to fulfill the time constraint, under the TCFM, an upper bound for  $P$  can be determined by finding the maximum possible value of  $P$  which meets the time limit  $T$ . Using the dataset, Figure 1 depicts the relationship between forecasting error (in terms of Mean Square Error (MSE)) and  $P$ .

It is well argued that the forecasting error tends to drop as  $P$  increases. In our experiment, as shown in Figure 1, there are sharp drops of forecasting error when  $P$  is small, and the variations become rather stable afterwards. This gives guidance on how to set the appropriate  $P$  in our model: While a large  $P$  makes the forecasting stable, the optimal  $P$  need not be very large. Based on the above analysis, an algorithm of setting the optimal re-

peating time  $P$  is devised and the details are shown in Figure 2.

As shown in Figure 2, the algorithm starts with a given initial value of  $P$  as  $P_0$ . The extended RVFL algorithm is run two times, with repeating time of 1 and  $P_0$ , respectively. The initial difference of error is calculated by  $\Delta E = |E_1 - E_{p_0}|$ . Parameter  $P$  is increased by 1, the previous value of  $P$  is denoted by  $p'$  and the error of the extended RVFL with  $p'$  is represented by  $E_{p'}$ . The extended RVFL (RVFLE) runs with a new value of  $P$ , and the error is called  $E_p$ . Hence the error difference is given by  $\Delta e = |E_{p'} - E_p|$ . The new difference of error is compared with the initial error difference by  $\Delta e < c\Delta E$ . Here  $c$  is a constant, precision threshold, which is given in advance. In our analysis,  $c = 0.1$  is used as it is able to determine whether the error becomes stable with larger  $P$ . If the previous comparison result is true, the change of error with increasing  $P$  is considered as small, and hence the algorithm stops with the current value of  $P$  as the optimal value. Otherwise, if the comparison result does not satisfy  $\Delta e < c\Delta E$ , the algorithm loops back with  $P$  incremented by 1 until the optimal  $P$  is found. During the loop, the expected time is compared against the given time limit  $T$ , the algorithm will end if the expected time exceeds time limit  $T$ .

*Figure 1. The relationship between forecasting error and  $P$*

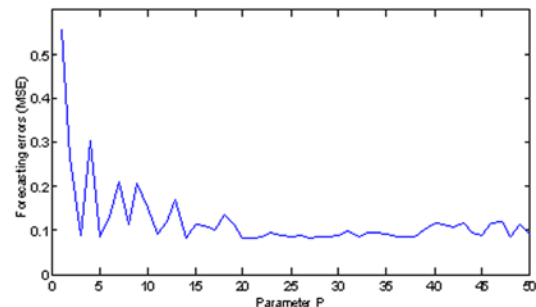


Figure 2. Flowchart for determining optimal  $P$  in the TCFM

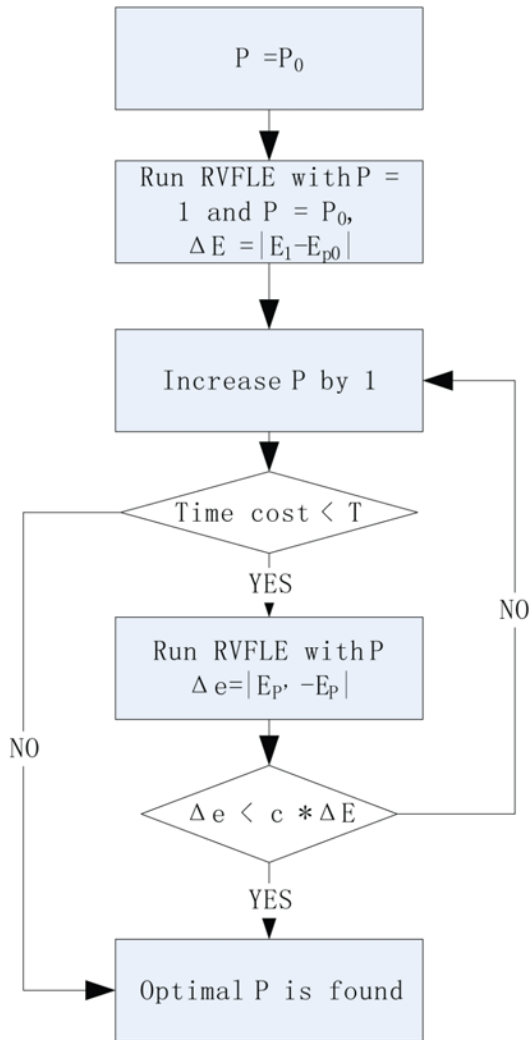


Figure 3. The sales data sample (daily)

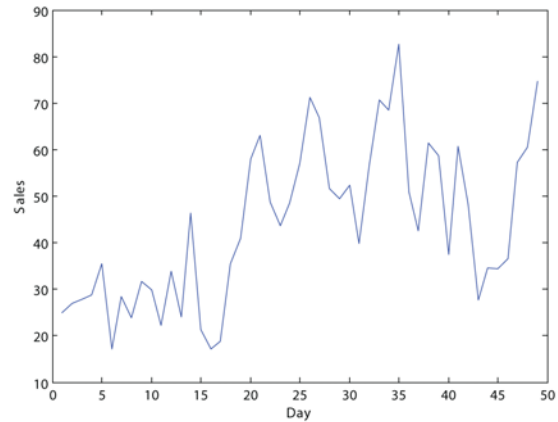
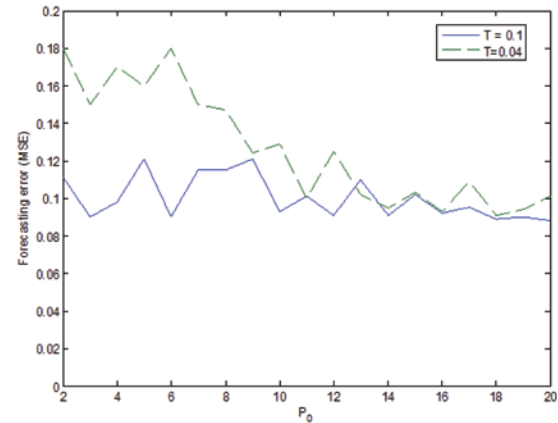


Figure 4. Forecasting error of the TCFM with different  $P_0$

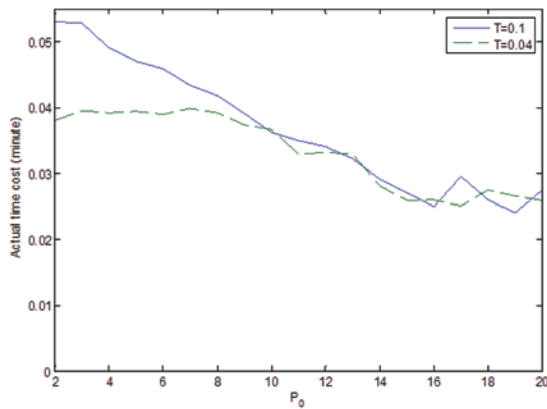


## Experimental Results

The propose algorithm is tested with the sales data given in Figure 3, and the experimental results are presented in Figure 4 and Figure 5. Two time limits  $T=0.1$  minute and  $T=0.04$  minute are used respectively. With each time limit, the algorithm runs with different  $P_0$ , ranging from 2 to 20. The forecasting errors are depicted in Figure 4. At  $T=0.1$ , the errors are generally fluctuating, and the

fluctuation becomes small when  $P_0$  is greater than a value around 16. With  $c=0.1$ , the algorithm finds the optimal  $P \approx 16$ . At  $T=0.04$ , the forecasting errors are greater than the errors at  $T=0.1$  and  $P_0 < 8$ , and the errors at  $T=0.04$  are close to the errors at  $T=0.1$  and  $P_0 \geq 8$ . It is because, with a short time limit, the algorithm does not have enough time to find the optimal  $P$ , and the lower value of  $P$  would lead to a higher forecasting error. The actual time is depicted in Figure 5. At  $T=0.1$ , the actual computation time also drops while  $P_0$  increases until  $P_0 < 16$ . Under this condition, a

Figure 5. Actual computation time of the TCFM with different  $P_0$



greater value of  $P_0$  makes the process of finding optimal  $P$  faster. However, after  $P_0 < 16$ , the actual computation time does not drop but goes up as the greater value of  $P$  introduces a longer time of running the algorithm. At  $T=0.04$ , a “flat pattern” in the computation time occurs until  $P_0 < 8$ . Under this condition, the algorithm manages to meet the time limit  $T$  with smaller value of  $P$ . With  $P_0 \geq 8$ , the actual computation times are almost the same as that with at  $T=0.1$ . This experiment shows that with the proposed algorithm, smaller forecasting error can be reached within the pre-defined time limit with a systematic scheme of selecting  $P$ .

**CONCLUSION**

In this paper, a time-constrained forecasting model (TCFM) for fashion sales forecasting is developed based on the extended RVFL model. The number of repeated running of the RVFL is selected with respect to the required time limit and the precision threshold determined by the user. Real time-series dataset of daily sales collected from a fashion retail company are used in this study. Our experiments have shown that the TCFM is capable of producing quality forecasting

within the required time limit for sales forecasting problems. Moreover, we find that the choice of the parameter  $P_0$  influences the forecasting accuracy. Future research can be conducted in several ways. Firstly, it is important to provide a scientific rule on the optimal determination of the parameter  $P_0$  (some results are found in our on-going work, see Yu et al., 2010c). Secondly, more datasets should be employed in verifying the performance of the TCFM. Thirdly, it will be interesting to explore the extension with customization of the TCFM’s from fashion sales forecasting to other domains such as color trend forecasting (Lin et al., 2010), and control loading prediction problems (see Yu et al., 2010b). Finally, detailed implementation steps for developing TCFM into a real decision supporting application (Thomassey et al., 2005) should also be investigated.

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## **KEY TERMS AND DEFINITIONS**

**Decision Support System (DSS):** Is a computer-based information system that supports business or organizational decision-making activities.

**Random Vector Functional Link:** Is a variation of ANN which implements functional like neural network with random vector.

**Sales Forecasting:** Is a quantitative prediction of the future sales pattern.

**Time-Constrained Forecasting Model (TCFM):** Forecasting tasks are often with time constraints, and the TCFM model takes the time

constraints into account to produce accurate forecasting within limited time, hybrid models are employed in the forecasting.

## **ENDNOTE**

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## Section 3

# Exploratory Study and Case Research

*Most scientific research in FSCM is inspired by real cases and industrial exploratory studies. This section presents a number of different studies, including cases, on many timely and emerging issues related to FSCM. It is expected that more future research, including many probable quantitative analyses, will be motivated by these cases and exploratory studies.*

# Chapter 11

## Fast Fashion Business Model: What, Why and How?

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### ABSTRACT

*The greatest difficulty any apparel company encounters is managing demand uncertainty and controlling strategic consumer behaviors (consumers' propensity to delay purchase intentionally until a sale occurs). Fast fashion retailers, however, have overcome these challenges by supplying the small quantities of latest fashion with agility, which has resulted in profitable revenue gains. This paper reviews what a fast fashion model is, why a fast fashion business model is becoming prominent in today's apparel business, and how the supply chain is managed in a fast fashion business model. By examining the operation strategies of two successful fast fashion retailers (Zara and H&M), this study concludes with the elements of the fast fashion business model that can be effectively adopted by fashion retailers and future of fast fashion business model.*

### INTRODUCTION

The apparel industry is indeed a dynamic business. The industry is characterized by demand uncertainty resulting from the high variation in styles and consumer tastes and the handling of

numerous SKUs (Stock Keeping Unit, the most detailed level of product specification) in a season, which makes it impossible to forecast demand accurately. Therefore, the ability to manage uncertain demand is a critical element of success for the industry (Hayes & Jones, 2006). Another challenge the apparel industry faces is the consumers' propensity to delay purchase intentionally until

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a sale occurs, which leads to fewer sales at full price, automatically eroding retailers' margins and drastically reducing profitability. Such consumer behavior is referred to as strategic or rational consumer behaviors in academic literature (Cachon & Swinney, 2009; Rozhon, 2004). Thus, another important success element in the apparel industry is how to control the strategic consumer behaviors and have them purchase at the initial full price.

Most fast fashion retailers (e.g., Zara, H&M, Forever 21) outperform non-fast fashion retailers (e.g., Gap, Ann Taylor). The average profit margins of fast fashion retailers are 16%, compared to 7% for the typical specialty apparel retailer (Sull & Turconi, 2008). Over the last five years, Zara (Inditex) and H&M have attained a 19.2% and 8.4% annual growth rate, respectively. In the

same period, Gap, Inc. has experienced a negative growth of -1.7% (Datamonitor, 2008; Gap, Inc., 2009; Hoover's, 2009a; Hoover's, 2009b; H & M, 2009; Inditex, 2009), resulting in Inditex's annual growth rate being nearly 20 times that of Gap, Inc. (Table 1). All three companies are comparable in the list of the 2008 top 250 global retailers in terms of sales volume: Inditex ranked 54, H & M ranked 60, and Gap, Inc. ranked 53. The group net income of Inditex (US\$1,842 million), however, is almost twice that of Gap, Inc. (US\$967 million) in 2008 (see Table 1). Gap, Inc. has also lost its brand share in the world apparel market, while Zara and H&M have both been growing steadily (Figure 1).

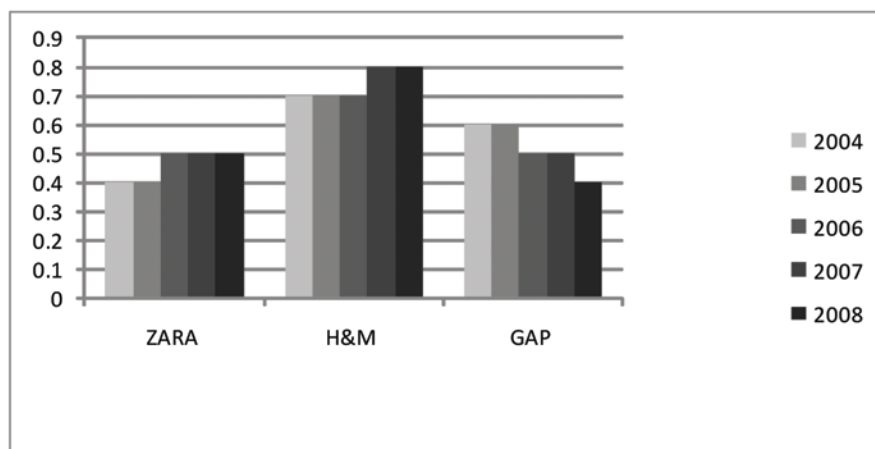
This paper regards the success of fast fashion apparel retailers as a result of solving two main

*Table 1. Financial Performance of Inditex, H&M, and Gap, Inc. as of 2008*

	<b>Inditex</b>	<b>H&amp;M</b>	<b>Gap, Inc.</b>
Sales rank among the top 250 global retailers as of 2008	54	60	55
2008 group revenue (US\$ million)	15,194	23,084	14,526
2008 retail sales (US\$ million)	15,048	14,154	14,526
2008 group net income (US\$ million)	1,842	814	967
2003-2008 retail sales compound annual growth rate	19.2%	8.4%	-1.7%

Source: Developed by authors based on information available at [www.deloitte.com](http://www.deloitte.com)

*Figure 1. Brand Shares (Market Shares) in the World Apparel Market. Source: Euro-monitor: <http://www.portal.euromonitor.com/Portal/ResultsList.aspx>*



## ***Fast Fashion Business Model***

challenges of the apparel industry: managing demand uncertainty and controlling strategic consumer behaviors. Fast fashion retailers solve the demand uncertainty issue by providing quick response (QR) by closely matching supply with uncertain demand. With regard to controlling strategic consumer behaviors, fast fashion retailers provide small quantities of highly fashionable trendy designs at reasonable prices, which increase consumers' willingness to pay full price. In short, *supplying small quantities of the latest fashion with agility* is the key to explaining the fast fashion retailers' success.

Fast fashion retailers' approach is fundamentally different from traditional fashion business models, as it essentially rewrites the success rules in the retail world and suggests how apparel retailers can effectively manage their supply chains. To fully understand their business model, this paper reviews *what* distinguishes the fast fashion business model from the traditional fashion business model, *why* the fast fashion business model is well-accepted in today's apparel business and *how* fast fashion companies successfully operate their businesses. While other factors such as market positioning are related to the success, this paper focuses on analyzing the supply chain management activities of two leading fast fashion retailers, Zara and H & M. In analyzing the SCM activities, this study is based on Lee and Kincaid (2003)'s categorization of SCM activities. They categorized SCM activities into six dimensions: knowledge of demand characteristics, utilization of information technology (IT), flexibility of operations, collaborative partnerships between chain members, service and performance, and top management commitment and leadership. Among these dimensions, this paper will focus on the first four aspects of SCM activities: knowledge of demand characteristics, utilization of information technology, flexibility of operations, and collaborative partnerships between chain members.

This paper begins with the two company overviews, followed by the concept of fast fashion business models (*what*) compared to existing fashion production systems, and the discussion of the *why* and *how* aspects of the fast fashion business model. This paper concludes with the elements of the fast fashion business model that can be effectively adopted by fashion retailers and future of fast fashion business model.

## **TWO COMPANY OVERVIEWS**

### **Zara**

Zara is the flagship brand of the Spanish retail group Inditex, comprised of over one hundred companies associated with the business of textile design, manufacturing, and distribution (Inditex, 2009). As the biggest and most profitable company in the Inditex group, Zara is present in 79 countries with a network of 1,520 stores in prime locations in major cities (Hoover's, 2009b), accounting for roughly two-thirds of Inditex sales (Murphy, 2008). Zara retains ownership of 90% of its stores (Sull & Turconi, 2008) and uses franchise only in risky countries or in countries where wholly owned is not allowed (Tokatli, 2008).

Zara believes in delivering quick, inexpensive, fashionable, and stylish garments to its target market, rarely runs sales and shuns advertising. Zara is a vertically integrated company, meaning that it is engaged in different aspects of production and management in-house (Ghemawat & Nueno, 2006). Such an approach is uncommon in the industry outside of the luxury segment (e.g., Gucci, Louis Vuitton, etc.). Vertical integration is not often recommended in most mature industries because of associated problems: inflexible commitment of assets (i.e., tying up large capital resources) and a greater risk of plant obsolescence as well as management problems (Richardson, 1996). Zara,

however, effectively combines its vertical integration system with outsourcing to handle demand uncertainty issues. For example, about 40% of the finished garments are manufactured internally and the remaining garments are outsourced, and 40% of its own fabric and most of its dyes are purchased from its own subsidiary companies (Gallaugh, 2008), which creates a tremendous amount of operational flexibility and helps close control over its operations. More details will be discussed under “how” section.

## **H&M**

Founded in 1947 in Sweden, H&M (Hennes and Mauritz) is a high performing competitor of Zara (Ghemawat & Nueno, 2006). The company is also known for featuring trendy, fashionable items at a reasonable price and actively internationalizing its business, operating 1,738 stores in 35 countries. As with Zara, all the H&M stores are managed by H&M, except in countries where wholly-owned is not permitted (Indu & Govind, 2008). One clear difference between H&M and Zara is that H&M does not own any factories or manufacturing units. H&M “outsources all its products with half of it from European suppliers, implying that lead times are good by industry standards but significantly longer than Zara’s” (Ghemawat & Nueno, 2006, p.5). This extra time gives the company a cost advantage thus clothes prices at H&M are 30-50% lower than at Zara (Indu & Govind, 2008). Another factor that sets H&M apart from Zara is its collaborative partnerships with well-known fashion designers. These began in 2004 with Karl Lagerfeld and have since included partnerships with designers, such as Stella McCartney, Viktor and Rolf, Matthew Williamson, Commes des Garçons, Roberto Cavalli, Jimmy Choo, and celebrities such as Madonna and Kylie Minogue. Such partnerships with the world famous fashion designers boost H&M’s brand image as well as its profits.

## **FAST FASHION BUSINESS MODEL: WHAT**

Fast fashion retailing is often referred to as fashion McDonaldization (Ritzer, 2008) because it has features similar to a McDonald’s fast food restaurant. McDonaldization is “the process by which the principles of the fast-food restaurant are coming to dominate more and more sectors of American society, as well as the rest of the world” (Ritzer, 2008, p.1), and it produces societies that are more efficient and fast-paced. As with McDonald’s taking only a couple of minutes to produce ordered food, fast fashion retailers have efficient and agile supplies that allow them to produce merchandise in three to four weeks, in contrast with the typical nine month timing of mass fashion retailers. Also, just as McDonald’s products are reasonably priced with moderate quality, the merchandise produced by fast fashion retailers is regarded as inexpensive, “not excessive physical quality, and clothes to be worn ten times” (Ghemawat & Nueno, 2006, p.13). This concept is different from traditional fashion retailers, which focus on quality that can be worn for a long time. This analogy seemingly describes the fast fashion; however, it misses one important element of fast fashion.

Fast fashion is defined as “various strategies to respond commercially to *the latest fashion trends*” (Moore & Fernie, 2004, p. 31). In a similar manner, Byun and Sternquist (2008) defined the fast fashion approach as a marketing strategy responding to *current fashion trends* quickly by providing frequently updated fashion products. “The key ingredients of fast fashion are the ability to track fashion trends quickly and to identify potentially *popular new designs* through daily proximity to fashion markets, fashion images and fashion markers” (Doeringer & Crean, 2004, p.17). As these definitions demonstrate, *providing the latest fashion trends* is another key element of fast fashion, along with agile response to consumer demand with reasonable prices.

## Fast Fashion Business Model

To clearly define the fast fashion system, it is important to understand how the system is different from both the traditional system and quick response (QR). Cachon and Swinney (2011) classified production systems into four possible systems (Table 2): Traditional, QR, Enhanced Design, and Fast Fashion. Here the traditional system represents a conventional retailer with long production lead times and standard product design. This system is often called a push supply chain (Levi & Beitz, 2007) in which production is based on forecasts from historical sales far in advance of actual season, thus resulting in average design and production lead times on the order of six to twelve months and operations based on inventory. On the other hand, QR, a concept developed by Kurt Salmon Associates (KSA) in the U.S. in a 1986 study (Barnes & Lea-Greenwood, 2006), focuses on reducing lead time from manufacturers to stores in collaboration with suppliers. Similar to QR, the concepts of just-in-time (JIT) and agile supply chain exist. While the focus of those terms subtly differs regarding who (i.e., retailer or manufacturer) views the system, the core element of both these concepts is reducing lead time based on consumer demand information. That is, in the QR system, production starts with consumer demand information, rather than with forecasts based on historical sales data. Therefore, QR is characterized as a pull supply chain, information-based and demand-driven system while the traditional system is a push supply chain, forecast-based and inventory-driven system (Christopher, Lowson & Peck, 2004). Next in Table 2, the enhanced design system focuses on design capabilities to enhance consumers' willingness-to-pay but does not necessarily focus on achieving lead time reduction.

The fast fashion system captures both QR and enhanced design capabilities. It aims "to reduce the processes involved in the buying cycle and lead times for getting new fashion product into stores, in order to satisfy consumer demand at its

Table 2. The Four Possible Production Systems

	Normal Design	Enhanced Design
Slow Production	<i>Traditional</i>	<i>Enhanced Design (highly fashionable design)</i>
Quick Response	<i>Quick Response</i>	<i>Fast Fashion</i>

Source: Modified slightly by the authors based on Cachon & Swinney (2011). p.781.

peak" (Barnes & Lea-Greenwood, 2006, p.259). This characteristic of the fast fashion supply system can be best described as *a rapid replenishment of small batches of new products*. This contrasts with traditional retailers that place bulk orders a season ahead with infrequent replenishment. Before a season, Zara outsources 65% of its design and raw material, and only 55% of external and 15% of internal production is completed. During the season, the remaining 40-50% of external and 85% of internal production is finished. This is in sharp contrast with traditional retailers that finish design and production before a season and only distribute the finished products during a season. Fast fashion retailers continue to design and produce small batches of products based on consumer demand during a season. When demand is uncertain, the best time to predict the demand is when an actual sale is happening. The closer the forecast to the actual selling time is, the better the demand forecast will be. Since traditional fashion retailers' demand forecasts are formed at least nine months ahead of a season, the forecast should be far less accurate than that of fast fashion retailers, which do it during a season. How fast fashion retailers achieve "*a rapid replenishment of small batches of new products*" will be examined in "how" section. Now that the concept of the fast fashion business model is clear, next this paper will review *why* the fast fashion business concept is becoming more prominent in today's apparel business.

## **FAST FASHION BUSINESS MODEL: WHY**

### **Factors Related to Demand Uncertainty**

One critical characteristic that sets fashion apparel products apart from other products is their unpredictable demand. Factors that contribute to the demand uncertainty include increased rates of product introduction and shortened product life cycles. These result in increased SKUs available to consumers in a season. For the most part, as a country's economy advances, the level of product variety increases. The U.S. apparel sector is no exception. Throughout much of the post-World-War II era, the majority of men's dress shirts sold in the U.S. were white dress shirts, sold primarily through department stores. Men's dress shirts available in today's retail stores include a wider selection of collars, patterns (e.g., different stripes, etc.), French cuff options, fabric constitutions, and fits (e.g., regular, athletic, loose, and long). Therefore, even within same size white shirts, a variety of choices with different combinations of options are available, such as white button downs, pinpoint oxford shirts with French cuffs and athletic fits, and so on. This wide range of choices increases consumer satisfaction levels, however retailers then have the burden of carrying at least a couple of items per SKU, resulting in a greater chance of not selling the entire inventory than before.

Moreover, frequent fashion and seasonal changes add more uncertainty to the demand. This means that unlike other consumer products, such as television sets, the fashion retailers' carrying items should be mostly renewed by season. Therefore, selling apparel items is like selling highly perishable items, such as fresh flowers. In addition, since apparel purchase decisions are mostly made by individual consumers' taste and social psychological reasons, rather than economical reasons (Sproles & Burns, 1994; Cholachatpinyo

et al., 2002), estimating what items will sell or not is extremely hard.

### **Agility: A Key to Meeting Unpredictable Consumer Demand**

Because of their unpredictable demand, supply chain management for fashion apparel products should be different from that of other products. Fisher (1997) suggested that the right supply chain management should be used considering its demand characteristics. He classified products based on their demand patterns: functional goods that have predictable demand and low product variety (10 to 20 variants per category) with long product life cycle (more than two years), and innovative goods characterized by unpredictable demand and high product variety (often millions of variants per category) with short product life cycle (three months to one year). Because of these demand patterns, average error in the forecast at the time of production is 40-100% for innovative products, compared to 10% for functional goods; an average stock-out rate for innovative products is 10-40%, compared to 1-2% for functional goods; an average forced end-of-season markdown for innovative goods is 10-25%, compared to 0% for functional goods (Fisher, 1997).

To meet these different demand characteristics, functional products require a physically efficient process while innovative products require a market-responsive process (Fisher, 1997) (Table 3). The focus of a physically efficient process for functional goods should be *cost minimization* because demand is stable and predictable. In contrast, *product availability*, supplying goods *with speed and flexibility* (i.e., agile supply), should be the focus of a market-responsive process for innovative products. Similar to the Fisher (1997)'s suggestion, Christopher (2000) proposed that agility is better suited for less predictable environments where demand is volatile and the requirement for variety is high, while lean works best in high-volume, low-variety predictable environments. He

### **Fast Fashion Business Model**

made it clear between *lean* and *agile* approach. The lean concept, originated in Toyota Production System, is about doing more with less (p.37) with its focus on the reduction and elimination of waste, and thus fits well in the car industry. In contrast, agility is “defined as the ability of an organization to respond rapidly to changes in demand both in terms of volume and variety” (p.39). HeBruce, Daly and Towers (2004) also suggested *lean supply* for functional goods and *agile supply* for innovative goods. Since fashion apparel products represent innovative products, agile response is the appropriate approach for managing apparel supply chain.

For apparel products, a high stock-out rate is a critical challenge. One-quarter of customers leave department stores empty-handed because specific items they want to buy are out of stock (Fisher, 1997). More recently, a KSA Consumer Insight survey found that although 68% of consumers enter an apparel store with a clear intention to buy, 49% do not find what they are looking for (Kurt Salmon Associates, 2005). If inventory level is increased to reduce stock-outs, it may result in a high quantity of unsold inventory. This cannot be easily eliminated because apparel products are in demand only for a short period of time due to fashion and seasonal changes. Unsold inventory, therefore, directly translates into mark-

downs after a short period of selling season, which in turn results in less profit. The apparel business is constantly faced with a dilemma of having either too much inventory which gives a high probability of markdowns, or too little inventory which often results in lost sales. The most effective way to handle these challenges (stock-outs and excess inventory) is increasing market responsiveness by reducing lead-time and increasing speed and flexibility. By supplying apparel products with agility, apparel retailers can reduce markdowns, operate with small stockrooms, lower inventory holding costs (Mcguire, 2001; Vitzthum, 2001) and increase sales associates’ morale.

For these reasons, more and more apparel retailers nowadays place frequent ongoing replenishment orders based on tracking real time demand with information technologies, such as bar codes and electronic data interchange (EDI), and request delivery in as little as three days. These changes in retailing are termed “lean retailing” and are becoming an industry standard (Abernathy et al., 1999). Manufacturers cannot fill these orders if they either hold more finished goods in inventory or shorten production time (Abernathy et al., 2000). Increasing finished goods inventories to allow for quick replenishment, however, incurs additional storage costs and the

*Table 3. Physically Efficient Versus Market-Responsive Process*

<b>Aspects of Supply</b>	<b>Physically Efficient Process (Functional Products)</b>	<b>Market-Responsive Process (Innovative Products)</b>
Primary Purpose	Supply predictable demand efficiently at the lowest possible cost	Respond quickly to unpredictable demand in order to minimize stockouts, forced markdowns, and obsolete inventory
Manufacturing Focus	Maintain high average utilization rate	Deploy excess buffer capacity
Inventory Strategy	Generate high turns and minimize inventory throughout the chain	Deploy significant buffer stocks of parts or finished goods
Lead-time Focus	Shorten lead time as long as it doesn't increase cost	Invest aggressively in ways to reduce lead time
Approach to Choosing Suppliers	Select primarily for cost and quality	Select primarily for speed, flexibility, and quality
Product-design Strategy	Maximize performance and minimize cost	Use modular design in order to postpone product differentiation as long as possible.

Source: Modified slightly by the authors based on Fisher (1997) p.108.



risk of excess supply due to changing demand. Thus, reducing production time is more efficient than holding large quantities of finished goods. As a result, manufacturers compete not only on the basis of price, but also on their ability to meet “rapid replenishment” requirements by retailers. For example, H&M gives suppliers 24 hours to make samples and if they are unable to meet the deadline, the order is given to another supplier (Indu & Govind, 2008). In summary, increased product proliferation in a market and shortened product life cycles accelerate demand uncertainty; thus, meeting uncertain demand is a critical competitive advantage in managing a fashion supply chain. The means of achieving agility are multiple: postponement, close partnership with suppliers for mutual benefits, utilization of information technology (IT), etc. Postponement (or delayed differentiation), the technique of delaying final product configuration until the actual order is in (Mathews & Syed, 2004), is a vital element in any agile supply. In this strategy, manufacturers hold standard semi-finished products until more accurate product- and market-specific demand information is known in order to increase market responsiveness. The advantages of the postpone-ment strategy include increased flexibility because the same components can be embodied in a variety of end products (Christopher, 2000). An agile supply base requires a high level of connectivity between the firm and its suppliers for shared demand/supply information and collaborative working relationships for mutual benefits, which necessitates IT utilization (Christopher, 2000). More details on means to achieve agility will be discussed under the “how” section.

### **Enhanced Design: A Way to Control Strategic Consumers**

Another important reason why the fast fashion business model works well in today’s fashion business is its ability to control strategic consumer behaviors (i.e., postponing their purchase until

sales). While the importance of agile response to market demand is widely documented, the reasons for why providing trendy, highly fashionable products (i.e., enhanced design) is another critical success element of fast fashion has received far less attention (Cachon & Swinney, 2011). In fashion retailing, due to a short selling season, the markdown ratio is relatively high compared to other industries. A recent study by Bain & Co. estimated that the industry average markdown ratio is approximately 50% (Sull & Turconi, 2008) and average forced end-of-season markdown is 10-25% (Fisher, 1997). As consumers learn the retailers’ markdown practice and become wiser through easy access to sales information via the Internet, more and more consumers wait for sales and refuse to pay full price. Therefore, the profitability of fashion business is a matter of selling it through at full price.

Two tactics are suggested to induce strategic consumers to purchase products at full price: limit quantities to avoid the need for markdowns (undersupply) and promote affordable full prices (O’Donnel, 2006). To combat with the strategic consumers, Zara chooses four strategies, combining these two suggested options (undersupply and selling at affordable prices) with two more strategies, offering the latest trendy fashion and offering new items twice a week. First, Zara intentionally produces small amounts of an item (i.e., undersupply), which means less availability for markdown. Second, affordable pricing encourages consumers to buy at full price as initial full price itself is not high. Third, Zara offers new items twice a week, meaning no replenishment of same items. There are either slight changes or big changes; thus, it is rare to see the same item being sold twice at Zara. Zara’s team of some 300 designers at its headquarter in Spain creates 30,000 items a year and H&M offers 2,000-4,000 items (“The future of fast fashion,” 2005), which contribute to cultivating the exclusivity of its product offerings. Fourth, the latest trendy fashion has a shorter life cycle than more conservative apparel products;

thus, buying it later leaves consumers little time to enjoy its trendiness fully. The third and fourth strategies are effective in ensuring the freshness of the items; when items lose their freshness, consumers buy it when it is fresh to enjoy its freshness fully.

Collectively, the basic principle of the four strategies is providing consumers with compelling reasons to buy now at full price; thus, the strategies effectively control strategic consumers' propensity to postpone purchase until sales. In particular, the undersupply strategy allows the firm to cultivate a sense of scarcity: consumers are given the sense that if items are scarce, one should buy it when it is on the shelf. Fast retailers deliver a strong message to consumers that "if you do not buy it now, you will not find this style again in our store." The message is clearly communicated as one 23-year old Barcelona shopper says, "If you see something and don't buy it, you can forget about coming back for it because it will be gone" (Gallaughier, 2008, p.6). The undersupply strategy is opposite to the traditional fashion retailing, which fundamentally assumes that stores should carry enough inventory for when consumers want to buy, and that not carrying items customers want to buy will decrease customer satisfaction levels. More and more retailers practice the undersupply strategy to induce consumers to purchase at full price. The stores of U.S. brand Anthropologie display new clothing items every day of the week and do not replenish even the best-selling outfits (Tokatli & Kizilgün, 2009).

Cachon and Swinney (2011) discovered that both agile QR and enhanced design complement each other, constituting strong success elements of fast fashion. They concluded that "while quick response decreases the expected *future* utility of waiting for a price reduction, enhanced design increases the *immediate* utility of buying the product at the full price (Cachon & Swinney, 2011, p.779)".

## **FAST FASHION BUSINESS MODEL: HOW**

In this section, *how* fast fashion companies provide highly trendy products with agility will be analyzed with the cases of Zara and H&M based on four aspects of supply chain management that Lee and Kincade (2003) suggested: QR knowledge of demand characteristics, utilization of IT, flexibility of operations, and collaborative partnerships between chain members.

### **Knowledge of Demand Characteristics**

Well-managed supply chains should start with the accurate understanding of demand characteristics. Activities related to this dimension include "characterizing demand patterns, aligning supply capabilities with demand cycles, and understanding the operational implications of surge or uncertainty caused by product proliferation and product line complexity" (Lee & Kincade, 2003, p.34).

Part of Zara and H&M's success can be explained by this aspect as both companies have a unique system to identify highly fashionable trendy designs in real time and to align the identified demands with their production in a timely manner. Instead of following the traditional design process based on consumer demands forecasting information mostly given by forecasting companies before the season, Zara actively engages in identifying fashion trends and customer demand through two sources: trend spotters consisting of designer teams and store managers (Indu & Govind, 2008). The trend spotters travel around the world looking for the emerging trends everywhere, from the streets to movies to fashion shows to discotheques, universities, and music videos (Sull & Turconi, 2008). Store managers, the other demand source, update the headquarters everyday about what sells and what their customers like, dislike and request. As Zara relies on their provision of accurate information, their compensation is in part

based on the accuracy of their sales forecasts and sales growth. Above the store managers, regional managers provide an aggregated view of regional trends to country managers who work in teams organized by region at the headquarters in Galicia, Spain. Country managers have often worked in stores as a manager, so they possess a deep understanding and are able to answer questions from both store and regional managers (Sull & Turconi, 2008). Consolidating the information from both sources, a team of 200 designers provide design specifications and production managers provide inputs regarding production capacity and costs. It should be noted that Zara's corporate culture helps develop highly fashionable trendy designs. To remove the layers of bureaucracy and encourage open discussions about designs, no one has an enclosed office and everyone has the same size desk at Zara's headquarters. The company does not use formal titles even though roles and responsibilities are clear, and designers at Zara are mostly young employees fresh from design school. In addition, an open layout at the headquarters with worktables surrounded by racks and shelves packed with sample garments creates a "culture of immediacy," which facilitates face-to-face discussions rather than communication through email or spreadsheets (Sull & Turconi, 2008).

As with Zara, all of H&M's collections are designed centrally by the company's procurement and design department in Sweden where 100 in-house designers, 100 buyers and 50 pattern designers collaborate (Indu & Govind, 2008). Information on sales and stock status are sent to the department from central warehouse, distribution center in each country, and individual stores. Similar to Zara, merchandise managers in all countries where H&M operates provide inputs and new trends are detected by central staff and national offices. After the design stage, production is coordinated by production offices which serve as buying offices that coordinate manufacturing activities between stores and 750 factories. H&M has 22 production offices, of which 10 are in

Europe and 10 are in the Fast East and 1 each in Central America and Africa as of 2006 (Tokatli, 2008). The responsibilities of the production offices include identifying new suppliers, developing sample garments and fabric testing, placing orders with the right suppliers, negotiating prices, ensuring that suppliers maintain quality, minimizing transport times, making sure suppliers conform to the company's code of conduct as for working conditions, etc. (Databank Consulting, 2009; Indu & Govind, 2008). Here the essence is that both Zara and H&M established a system that detects ever-changing consumer demand during the season and immediately aligns the identified demand with agile supply. The system has been possible by virtue of information technology. The next section details the critical role of IT in providing trendy designs with agility.

### **Utilization of Information Technology**

For any apparel company, having effective communication with its suppliers is extremely vital to exchanging information in a timely manner. Both Zara and H&M effectively utilize IT to quickly respond to consumer demands. Every Zara employee has a personal digital assistant (PDA) that is used to gather customer opinions on a daily basis about its products and what they want to see in the store (Mital, 2009). This data is then sent directly to headquarters, which helps in developing new products reflecting consumer demands. Another important aspect of Zara's utilization of IT is a point of sales (POS) system connected to a radical quick response (QR) system. Through the POS system, the cash register at each store monitors what is selling and what is not, allowing the company to track popular items so that Zara can reduce fashion forecast mistakes, make plans for assortments, and reorder frequently and quickly (Mital, 2009).

H&M also utilizes IT effectively. Each store is directly connected to the procurement and logistics departments, as well as to the 22 production offices

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and a central warehouse in Hamburg, Germany (Databank Consulting, 2009). The integrated IT system among the central warehouse, 22 production offices, and individual stores across the globe allows them to communicate effectively with each other and restock each store promptly based on its demand (Datamonitor, 2009).

### **Flexibility of Operations**

Flexibility refers to the ability to vary production volumes, to make minor changes in response to market demand, and to reduce lead time (Lee & Kincaid, 2003). Fast fashion retailers achieve operational flexibility through a combination of onshore and offshore production, a quick replenishment system, and the purchase of half of its fabric in the form of greige (undyed) fabric. First, perhaps the most important aspect of operational flexibility is the utilization of combined onshore and offshore manufacturing considering the demand characteristics. That is, for fashion items, Zara primarily uses onshore manufacturers in Spain and Portugal, which helps restock its stores with new designs rapidly; however, for basic items that have a longer product life cycle than fashion items, such as t-shirts and underwear, Zara uses low-cost offshore or near-shore manufacturers (Ferrer, Karlberg, & Hintlian, 2007). Zara intentionally leaves extra in-house production capacity so that production can be available anytime it is needed (Ferdows, Lewis, & Machuca, 2004), which contrasts with traditional production management that believes all the production facilities should be fully operated at all times in order to reap the benefits of an economy of scale. In addition, many of Zara's factories operate for only a single shift; thus, Zara can flexibly increase or decrease its production of specific merchandise rapidly and operate extra hours for seasonal and unpredicted demands (Ferdows et al., 2004). H&M also handles fashion-sensitive items and basic items differently with two supply chains: H&M uses the suppliers in Europe for fashion-sensitive

items and items which require rapid replenishment, but basic items are sourced in Asian countries in order to optimize time and cost. These combined approaches help Zara and H&M stay true to the fast fashion model while keeping their production costs low.

The next aspect of flexibility is a fast retailers' quick replenishment system. At Zara, logistic centers in Spain collect all products, regardless of their origin or destination and then send out about 25,000 units of new products to each store at the beginning of each season. After this, replenishment decisions made by store managers based on customer demand, inventory, and available items at the logistics centers (this information is sent to stores twice a week) are directly sent to the distribution center twice a week (Ton, Corsi, & Dessain, 2010). European stores receive their orders within 24 hours, while stores in Asia and the Americas receive theirs within 40 hours because these orders are distributed by air freight. This replenishment system maximizes flexibility because each store manager has the authority to make replenishment order decisions matching the individual store's demand to supply availability at the logistics centers. H&M has a similar replenishment system. Most of the goods manufactured from the production centers across the world are shipped to one central warehouse in Hamburg, Germany, which serves as the transit terminal. From this transit terminal, goods are sent to the distribution center in each country in which H&M operates and are then delivered to stores daily or kept in a call-off warehouse, a centralized room which holds the stock, from which replenishment orders are sent to stores. Restock at each store level is done every day between 7 AM and 9 AM but it could rise up to several times a day if high demand occurs; thus no item stays in the store for over a month.

A third aspect of flexibility at Zara is the purchase of half of its fabric in the form of greige (undyed) fabric. Based on market demands, the greige fabric is dyed flexibly at the company's

subsidiaries located near its distribution center (Ghemawat & Nueno, 2006). This is a form of the aforementioned postponement, holding semi-finished products until more accurate demand information is known.

### **Collaborative Partnerships between Chain Members**

The existence of collaborative partnerships between suppliers and retailers ensures higher levels of flexibility, allowing them to cope with sudden changes in demand (Hines & McGowan, 2005; Doyle, Moore & Morgan, 2006). However, the approach to the partnerships is rather different between Zara and H&M. Zara keeps a smaller number of partners to ensure responsiveness and tries to have strong relationships with 20 partners that account for 70% of all external manufacturing. In addition, Zara has more than 200 external fabric or other raw material suppliers that are working exclusively for Inditex. In return, the subcontractors receive technological, financial and logistical supports that are needed to achieve time and quality requirements (Christopher, 2000). Sourced fabric or other raw materials from these suppliers are sent to 450 workshops, located mainly near the headquarters where labor-intensive activities, such as embroidery, are completed and the items are then sent back to the manufacturing complex for inspection, ironing, folding, bagging, and ticketing.

While supply chain management literature suggests exclusive partnerships, most retailers are careful about having exclusive partnerships because they desire to share risks with many suppliers. H&M is such a case. In contrast to Zara's close partnerships with about 20 suppliers for their production, H&M keeps a close partnership with 700 independent suppliers across the globe (Ghemawat & Nueno, 2006) who can manufacture flexibly to their orders. When receiving design specifications, H&M's production offices review the list of suppliers to select suppliers based on

their facilities to produce the required garments (Indu & Govind, 2008). As with H & M, New Look, a U.K. fashion retailer, does not use more than 70% of a factory's capacity and Gap, Inc. outsources from 600 vendors in 60 countries and no one vendor accounts for more than 3% of total purchasing, according to their 2009 annual report. While the numbers of suppliers is different between the two fast fashion retailers, the key to agile supply is their close collaborative partnerships with suppliers who can react flexibly to the demand changes.

### **SUGGESTIONS FOR NON-FAST FASHION RETAILERS**

It is evident from the data highlighted in this paper that fast fashion retailers have efficient supply chain strategies. Hayes and Jones (2006) concluded that a fast fashion strategy increases stock turnover and hence results in reduced markdowns and lower inventory costs. In support of this finding, literature suggests the evidence of superior operational performance of fast fashion retailers over non-fast fashion retailers. For example, unsold items account for less than 10% of stock whereas the industry average is 17-20% (Ferdows et al., 2004). On average, Zara sells only 15% of product through biannual discount sales whereas the industry average is 30-40% (Ferdows et al., 2004). Fast fashion retailers sell only 15% of their products on sale whereas the industry average markdown ratio is approximately 50%, according to a recent estimation by Bain & Co. (Sull & Turconi, 2008).

Figure 2 summarizes how fast fashion retailers achieve higher profits than non-fast fashion retailers. Simply stated, it is possible because of fast fashion retailers' ability to manage uncertain demand effectively through flexible production and to control strategic consumer behaviors by purposefully creating a rapid turnover through offering limited quantities of the latest fashion

### ***Fast Fashion Business Model***

at affordable prices. Since fast fashion retailers carry very low quantities for each item and new stock arrives twice a week, each item lasts for a very short period of time at stores. As a result, stores always have new styles; one never sees the same product at Zara (Mital, 2009) and no item remains on the shelves for more than a month at H&M (Indu & Govind, 2008). Such rapid turnover creates the sense of scarcity and encourages customers' frequent visits and immediate purchase at full price. According to Zara, its customers visit 17 times a year on average while they visit Zara's competitors only 3-4 times a year (Indu & Govind, 2008).

Non-fast fashion retailers could benefit from adopting some elements of the fast fashion model. Firstly, it is evident that fast fashion retailers achieve both agility and low cost combining onshore and offshore production flexibly; thus, this study suggests that non-fast fashion retailers should consider adopting the combined strategy considering the dynamic demand patterns of production items. That is, non-fast fashion retailers should source at least some portion of their fashion items that require fast turnaround and accurate forecasting from areas closer to their markets. Basic items that have relatively stable demand, such as basic socks and plain t-shirts, should be outsourced from countries that offer competitive labor costs. By employing the optimal combinations, non-fast fashion retailers can have popular items always in stock and bring fast selling items quickly into the stores, which enhance operational profits.

Secondly, one major characteristic of the fashion industry is demand uncertainty. Fast fashion retailers have effectively overcome this inherent difficulty by forecasting fashion trends during the current season, meaning the prediction and production of fashion trends are done in the same season. In contrast, non-fast fashion retailers finish production before the season and do not participate in any designing/manufacturing activities during the selling period; thus, they

are not able to make any changes to merchandise if their trend forecasts need to be modified. This results in predictions that are more risky and less accurate, which leads to frequent markdowns of merchandise- reducing profitability. To remedy this situation, non-fast fashion retailers should adopt a system of forecasting and developing a selected number of items during the season. This ties in to the first point of sourcing from a closer proximity- which results in more flexibility to modify production during the season.

Thirdly, in addition to sourcing from countries in close proximity, non-fast fashion retailers should consider establishing close collaborative partnerships with local suppliers who can flexibly produce small batches of urgent items, which will increase operational flexibility. The small batch orders from the suppliers may cost more, but all the benefits from agile response based on accurate demand forecast, such as fewer markdowns and higher percentages of merchandise sold at full price, will be high enough to compensate the cost.

Fourthly, one clear advantage fast fashion retailers have over non-fast fashion retailers is their extensive use of IT to communicate seamlessly with customers, store managers, designers, production staff and distributors in identifying, producing, and shipping the desired items to the stores rapidly. Gap, Inc. for example, is more likely to use IT to better cater to customer taste and fit by localizing the products offered in its store using tracking technology, which can help decrease the need for markdowns, than to gather customer demand information for new product development (Wells & Raabe, 2006). Non-fast fashion retailers should actively use their IT resources to identify best/worst selling items for small batch production, reordering items, assortment planning, etc. Effective use of IT will also allow them to have effective communication with their branch stores, subcontractors, and distribution centers, which will help them monitor production and avoid miscommunications, mistakes, and delays.

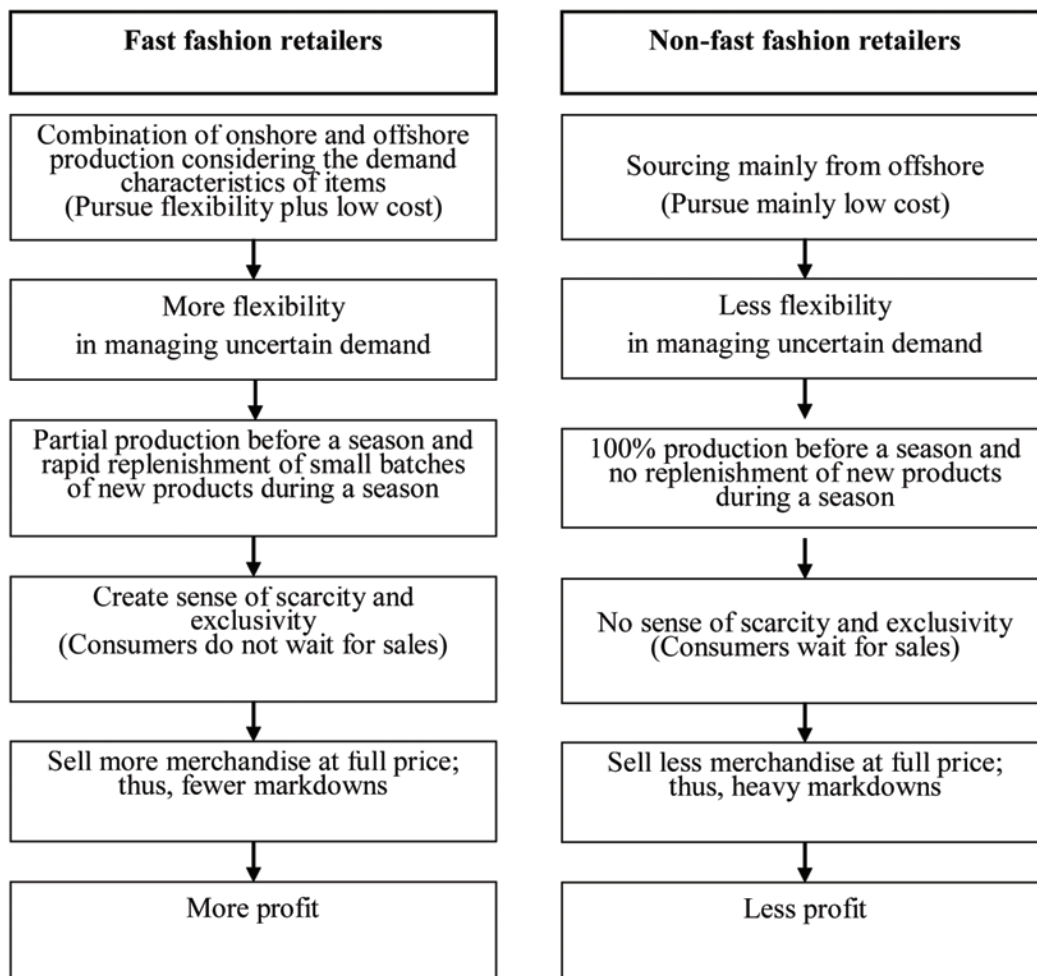
**CONCLUSION**

The fast fashion business model, pioneered by Spain’s Zara and Sweden’s H&M, has revolutionized the industry. This chapter reviewed the concept of the fast fashion business model, and why and how the business model is successful. Based on the intensive analysis of the two fast fashion retailers’ supply chain management activities, this chapter concludes that their remarkable operational performance is a direct result of their ability to effectively solve the two main challenges of fashion industry: managing demand uncertainty and controlling consumers’ strategic

consumer behaviors. The demand uncertainty issue is resolved by providing a super-responsive supply chain (i.e., QR) and the consumers’ strategic consumer behaviors are controlled by providing small quantities of the latest fashion frequently at affordable prices (i.e., enhanced design by Cachon & Swinney (2011)’s term), which nullifies the reason for delaying the purchase and increases the willingness to buy now at full price.

Their super-reactive supply chain can be best epitomized as “rapid replenishment of small batches of new products,” which is possible through their well-aligned effort to understand consumer demand and tightly match it with

*Figure 2. The Impact of Operational Strategies on Financial Performance*



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supply, effective use of IT technology, flexible operations, and collaborative partnerships with supply chain partners. Some elements of their supply chain activities can be effectively applied to non-fast fashion retailers: They can improve their flexibility of operations by optimally combining onshore and offshore sites considering demand characteristics of production items, adopt fast fashion retailers' system of designing and producing a selected number of items during the season, use collaborative partnerships to be flexible, and wisely utilize IT in analyzing consumer demand during a selling season for small batch production, assortment planning, etc.

It should be noted that the fast fashion model is a success because the two strategies (i.e., QR and enhanced design) complement each other. Cachon and Swinney (2011) concluded that employing the two strategies simultaneously yields significant benefits; thus, merely imitating one-half of a fast fashion system, either enhanced design or QR, may be unprofitable. Most non-fast fashion retailers may put effort in developing an agile supply system but they cannot simply change their focus to offering the latest fashion at reasonable prices; thus, they need to be careful when adopting the suggestions above.

Some apparel companies may think developing the agile supply system may require high investment. Such an assumption may not be true because the fast fashion business model has maximized their profit with efficient deployment of their operational expenses. Zara believes in market responsiveness, so it effectively allocates their operational expenses for achieving market responsiveness. Zara sends a half-empty truck across Europe, pays for airfreight twice a week to ship coats on hangers to Japan, runs factories for only one shift (Ferdows et al., 2004), all of which are against the usually accepted industry norm of the economy of scale. While expenses that increase market responsiveness are adequately allocated, expenses that do not help increase market responsiveness, such as advertising costs,

are trimmed down. As evidence, Inditex spends "only 0.3% of its revenue on media advertising, compared with 3%-4% for most fashion retailers (Ghemawat & Nueno, 2006, p.13). Another cost effectiveness example within Zara's practices is its IT spending level. While Zara is known for IT utilization, Zara's IT expenditure is less than one-fourth that of the fashion industry average (Sull & Turconi, 2008). These examples tell us that it is not a matter of the level of spending, but a matter of how the spending should be directed towards achieving their goals.

The future of fast fashion is promising. Fast fashion stores occupy the major fashion streets in each country where they operate. In the U.S., New York's Fifth Avenue, once home to haute couture and designer stores such as Gucci, Prada, Versace and Ferragamo, is now becoming a street of fast fashion (Tokatli, 2008). In Japan, Forever 21, a U.S. fast fashion retailer, will open its store in Japan's high-end Matsuzakaya department store in 2010 in the space previously occupied by Gucci (Sanchanta, 2010). More and more product categories increasingly exhibit the characteristics of fashion goods, such as demand uncertainty, short product life cycle, high product variety, etc. Just as quick response technology evolved in the apparel industry and became an industry standard in the retail industry, it is anticipated that the fast fashion business model will be applicable to other product categories as the model has several critical advantages to be adopted. However, the fast fashion business model is not without any challenges. They should be able to answer questions such as: What if consumers increasingly favor quality and buy superior goods? What if they become concerned about the environmental impact of disposable clothing? What if labor cost in Spain increases? Then can Zara still successfully utilize a large portion of in-house production in achieving agility? Increasing numbers of fast fashion competitors in many countries, such as Mango in Spain, Forever 21 in the U.S., Uniqlo in Japan, and Renner in Brazil may be another



challenge since they are potential competitors in international markets.

## **FUTURE RESEARCH DIRECTIONS**

While this paper provides an extensive overview of the fast fashion business model, the overview is mainly based on an analysis of two fast fashion retailers. As a growing number of fast fashion companies are operating worldwide, it is worthwhile to compare their operational strategies. This merits future study. Also this study mainly reviewed the fast fashion model from the operational management perspective. Other aspects, such as internationalization, corporate culture, market positioning, etc., may collectively explain the success of fast fashion retailers; thus, future studies should direct their efforts in this direction. In addition, quantitative analysis similar to Caro and Gallien (2010) can be conducted to yield additional insights on fast fashion business model.

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## KEY TERMS AND DEFINITIONS

**Agility:** Is defined as the ability of an organization to respond rapidly to changes in demand both in terms of volume and variety.

**Fast Fashion:** Is defined as various strategies to respond commercially and operationally to the latest fashion trends.

**Flexibility:** Refers to the ability to vary production volumes, to make minor changes in response to market demand, and to reduce lead time.

**Lean Concept:** Originated in Toyota Production System, and involves doing more with less resource. Its main focus is on the reduction and elimination of waste.

**McDonaldization:** Is defined as the process by which the principles of the fast-food restaurant are dominating more and more sectors of the American society, as well as the rest of the world.

### ***Fast Fashion Business Model***

**Quick Response:** Focuses on reducing lead time from manufacturers to stores in collaboration with suppliers.

**Vertical Integration:** Is defined as the process in which several steps in the production and distribution of a product or service are controlled and owned by a single company.

## Chapter 12

# “Network Process Re-Engineering” in a Home Textile Network: The Importance of Business Relationships and Actor Bonds

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### **ABSTRACT**

*This chapter relies on a case study featuring the business network around Stella, an Italian home textile manufacturer, to illustrate the challenging issue of engaging other firms into complex “Network Process Re-engineering” (NPR) projects. While the strict technological dimension of selecting, developing, and implementing ICT solutions is certainly very important and poses several challenges to this type of projects, this chapter focuses on other types of challenges, namely those pertaining to the nature and quality of relationships between the actors taking part in a NPR project. We stress the importance of the connection between the specific inter-organizational activities that need to be redesigned and coordinated in better ways, on the one hand, and the bonds existing among the actors, on the other hand. We suggest that very advanced and complex coordination tasks, entailing sensitive communication patterns, can be tackled only if supported by strong, integrative relationships characterized by high trust and commitment between the involved parties. We conclude by discussing how the pivotal firms or the “strategic centers” of a network can support and facilitate complex change projects like NPR by carefully combining different strategies, whereby they both exert coercive power and make concessions to their counterparts in the network.*

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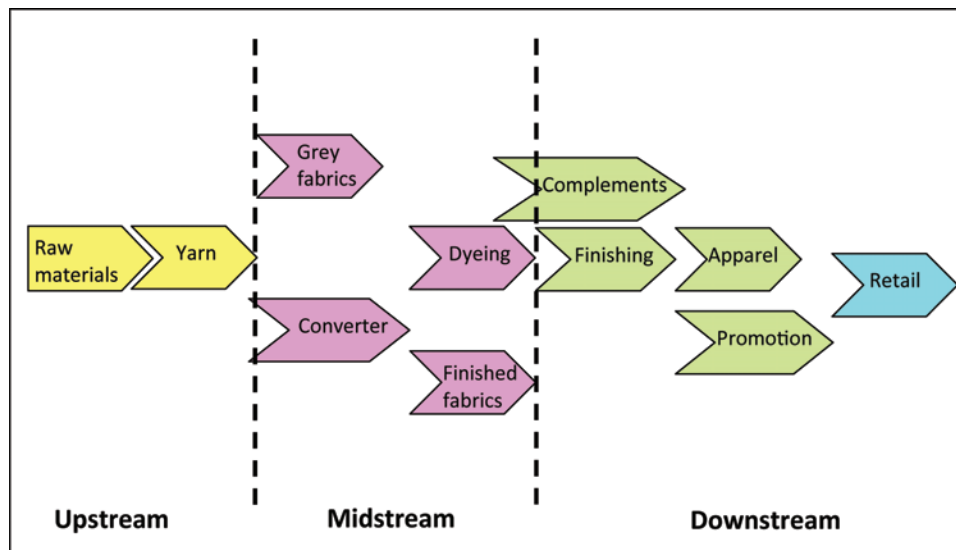
## INTRODUCTION: RE-ENGINEERING PROCESSES IN TEXTILE NETWORKS

The structure of the textile and clothing industry is very de-integrated and fragmented, with many firms typically performing just one or a few of the separate activities going from raw material supply to retailing (Hwang, 2005; Camuffo, Romano & Vinelli, 2001; Forza & Vinelli 1996). Therefore, in a typical textile production system there are several activities that need to be coordinated across the boundaries of several firms (Rich & Hines, 1997; Abernathy, Dunlop, Hammond & Weil, 1999). These activities stretch from the production of yarn, through various processing steps performed on fabrics, and to the distribution of the finished textile product (see Figure 1 taken from Hwang, 2005). But more precisely, as each firm taking care of a specific activity – be it yarn production or home textile production – supplies several customer firms, the emerging structure of this system is not a streamlined chain, but rather a more *complex network* (Håkansson & Snehota, 1995; Gadde & Håkansson, 2001; Ford, Gadde,

Håkansson & Snehota, 2003; Håkansson, Ford, Gadde, Snehota & Waluszewski, 2009).

If one adds to this complex structure the importance of fashion in this industry, time issues and coordination among the various companies involved assume a pivotal role (Guercini & Ranfagni, 2003; Guercini, Ranfagni & Runfola, 2010). In fact, the time available for developing, producing, distributing and selling each collection becomes lesser and lesser (Forza & Vinelli 2000). Therefore, speed in product development and delivery precision, for two or even more collections per year, are main competitive goals on the agenda of textile producers (Jin, 2006; Barnes & Lea-Greenwood, 2006; Christopher, Lowson & Peck, 2004). However, no firm can reach these goals by working alone because the context is characterized by strong mutual dependence between the many firms operating in this fragmented industry; instead these actors need to cooperate with each other around the creation, production, marketing and distribution of each single new collection (Baraldi & Nadin, 2006). In order to improve any of these four key processes each firm needs to properly connect and

Figure 1. A typical supply chain in the textile industry



coordinate its activities with those of the other companies across the entire network, stretching from raw materials to final customers.

Proper connections and improved activity coordination across the boundaries of the involved firms are essential in order to make the whole process from raw materials to retailing more efficient and agile, so that it can respond more swiftly to the increased time pressures imposed by modern fashion cycles (Barnes & Lea-Greenwood, 2006; Christopher, Lowson & Peck, 2004). But coordinating activities between organizations requires that they have created among them *business relationships* characterised by a certain level of trust and commitment (Anderson, Håkansson & Johanson, 1994; Håkansson & Snehota, 1995; Ford et al. 2003).

It is very important especially for Italian textile producers to improve inter-firm coordination in order to streamline network-level processes (Camuffo, Romano & Vinelli, 2001): in fact many Italian firms consider increased efficiency and improved innovation processes as the only ways to match the threat coming from low-cost foreign competitors. Facing these types of problems, in 2001 the Italian home-textile manufacturer Stella (a pseudonym we use for confidentiality reasons) promoted with its network partners a complex project aiming to use Information Technology (IT) to improve several processes across the entire business network. The classical “Business Process Re-engineering” (Davenport & Short, 1990; Davenport, 1992) would not help to improve these processes due to its focus on the activities performed within just one organization. Stella was the major manufacturer and owner of the most prominent trademark in that network so it took a leading role and promoted the idea that this type of inter-organizational process reengineering was necessary. Stella eventually managed to convince other firms in the entire network (i.e. 8 companies, with 15 operative branches such as production plants) to participate in this project. More than 20 people from these 8 companies worked directly

on the project, but several external consultants and academics also participated in this project.

Important steps in this “Network Process Re-engineering” project include (1) the analysis of the activities performed by the individual firms, (2) the redesign of certain activities and how they were distributed and connected across the firms, and (3) the introduction of IT solutions for improving communication and coordination among the involved parties. Several activities and their links across companies had to be modified in order to make the overall network processes more efficient and to match the new IT infrastructure that was being implemented. A complex project like the one promoted by Stella, which also aimed to use IT systems to digitalize network-level processes and the business relationships among companies, entails a series of challenges. These challenges include: (1) the sheer difficulty in mapping all activities/processes and the heterogeneous resources involved (Baraldi & Nadin, 2006: 1121-22), (2) social issues of trust and power when dealing with confidential information and the control of the IT infrastructure (Ibid: 1122), and (3) cognitive problems in representing and codifying by means of hard data and computerized routines the subtle interactions, communications and other processes that characterize business relationships (Ibid: 1122-23).

These types of challenges are certainly important (and were properly handled in the Stella network during that project), but these challenges are tightly linked to the IT realm (building data matrices, creating computerized routines, defining the IT infrastructure and information flows, and representing the actual activities and resources). There are also other challenges to “Network Process Re-engineering” which derive from the *very nature* of the business relationships among the involved firms and the strategies of each of them, beyond a specific IT project. In fact, depending on the type and strength of a specific relationship it will be possible to achieve different levels of coordination of the two firms’ activities. Stated

differently, coordinating different types of activities and doing it more or less precisely requires different quality of communication among the involved parties and in turn different levels of trust and commitment between the parties. For instance, reducing overall lead-times between the production of home textile and that of fabrics required Stella to communicate its production schedule to fabric producers, but no particular constraint appeared in the relationship “Stella-fabric producers” because the parties considered the necessary information as not so confidential. Therefore, this type of information could be exchanged also within relatively superficial relationships. On the other hand, exchanging “point-of-sale” data on stocks and sales with garment suppliers, for instance, to implement “Vendor-Managed Inventory” (VMI) imposes much more constraints on the type of relationship between retailers and garment suppliers because retailers view inventory management as an absolutely critical activity and the underlying information as highly confidential. Therefore, the parties engage in this type of coordination only if they share a strong, long-term and high-trust relationship.

As we acknowledge the importance of these relationship-related challenges to implementing Network Process Re-engineering, the purpose of this chapter is to discuss how *activity coordination improvements* relate with the *nature and quality of the specific relationship* between the firms performing these activities. In order to achieve this purpose we analyze a single case study centred on the Italian home textile producer “Stella” and the relationships within its network. The next section presents a set of concepts and theoretical tools that help us frame the case and highlight the key features of business relationships and networks. Then, we present the Stella case where we explicitly stress and discuss the connections between type of activities to be coordinated and relational challenges to the re-engineering of network-level processes. The chapter concludes with a discussion on the strategies that one or

several firms in the network can use in order to influence other actors to facilitate a Network Process Re-engineering initiative.

### **Theoretical Framework: Business Relationships and Coordination in Networks**

The focus of the management literature on IT issues during the 1990s and early 2000s has led to important insights into the pitfalls of as well as the conditions for successful IT-steered process re-engineering (see e.g., Davenport, 1998; 2000). However, this literature often takes as a point of departure the very IT solution, be it an ERP system or an EDI solution. Recent developments also in the technical domain of IT, such as service-oriented architecture (SOA) and software-as-a-service (SaaS), make the sheer IT artifact less of a problem so that the attention can be shifted to the social interactions around the IT solutions. For instance, Lusch, Vargo and Tanniru (2010) stress that the main challenge is not the technological one, but it is to convince all firms in a complex and interdependent network to participate. In fact, Mentzer, Min and Zacharia (2000) point out that lack of trust in sharing critical information with partners is a major constraint to collaborative efforts. Therefore, analyzing the type, nature and quality of the business relationships among the firms involved in a business network (or a supply chain) is a key starting point for any effort to improve the processes performed within the network (or the chain).

By “quality” of a business relationship we mean the degree to which the following characteristics are present in a relationship: trust, commitment, cooperation, adaptations, mutuality, open communications, goal convergence, and intensity of interactions. We now review how these features are interrelated in business relationships.

Trust can be viewed as a key determinant of a good relationship (Dwyer, Schurr, & Oh, 1987; Morgan & Hunt, 1994). According to Anderson



and Narus (1990) trust is the belief that the partner will behave so that positive outcomes will result for the firm and that the partner will not cause negative outcomes to the firm by taking unexpected actions. Moorman, Deshpande and Zaltman (1993) define trust as the willingness to rely on a party in whom one has confidence because of the party's expertise, reliability, and intentionality. The important impact of trust on business relationships is that it reduces the uncertainty perceived and stimulates innovative and risk-taking actions by both parties, while fostering cooperation among them (Morgan & Hunt, 1994). In such a situation the supplier and the buyer can develop their interaction into a full blown business relationship including also technical and economic adaptations (Hallén, Johanson & Sayed-Mohamed, 1991) from both sides and increased commitments into each other (Håkansson & Snehota, 1995). The development of a business relationship can be viewed as a process following certain stages (see Ford, 1980; and Dwyer, Schurr & Oh, 1987) of growth and/or dissipation that are driven by specific interaction episodes, including critical events, which change the state of key relational constructs such as trust, commitment, and adaptations (Schurr, Hedaa & Geersbro, 2008: 878-9).

Adaptations are changes either in the physical resources or in the ways activities are performed which lead to more efficient ways to combine the two companies' resources and activities (Hallén, Johanson & Sayed-Mohamed, 1991: 30). But adaptations are important not only from an economic point of view (time or resource saving) but also from a social and relational point of view: when made voluntarily, adaptations signal to the counterpart one's commitment to a relationship and can stimulate the counterpart to adapt and commit resources in turn (Ford et al., 2003: 55). When this happens, a positive cycle of relationship development can ensue and the relationship can progress to a higher level of intensity, deeper interaction and increased trust and commitment, the so called “mature” stage (Ibid: 55-56). However, not all

relationships ever evolve to this stage and some relationships that have reached there might revert to simpler forms of interaction, with less trust and commitment (Ibid: 51-58). One of the reasons that impede relationships to develop in terms of trust and commitment is the power unbalance deriving from one party being over-dependent on the other, who is viewed as irreplaceable (Kumar, Scheer & Steenkamp, 1998): in such a situation; cooperation is difficult (Ogenyi, 1998); communication is hindered (Kumar, Scheer & Steenkamp, 1998); the parties do not really trust each other (Anderson & Weitz, 1989); and the relationship is far from stable (Stern & Reve, 1980). Therefore, the relationship is not held together by the trust and the affective commitment between both parties but rather by the calculative commitment of the weaker party who simply complies passively to the request of the stronger party (Nadin, 2008; Nadin & Baraldi, 2009).

If we extend our analysis to a *whole network* of relationship, the above reasoning suggests that a network includes relationships of varying quality and of many different types – in terms of depth, level of trust and commitment – and in many different developmental stages. This variety of relationships derives from the fact that networks are heterogeneous in terms of the companies that compose them, their goals and motivations, their resources, their performance, their produced and exchanged volumes (Ford, Gadde, Håkansson, Lundgren, Snehota, Turnbull & Wilson, 1998: 71-2). Therefore, the ways in which companies interact with each other vary greatly depending on the specific parties involved, with each party possibly choosing a different approach to different counterparts. It is important to recognize this relationship variety if one aims to improve coordination across a whole network, as in the case of “Network Process Re-engineering” projects. The reason is that it is easier to improve coordination via and within a long-term, ideally mature relationship characterized by high trust and commitment (i.e., a high-quality one),

compared to a new relationship characterized by low trust, an arm’s length and adversarial style (i.e. a low-quality one). In fact, parties that do not trust each other or view the relationship as a simple market transaction are unwilling to share critical information and to change their internal activities or make investments in order to fit the needs of a specific counterpart. Therefore, when the network-level processes to be improved are identified, it is useful to conduct a detailed analysis of which firms need to be involved in relation to which specific activities they currently perform or will perform, as well as the quality and type of relationships that connect the various firms.

A powerful analytical tool for analyzing networks and the above coordination and relational issues is the so called Activities-Resources-Actors model (ARA), introduced by Håkansson (1987: 17) and further developed by Håkansson & Snehota (1995). Activities, resources and actors are considered as three separate layers of a business network and of a business relationship, but they are mutually related in the sense that *activities* are transformation and transaction acts performed by *actors* on *resources*; *resources* are controlled by *actors* and utilized in performing *activities*, and *actors* perform *activities* and aim to control *resources* in the network (Ibid). However, the three layers can be analyzed separately in order to obtain different insights about a network or a relationship: an “activity analysis” enables firms to tackle efficiency issues (see e.g., Dubois, 1994), such as those related to reduction of lead-times, inventories or transportation costs; a “resource analysis” can address development issues (see e.g., Gressetvold, 2004), such as selection of production technologies or product development; and an “actor analysis” helps to tackle strategy and network positioning issues (see e.g., Henders, 1992).

As the purpose of this chapter is to discuss how business relationships (and especially their varying types and quality) can be employed to foster network-level activity coordination, we will focus from now only on two layers of the

ARA model, namely the activity and the actor layers (for an analysis of the connections between the resource and the activity layers in the Stella network, see Baraldi & Nadin, 2006). Focusing on activities is quite natural as “Network Process Re-engineering” implies reorganizing the activities between the involved companies. The focus on the actor layer depends instead on the fact that in order to improve coordination among companies it is fundamental to mobilize and engage these companies to make further adaptations and even investments, which are motivated for each firm on the basis of such actor-related dimensions of a relationship as trust and commitment and the strategies of each counterpart.

The activity layer in a network can be analyzed both at the level of a single dyad by looking at the “activity links” (Håkansson & Snehota, 1995: 28-30) that connect the activities of two parties, typically a supplier and a customer, and at the level of the entire network, by looking at the “activity pattern” than spans across several dyads and companies (Ibid). Analyzing the activity layer, and especially activity links, can provide insights into (1) how two companies’ current activities can be better coordinated in terms of time (such as in a just-in-time system), (2) how activities can be distributed or shared among the two firms, and (3) how some activities can be eliminated altogether. Similarly to activities, the actor layer can also be analyzed both within a single dyad by looking at the so called “actor bonds” (Håkansson & Snehota, 1995: 32-4) that connect two specific organizations from a social point of view, and across the entire network, by looking at the so called “web of actors” (Ibid). Analyzing the actor layer helps understanding, for instance, (1) how two actors interact and communicate, (2) how these interactions relate to their mutual trust and commitment, (3) the network position of various actors in terms of power and dependence, and (4) the goals and the strategies of each actor, which is necessary in order to evaluate if they can cooperate at all. Therefore, the actor

layer is important for understanding the quality of a business relationship, especially in relation to other relationships in a network.

Within the context of “Network Process Re-engineering”, the ARA model is useful also because it allows classifying relationships on the basis of the strength of the connections across the three dimensions of activities, resources and actors. It is important to identify the stronger relationships because they are those that are easier to mobilize so that the respective partners can be engaged in actively taking part in such complex projects as network-level activity reorganization. Relying on the ARA model, Ford et al. (1998: 166-8) propose a classification of relationships into three typologies, which imply increasing quality levels: *transactional*, *facilitative* and *integrative* relationships (see also Lind & Strömsten, 2006: 1260). “Transactional” relationships are the weakest type, with so thin actor bonds that do not warrant mutual trust and commitment and with only superficial activity links: in this type of relationships the parties have not adapted their activities and resources and, as they are not dependent at all on each other, they can easily switch counterpart. “Integrative” relationships are instead the strongest type, with well established actor bonds deriving from a deep mutual understanding of each other competences and strategies and a high level of trust and commitment, grounded concretely in high investments made to adapt both activities and resources to each other. Moreover, the goals and the strategies of two “integrative” counterparts tend to converge as they have grown increasingly dependent on each other. Therefore, counterparts with whom a firm has integrative relationships are the ones that are more likely to be engaged in complex future-oriented innovation projects. Finally, “facilitative” relationships are somewhat in between the two former types, with adaptations mostly in the activities performed, which are easier to attain than adaptations in such physical resources

as products and machinery or immaterial ones as know-how and organizational capabilities.

### **The Case of the “Stella” Network: “Network Process Re-Engineering” and Actor Bonds**

The empirical materials behind this case were collected between 2001 and 2003 that comprise (a) in-depth interviews, (b) direct observations and (c) active participation in the “Network Process Re-engineering” project promoted by the textile manufacturer “Stella” across its network. Direct participation in the project offered a highly qualitative access to the empirical materials, including in-field observations. One of the authors of this chapter acted as a consultant during the project and could participate in 15 meetings, while contributing to analyzing the processes and developing the solutions emerging during the project. We interviewed and observed in their daily work for about two years all the people responsible for key activities at each company (or branch office/factory) in the network. This meant interviewing twice two people from each of twenty offices, for 3 to 4 hours each time, for a total of about 300 hours of interviews.

During the actual re-engineering project a team with representatives from each firm/office and external consultations was formed. This team started by analyzing each one of the current processes and activities and then grouped them at network level. Afterwards the team created basically two pictures of the network-level processes: an “as-is” situation and a “to-be” picture including the details of how the operative processes should be redesigned. Each firm considered this picture to be striven after and evaluated the gap to be filled (by changing routines and activities, hiring personnel or acquiring resources) to achieve the “to-be” picture. In this section we ground much of our analysis in this picture generated during the actual project (see for instance Figure 2) and we prepare a discus-

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sion of the challenges to re-engineering network processes that derive from the nature of business relationships among the network players, with a special focus on the quality of actor bonds. In the next section, we introduce Stella and its network; then we penetrate the nature and quality of the involved relationships; and finally in we point out the role and strategies of Stella in facilitating the “Network Process Re-engineering” project.

**INTRODUCING STELLA AND THE NETWORK AROUND IT**

The network of actors that participated in the re-engineering project promoted by “Stella” is composed of 8 companies and involved 15 production sites. This restricted network is indeed only the core part of a much larger network consists of many other actors that interact as suppliers or customers. Still these 8 firms in the core network cover the entire home textile manufacturing chain,

*Figure 2. The activities, information flows, benefits and constraints in the Stella network*

Activity	Output process links			Potential constraints		
	Info to be released	to	Benefit	Management	Technology	Relational
Yarn	Production scheduling	Fibre	Fibre producers know anticipatedly the requirements	low	low	high
	Production and delivery lead time	Fabric	Fabric is able to optimize just in time production plan	medium	low	medium
	Access to stock information	Fabric	Fabric can take advantage from ready to use product in the stock	low	medium	high
Fabric	Blanket orders	Yarn	Blankets permit Yarn supplier to deploy the best master production plan	high	low	medium
	Production capacity	Home textile	Home Textile can define the source of procurement	low	low	high
	Stock available	Home textile	H.T. can select quickly the source for Fabric replenishment	low	medium	high
	New Fabric Development	Home textile	H.T. knows constantly all the improvement the supplier is able to assure as range of product and quality	high	low	high
Finished fabric	Ennobling forecasting	Finished fabric	Ennobler can know anticipatedly the request for service	medium	medium	low
	Production capacity	Fabric; Home textile	Partner at the top and down of the chain knows the reaction and the time required to have the fabric finished process done	low	medium	high
	Detailed production scheduling	Home Textile	H.T. can select quickly the best source for Fabric ennoblement	medium	high	low
Home Textile	Finishing design selection	Home Textile	H.T. has wide information as regards the potential variety of finishing treatment available from which to select	low	low	medium
	Blind purchase	Fabric	Blind purchase grants the Fabric supplier the chance to optimize batch productions	high	low	low
	Detailed production scheduling	Fabric	Fabric producer is able to know the best delivery time and consequently to optimize its production plan	medium	high	low
	Product working orders	Finished fabric	Ennobler can manage the customer requests effectively	medium	high	low
	Finished product stock available	Distribution	Retailers have the knowledge to replenish final stock effectively reducing the risks of out of stock	low	medium	high
Distribution	Product Promotion Announcement	Distribution	Distribution can manage promotion plan in sync with the measure taken by the supplier	low	low	medium
	POS data	Home Textile; Finished Fabric	The entire chain benefits from the knowledge of sell out and therefore anticipate potential capacity and optimization decisions	medium	high	high
	Replenishment and delivery time	Home Textile	H.T. has full information to plan ready-to-use replenishment	medium	medium	high
	Communication & promotion campaigns	Home Textile; Finished Fabric	Chain operators are able to know final push initiatives and therefore synchronize marketing effort	low	medium	medium
	Virtual Stock in distribution Chain	Distribution	Retailers share information about the ready-to-sell product in the stock and therefore re-align demand picks with local offer	high	high	high

except for fiber production. Therefore, we chose to set the boundaries of our analysis around this restricted network. The core network is located in the northern part of Italy, but its firms have subsidiaries in two European countries and one in China, which focuses on home textile manufacturing. Even if the actors in the network interact with each other as buyers and sellers, one company holds a central position: this pivotal company is “Stella”, which is both older and bigger than the others and commands a set of famous consumer brands. Hence, this network can be somewhat simplistically termed “the Stella network”.

The Stella network focuses on the manufacture and commercialization of home textile finished goods, such as textiles for bedrooms (sheets), garments for kitchen (tablecloths), and bathroom textiles (towels). The combined turnover of all the firms in this network is about Euro 500 million, with Stella standing for more than 1/3 of this value creation. The total gross exchange among the players of the network is about half of the combined turnover. This means that these firms are closely related with each other, having thick and deep exchanges and business relationships. All the firms in this network experience a strong competition from Eastern Europe and Far East producers and therefore they felt compelled to look for any room for improvements to be able to better fight the price war in the European consumer markets.

Stella, the central company, reached the conclusion in the early 2000s that process innovation was the key to obtain savings in production costs. After several years during which Stella and the other firms in the network had separately pursued restricted improvement projects to reduce inefficiencies, at last Stella realized that in order to obtain substantive cost savings and other operational improvements, the *entire* network had to implement a lean manufacturing program involving all actors linked for different reasons to the chain going from yarn production to retailing.

In this perspective, Stella planned to launch a new project by the year 2001 with the aim to redesign the entire flow of work across the chain and streamline it in the logic of process reengineering, trying also to improve the connections between each enterprise. For this reason the project was labeled “Network Process Reengineering” (NPR). Stella and its counterparts realized that Information Technology was changing the shape of all their business relationships, in terms of how the enterprises were communicating and cooperating across organizational boundaries. Therefore, it was important to consider the type of IT solutions that could create an Inter-Organizational System (IOS) in order to enable all the improvements foreseen during the re-design of network-level processes.

In order to coordinate the overall performance of the activities performed by the various firms in the Stella network it became pivotal to share information across the whole network. However, as will be shown below, the complex and open-ended nature of this network structure created a set of constraints to improving coordination and fully synchronizing this textile network, even with the help of sophisticated ICT (Information and Communication Technology) solutions. While there were many possibilities to increase efficiency and create economic value for the involved actors by coordinating better such activities as sales campaigns at retail stores and production scheduling (in order to reduce stock-outs) or yarn production and new fabric development (in order to accelerate new collection releases), attempts at increasing inter-firm coordination met obstacles such as difficulties in codifying and standardizing fundamental data, incompatible IT infrastructures and lack of willingness to share key information with suppliers or customers.

The following scheme<sup>1</sup> in Figure 2 relates the activities performed by the various actors in the Stella network with the information and process outputs that should be shared among the participants in the industrial network in order to better coordinate the whole network and gain

**“Network Process Re-Engineering” in a Home Textile Network**

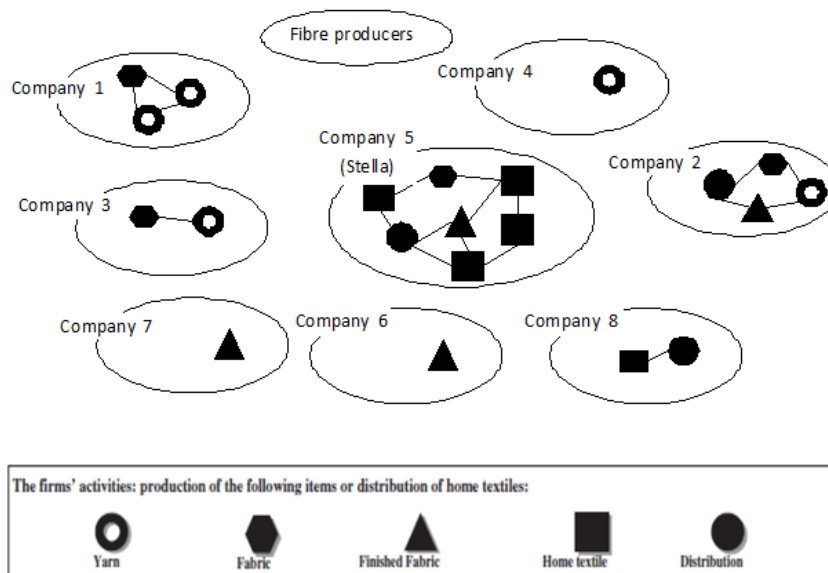
certain specific benefits. Starting from the “as is” situation in the network, mainly based on ad hoc human interactions and communications, the “to be” picture was defined having in mind the goal of broadening mutual collaboration. The “to be” picture implied a focus on mutual exchange of data, information and knowledge, and generally speaking on innovating the traditional supply-chain business model, which was based only on discrete 1-to-1 inter-firm cooperation.

Figure 2 shows the information flows that needed to be produced and shared among the Stella members in order to enable the actors from the top to the bottom of the figure to perform their activities better and gain thereby certain specific benefits. The figure applies the IPO (Input-Process-Output) approach: the first column “activity” shows the initial process (input) and defines the owner of the information that should be shared in the network. For instance, the first row of the figure indicates “yarn” and concerns all the firms in the Stella network who perform activities involving yarn. As we shall see below, in the Stella network there are four firms (companies 1, 2, 3 and 4 in Figure

3) performing these types of activities: these four firms are the owners of the information to be sent to other firms in the network to achieve the benefits of NPR shown in the fourth column.

The next three columns on Figure 2 illustrate respectively the information output (second column) that should be provided by the owner of the activity in order to enable another actor (specified in the third column) to obtain a certain benefit (shown in the fourth column) by performing better its own activity. Looking at column two, the number of information outputs varies between three and five information pieces to be shared. For the actors who produce yarn (the first row right under the figure headings), there are three kinds of information to be sent in order to facilitate mutual coordination: (1) production scheduling, (2) lead-time to deal with an order, and finally (3) access to yarn stock information. “Production scheduling” is released for the benefit of fiber producers who can anticipate their planning and therefore assure a more qualified service. “Lead-times” and “yarn stocks” are pieces of information that are useful for the actors

*Figure 3. The companies and their respective activities in the Stella network*



in the rows below yarn producer in Figure 2, but especially for fabric manufacturers. In fact, information about detailed yarn lead-times can grant a fabric manufacturer the possibility to introduce a just-in-time production and thus reduce production costs. As for yarn stocks, accessing this information by fabric producers is crucial in order to plan effectively fast fabric production as the fabric producer can select ready-to-use materials already in stock.

Finally, the last three columns of Figure 2 evaluate the potential constraints related to sharing each specific type of information between the actors in the first column (“activity”) and those in the third column (“to”). We have made an assessment<sup>2</sup> based on three dimensions, displayed in each of the last three columns: *managerial problems*, difficulty in *finding and devising an ICT solution* (technology), and *relational issues*. The first dimension is related to the challenges in transforming actual routines and physical events into codified information and data that can be exchanged between suppliers and customers to improve their separate or joint processes. If we still focus on the information outputs to be produced by yarn producers (the first three rows in Figure 2), the managerial challenge is low in producing information about production schedules and stocks, because these are data directly generated by internal management information systems; whereas the managerial challenge is medium when it comes to codifying information about lead-time because the owner of the activity has to state clearly the time per each production cycle, which can vary from a moment to another.

The ICT constraints concern the difficulties in sharing electronically the information that can sustain improved inter-firm coordination. These difficulties include problems in transforming the codified information into “bits & bytes”, in selecting or designing appropriate software and hardware capable to handle these data, and building an ICT infrastructure that provides these data to selected operators with the required fre-

quency and quality. As for these IT challenges, the information in the first two rows (production scheduling and lead-times) represent only low IT-related constraints, whereas the information in the third row (stocks) poses medium-level constraints because exchanging it requires a complex ICT infrastructure capable to connect simultaneously all the operators with on-line and continuously updated information.

Finally, relational constraints emerge because sharing information requires an *open and collaborative* relationship among the enterprises involved in the NPR project and the commitment of resources to a specific relationship, so that they cannot be utilized elsewhere. These relational constraints are different from the previous two because they are not always clearly recognizable before actually attempting to exchange information. Computer-supported data interchange often means altering the balance of power among the actors in the network; thus, to overcome the reluctance to share critical and sensitive information it is necessary that the parties have strong actor bonds and a trust-based relationship. Lack or low levels of trust among players can create major problems and jeopardize the entire NPR initiative. A key relational problem is that the more a piece of information is pivotal for the internal operations of a firm, the more that firm is reluctant to share it with other participants within the textile network. In the examples of information in the first three rows of Figure 2, we assessed the relational constraints as quite high because the information pieces to be released (production schedules, lead-times and stocks) were at the core of the business of the yarn producers and thus their willingness to share them must be evaluated in relation to the quality of the actors bonds established with the receiver and user of that information. If we extend our analysis to other activity and information owners in the Stella network, Figure 2 shows that production schedules, stock levels and POS (point of sale) data are so critical internal information that high relational constraints in sharing

them often appear. Ten out of the twenty output processes identified in Figure 2 entail high relationship constraints that need to be overcome if one wants to “reengineer” the entire network process in order to improve its efficiency and create value for the various firms involved.

Therefore, the quality of relationships matters: the closer and more trust-based the relationships among the network participants are, the higher the probability of success will be for any attempt to streamline network-level processes. On the contrary, it will be much more difficult to induce actors involved in an arm’s length relationship to share specific, critical and valuable information. An important starting point for any “Network Process Re-engineering” is therefore to identify which company performs each single activity and to understand the nature and quality of the relationship between each of these companies.

### **The Importance of Relationships and Actor Bonds in the Stella Network**

The industrial network around “Stella” comprises 8 companies and several suppliers of fibers, as shown in Figure 3. Each of these firms performs one or several of the activities reviewed in the previous Figure 2. Figure 3 also shows on which key component or product (yarn, fabric, finished fabric and home textile) each company performs their production activities. All companies are engaged in some form of manufacturing activity, but only two of them (company 5 and 8) also deal with *distribution* and *retailing* of their home textile products.

The relationships among the firms in this network are quite heterogeneous, being the result of interaction processes of different duration, depth and complexity. Most relationships are longer than a decade, while some are even older, dating back to the establishment of the focal firm, Stella. A handful of relationships are instead younger than a decade. The quality of these relationships can be classified depending on their predominant content

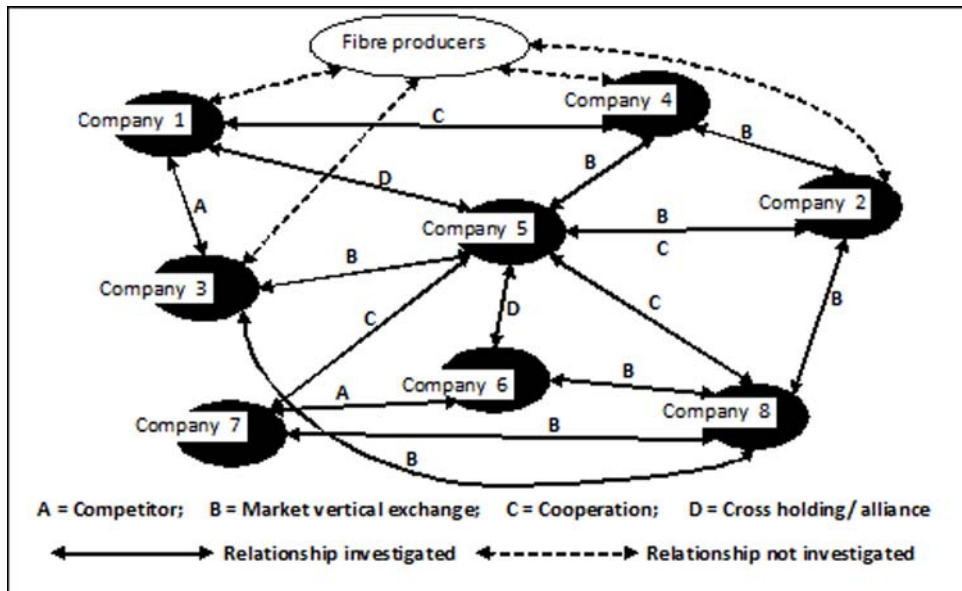
in terms of simple *vertical market exchange*, *cooperation*, *joint ownership*, and finally *competition*. Figure 4 displays the relationships among the 8 key firms within the Stella network according to these four categories.

Simple vertical exchange relationships between suppliers and sellers are common in business-to-business markets: under this type of relationship, firms have exchanged products and services for several years and therefore have created a secure and long-lasting base of mutual knowledge on such central topic as contracts, continuing negotiations and production conditions. This type of simple vertical relationships embraces certainly the “transactional” and partly the “facilitative” types of relationships as reviewed in the theoretical section of this chapter. These simple vertical relationships are eight in numbers and therefore the most common in the Stella network (see the “B” markers in Figure 4). Cooperative relationships, corresponding partly to the “facilitative” and the “integrative” types, emerge instead if companies develop deeper mutual knowledge and trust each other in order to design cooperative project aimed to improve the relationship or reduce costs with a mutual benefit. There are four such cooperative relationships, thus a bit less in number than simple vertical ones in the network around Stella (see the “C” markers).

A further qualitative development of cooperative relationships is the creation of so strong bonds that lead to full-blown alliances with joint ownership or cross holding (corresponding to “integrative” relationships), which is the case for two relationships in the Stella network (see the “D” markers). Finally, there are two couples of firms (company 1-3 and company 6-7), who participate in the network even if they see each other as competitors because they perform the same activity and share the same customers. In these two cases the link between the two firms persists because Stella (i.e., company number 5) wishes to keep this type of relationships in the network, even if



Figure 4. The type of relationships connecting the firms within the Stella network



this competition might reduce the stability of this network. Stella did not certainly create alone this network, which is instead a result emerging from the stratification of all relationships, but Stella can push for certain developments while opposing others. Moreover, things get complicated in this network by the multilateral relationships of each firm and by indirect relationships, that is, how two or more relationships affect each other. For example, the yarn and fabric producers 1 and 3 compete with each other for supplying Stella with fabric. Even if apparently Stella might be satisfied with purchasing only from company 1, with whom Stella has a much deeper and more collaborative relationship, Stella wishes to keep also company 3 as a supplier because company 3 supplies another key cooperation partner of Stella, namely company 8. In this scenario, Stella constantly works for moderating the effect of competition between the two couple of firms. But next to the risk of the destabilizing effects of this competition inside the network, Stella can at the same time exploit tactically this competitive situation and push the two companies to improve

product and service or to reduce final prices for its own benefit and for indirect benefits to other actors in the entire network.

This network is even more heterogeneous and complex if we take in account not only the relationships at company level, but also the specific actor bonds that emerged between the specific departments within each firm. For instance company 2 is a multidivisional firm specialized in fabric production, but at the same time owns a division which manages a franchise retail network for the commercialization of home textile. For this reason, the relationship between company 2 and Stella (company 5) has a dual content: on the one side, the relationship is based on a pure vertical market exchange (see B in Figure 4) because the fabric division of company 2 is simply a fabric supplier of Stella, but on the other side, the retailing division of company 2 works in cooperation with Stella in order to commercialize Stella’s final product to the final customer in their franchise shops (see C in Figure 4).

The emerging complexity and heterogeneity of the relationships and actor bonds in this network

influences the potential constraints to changing the business model, especially when it comes to the aforementioned relational aspects. The business model that had been historically established in the Stella network was “company-centered” instead of the new (“to be”) business model that was to become more “network-centered”. Before this NPR project, each company in the network acted as a “silos” in the sense that each firm had a proper business model focusing mostly on internal activities and indicators. Commercial exchanges were made mostly according to market rules, also by the companies who shared cross-holding alliances. There existed informal means of coordination between the firms who had strong and historical bonds, but they were not explicit and were very individual-dependent, making them very ad hoc. For instance, the information on a supplier’s stock was not a basic and reliable input on the basis of which to plan proper production schedule, but an erratic and isolated piece of information that could be gathered only if some people opened themselves freely during a dialogue. Therefore, the change entailed by the NPR project from a firm-centric model to a network-centric one would imply a new view on how each business was to be run, which would require a substantial change of many companies’ strategy, alongside the reengineering of their processes.

Some of the improvements entailed in this NPR project required high involvement and commitment by the parties, such as the initiatives to create “virtual stocks in the distribution chain for final products” or to increase the visibility of “raw product stocks” and “production capacity” for fabric producers (see Figure 2). For these types of initiatives, it was pivotal to have strong bonds among the involved firms that could facilitate the effective deployment of the business improvement. Therefore, not all the improvement goals of this project would have the same probability of success, if we take into account the actors involved in the implementation and especially the relational climate existing among them. Figure 5

connects the various improvement goals identified previously on Figure 2 with the types of relationship among the specific members of the Stella network involved in each single improvement line. These relationship types are classified as “B”, “C” and “D” using the same categorization<sup>3</sup> applied in Figure 4.

According to Figure 5, there are network process improvements in the Stella network that entail high relational constraints to be implemented, such as the diffusion of POS data and the creation of virtual stocks in the distribution chain. However, as most of the relationships required to implement these specific improvements are of cross holding or collaborative type (see the columns labeled “D” or “C” on Figure 5), the improvements can be nonetheless successfully achieved because the firms involved have strong relationships and actor bonds, making them willing to cooperate in a network perspective. Improvement initiatives can instead be jeopardized if they both entail high relational barriers and most of the companies involved have lower-quality market exchange relationships (lie in column “B” on Figure 5): this is clearly the case of the initiatives “production capacity”, “stock available” and “new fabric development” which involve fabric producers and home textile makers.

The dotted circle on Figure 5 shows that many firms who need to be involved to achieve the above network level improvements do not have actor bonds strong enough and their relationship is purely market exchange-oriented. More precisely, company 8, which is primarily a producer of home textile would greatly benefit from better and expanded information coming from a fabric producer such as company 3. However, their relation is too superficial or too arm’s length to create the trust necessary for these inter-organizational process improvements, all of which require a high level of collaboration. The situation is a bit more complex for company 2 and Stella: even if they have strong collaborative bonds when it comes to joint retailing efforts for final products, their

Figure 5. Relating Network Process Re-engineering goals with relationship types in the Stella network

Activity	Output process links			RELATIONSHIP TYPE		
	Info to release	To	Relational constraint	B	C	D
Yarn	Production scheduling	Fibre	high	n/a	n/a	n/a
	Production and delivery lead time	Fabric	medium	2; 3; 5	4;1	1; 5; 4;2
	Access to stock information	Fabric	high	2; 3; 5	4;1	1; 5; 4;2
Fabric	Blanket orders	Yarn	medium	2; 3; 5	4;1	1; 5; 4;2
	Production capacity	Home textile	high	2; 3; 8; 5		1; 5
	Stock available	Home textile	high	2; 3; 8; 5		1; 5
	New Fabric Development	Home textile	high	2; 3; 8; 5		1; 5
Finished Fabric	Ennobling forecasting	Finished fabric	low	3; 5; 6; 7	7; 5	5; 6
	Production capacity	Fabric; Home textile	high	3; 5; 6; 8; 7	7; 5	5; 6
	Detailed production scheduling	Home Textile	low	6; 7; 8; 2; 5		
Home Textile	Finishing design selection	Home Textile	medium	6; 7; 8; 2; 5		
	Blind purchase	Fabric	low	2; 3; 8; 5		1; 5
	Detailed production scheduling	Fabric	low	2; 3; 8; 5		1; 5
	Product working orders	Finished fabric	low	6; 7; 8; 2; 5		
	Finished product stock available	distribution	high		5; 8; 2	
Distribution	Product Promotion Announcement	distribution	medium		5; 8; 2	
	POS data	Home Textile; Finished Fabric	high		5; 8; 2; 7	5; 6
	Replenishment and delivery time	Home Textile	high		5; 8; 2	
	Communication & promotion campaign	Home Textile; Finished Fabric	medium		5; 8; 2	
	Virtual Stock in distribution Chain	Distribution	high		5; 8; 2	

relationship is only market-based when it comes to company 2 supplying fabrics to Stella. Therefore, these two companies too face problems in trying to implement the three process improvements with high relational constraints (“production capacity”, “stock available” and “new fabric development”).

The improvement initiatives identified by the squared dotted line in Figure 5 (e.g., “blind purchase” and “detailed production scheduling”) involve firms who are linked mostly by weak market-based relationships (column “B”). However, rather than being impossible to achieve, these process improvements are less intrusive and less

strategically sensitive for each of the involved firms. Therefore, the quality of these relationships, even if rather superficial, may be enough to sustain a program to share information between home textile producers and fabric producers.

Finally, the area within by the dotted hexagon in Figure 5 includes lines of interventions where the strong bonds and the collaborative relationships among the involved firms can sustain any projects of data interchange and information sharing, including those that affect very critical information for the core business of each participant (e.g., “sharing POS data” and “replenishment

and delivery time”). These strong collaborative relationships are typically found in the Stella network between distribution units and home textile producers. Although the relationship constraints to implementing these types of improvements is medium to high, the firms involved in sharing this information trust each other and this is a key ground for a complete collaboration and openness to data and information sharing.

### **The Strategies of the Central Actor to Facilitate “Network Process Re-Engineering”**

In reviewing the implementation constraints and the strength of relationships in the Stella network, we have so far taken a dyadic perspective on the information exchange, that is, we have focused on single pairs of participants, one counterpart being the sender of some piece of information and the other one being the beneficiary of that type of information. However, in a network perspective it is important to take into account the impact also of all other actors that surround a dyad. While this broader perspective surely raises the complexity of any process improvement, it simultaneously stresses that even more mutual trust is necessary among the involved firms. In the Stella network there is another important element that can partly counterbalance those situations where trust and will to collaborate between specific actors is not so high (i.e., the “B” relationships in Figure 4): this counterbalancing element is the role played by the pivotal firm, Stella (company 5), who has taken a leading position acting as the sponsor of the entire project for digitalizing this network.

The role, the inventiveness and the strategies of Stella are pivotal for the success of this NPR project because this firm stimulates the adoption and implementation of the improvement initiatives by the other actors. From its central position in this network, Stella has relationships with *all* the other firms in the network and can influence them by using various strategic maneuvers. Namely,

Stella from time to time either exploits its commercial power to *impose its own will* on the other participants or *concedes to their wills* in order to facilitate the deployment of the re-engineering of network-level processes. Stella has applied this type of strategy to its relationships with fabric producers (see the dotted circle in Figure 5): despite the strong cross-holding relationship between Stella and company 1, the latter tried to postpone the deployment of the improvement initiatives (stock availability, new fabric development information, etc.) because the related information would circulate in the network and become available also to company 3, which company 1 considers a direct competitor. Stella’s strategy in relation to company 1 and company 3 has been very intransigent in firmly requesting that both companies adopted the change project, while at the same time allowing them to receive in return information about its own production scheduling and assuring blind purchases if requests are met (see the dotted square on Figure 5).

Stella also alternates between *confronting the routines* in certain relationships and *accepting the status quo* in other relationships. Stella applied this type of strategies to the firms included in the dotted hexagon on Figure 5. Implementing the initiatives related to this hexagon would have required retailers to make investments in shop equipment enabling POS data exchange, which would have jeopardized another project of theirs aiming to rejuvenate the premises of many shops belonging to company 2. In this regard, Stella chose to accept the request of company 2 to postpone the investment in POS equipment by one year in order to let each shop collect the additional resources to make the investment. But at the same time Stella chose to oppose the request of company 2 to suspend the introduction of the initiative aiming to create a platform for virtual stock consultation for all the participants of the distribution chain. Stella started instead to persuade all the three companies that distribute its final product by means of a detailed information campaign: the

goal was to show each of these firms the benefit for all to share information about the stocks as a way to facilitate retailing operations. This goal was pursued also by a stable confrontation with the actors reluctant to embrace this initiative.

Finally, in order to improve efficiency and facilitate the digitalization of network-level processes, the strategies of Stella also aim to either *challenge* or *reinforce the existing structure and content* of its business relationships. The structure was challenged for instance when Stella involved in the network company 7, a finished fabric operator. The reason was that Stella’s relationship with company 6 was becoming too consolidated and was becoming less vital in terms of innovations. Therefore, Stella asked company 8 to invite in the network a new firm, here labeled company 7. This structural change in the network has brought in a new source for innovation and has stopped the relationship between Stella and company 6 from becoming too conservative and institutionalized.

## **CONCLUDING DISCUSSION**

The case of the Stella network illustrates the importance for Network Process Re-engineering of carefully analyzing not only the processes to be redesigned and the specific IT solutions to be implemented, but also the *type and quality of the business relationships* with each single actor to be involved in the NPR project. There are two main reasons for paying attention to each single relationship:

1. In a network there is typically a high degree of specialization, so that each firm performs only one or a few activities. At the same time, overall coordination is achieved by means of complex technology and process connections, known as “activity links” (Håkansson & Snehota, 1995), established between the activities of two or more firms in the network. The improvement potential of

each of these activity links strongly depends on the nature of the relationship between the involved parties. In our case, for instance, improving home textile deliveries and stock management at retail sites is made easier by the close communication and high level of trust between the home textile producer, Stella, and the distributors (see the dotted hexagon on Figure 5).

2. The possibilities of mobilizing and engaging each firm to invest and participate in a re-engineering effort depend on the type and quality of its relationships with the other firms (with whom each firm needs to improve coordination) and with a pivotal firm (who may assume a leading role for a NPR initiative, as Stella did in our case). In fact, counterparts are willing to invest additional resources and to share confidential information, as required by NPR, only if they highly trust and are committed to each other. When trust and commitment are low in a relationship, the parties are willing to make only minor investments and to share only less critical information, as in the case of the blind purchases, production scheduling and working orders exchanged between Stella and fabric suppliers, among which exist mostly transactional relationships (see the dotted square on Figure 5).

Thus, a substantial level of trust and commitment among the parties facilitates mobilizing and engaging partners in a complex, time-consuming and expensive project like a NPR. Moreover, if actors are highly interdependent because of strong technological connections or because they are very important for each other’s businesses, it is easier to identify strategic goals on which the parties can agree and that can be eventually matched (Baraldi, 2008: 116-7). Having converging goals with one or several other actors is another important factor to facilitate even the most complex tasks in a network process re-engineering: this situation is

exemplified in the Stella case by the strong integrative, alliance-type relationship between Stella and the finished fabric producer company 6, who can agree on such a complex task as transferring point-of-sale data not one, but two steps upstream – from retailing, via home textile production, to fabric production.

Even if the Stella network is not a very complex one (its boundaries were restricted for the purpose of this NPR project to include only 8 actors), this constrained network shows a general property of networks, namely, each relationship is interconnected with other relationships (Anderson, Håkansson & Johanson, 1994). This interconnectedness of relationships implies that all actors in a network are held together by many direct and indirect relationships that create a strong embeddedness: for instance, as we saw in the Stella network, company 1 and 3 are competing suppliers to Stella, but company 3, who appears to have a weaker relationship to Stella, is also supplier to company 8, who has a stronger relationship to Stella. This embeddedness entails that what goes on in a relationship in terms of interactions and cooperation both depends on and influences other relationships. Because of this type of social, technical and economic interdependence, the companies in a network are not entirely free in developing their strategies, but their strategies are connected to those of the other firms directly or indirectly related (Håkansson & Ford, 2002; Gadde, Huemer & Håkansson, 2003). Therefore, analyzing the nature and type of specific relationships, as well as the overall structure that connects them, can help the single firm to understand which relationships and actors are relevant and need to be mobilized for a certain strategic task (cf. Baraldi, 2008: 103-4).

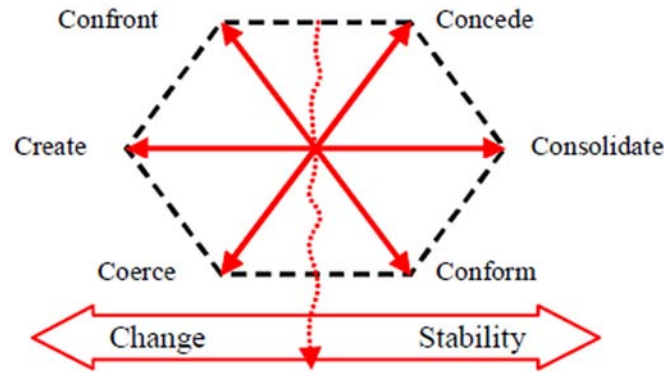
The most challenging situation is clearly the one in which a strategic task impacts, and consequently needs to involve and mobilize, the whole network, as in the case of Network Process Re-engineering. These highly complex tasks are difficult to pursue by means of a completely

spontaneous and free coordination, with all the actors in a network equally engaged and ready to participate. In the Stella network case, it was the company with a central position and the greatest power in that network who took the initiative and a leading role for a complex change project. This situation is however not unique: the so called “strategic center” (Lorenzoni & Baden-Fuller, 1995) typically acts as a promoter of change initiatives that impact, and thereby need to involve, the majority of other actors in the network. For instance, IKEA (Baraldi, 2008; Baraldi, 2003: 164-182) is often the initiator of projects aiming to make its whole supply and distribution network more efficient, often by means of IT, or aiming to develop new furniture-related technologies.

Compared to letting any other firm in the network take the lead of innovation initiatives, the “strategic center” has the advantage not only of sheer bargaining power but also of being in a central position because it entertains direct relationships with a greater number of actors than anyone else in the network. Starting from this stronger position, the central firm can apply a mixture of three strategic vectors, displayed in Figure 6, in order to influence other actors towards certain goals that can be beneficial for the network as a whole. As we have seen in the examples about Stella in the previous section, the central firm can combine in different ways the three opposed forces of “coerce vs. concede”, “create vs. consolidate”, and “confront vs. conform” (Ritter & Ford, 2004: 112).

The coerce-concede vector concerns the choice between imposing on other actors a company’s will by leveraging its power, on the one hand, and accepting the wills of other actors and thereby following their goals, on the other hand. The create-consolidate vector concerns the choice between building new relationships with new actors, on the one hand, and reinforcing the existing relationships, on the other hand. Finally, the confront-conform vector concerns the choice between challenging and maintaining the status

Figure 6. Three strategic vectors in networks



quo of the interaction within an existing relationship. The possibility for a “strategic center” to orient the development of a network lays specifically in finding an adequate combination and mix of the extremes for each of the vectors. However, if one single firm were to succeed in constantly coercing the other firms and in winning all confrontations, the network would be turned into a hierarchy controlled by a single firm, which reduces tremendously a network’s potential for innovation (Håkansson & Ford, 2002; Gadde, Huemer & Håkansson, 2003). In order to avoid this risk, companies may gain a lot if they refrain from exerting all their power to direct unilaterally a network. For instance, a powerful company such as IKEA chooses explicitly not to control and steer all interactions with its counterparts: especially when IKEA aims to engage the network into highly innovative and explorative tasks such as development of new materials, IKEA prefers to delegate a lot of responsibility to its network partners (Baraldi & Waluszewski, 2007; Baraldi, 2008).

Even if the results of this explorative case study cannot be straightforwardly generalized, our finding that relationship quality strongly matters for Network Process Re-engineering can be conceptually and analytically expanded to other fashion-intensive industries, and in general to any

industry where speed and timing issues in product development are essential. Indeed, the importance of the quality of relationships for NPR should be even greater in industries with a higher fashion content, such as garments, where timing and inter-firm coordination need to be even higher than in apparel and home textile networks, because clothing companies launch several collections per year and even products in between collections. Moreover, the importance of relationships quality for IT-driven process development should hold also in less fashion-oriented industries, such as furniture distribution, as witnessed by IKEA’s selection only of the best type of suppliers in order to conduct advanced IT-based projects such as VMI (see Baraldi, 2008).

The case study presented in this chapter can stimulate further research moving ideally in two directions: (1) A more systematic analysis of the impact of the nature and quality of business relationships on complex process re-engineering projects. This analysis could compare, via larger samples, various combinations between different types of relationships, on the one hand, and different re-engineering projects taken from several industries, on the other hand. In this way, it would be possible to obtain more general results on the importance of relationships and actor bonds for NPR projects. (2) A deeper analysis of how NPR

projects are affected by the connections between the social dimensions of a relationship (e.g., trust, commitment) and its technological dimensions (investments, volumes, adaptations, etc.), and by the interconnectedness between the many relationships involved in a NPR project. This type of study would ideally also need to expand the analysis to include the relationships stretching outside the focal network involved in the NPR project, because these relationships, especially if they embrace important counterparts, may have a strong impact on the NPR project, both by creating constraints and opening possibilities.

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## ENDNOTES

- <sup>1</sup> We have elaborated this figure as a synthesis of a series of meetings and interviews with the actors in the Stella network. In particular, the information on Figure 2 is grounded in three

brainstorming meetings with a delegation from each firm involved in the network and in a series of interviews with key informants in order to gather a wider knowledge about the processes and activities performed by each actor in the network.

<sup>2</sup> Our assessment has been made on the basis of the answers gathered from the owner of each activity during in-depth interviews performed following a checklist of issues to be analyzed. The evaluations reported in the last three columns of Figure 2 are our

reasoned conclusions from the various issues emerged from each interview.

<sup>3</sup> In the new Figure 5, the relationships of type “A” have been left out as they are not relevant to the analysis of relational constraints in the implementation of the selected improvement lines since the level of competition belongs to the duality of the firms but does not influence the network. As stated before, it is Stella, the focal company, who strives to balance between competition and collaboration in each single case of competing counterparts.

# Chapter 13

## Matching Manufacturing and Retailing Models in Fashion

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### ABSTRACT

*The aim of this chapter is to examine the interdependencies that have been established with reference to the manufacturer-retailer interaction in textile and apparel (TA). Retailers' strategies seek to reduce the risk of losses from unsold stock, mark-down policies, and stock-outs. These strategies call for manufacturing suppliers to adopt new practices for fulfilling orders flexibility, rapidly, and efficiently. The practices of "lean retailing" imply new manufacturers' strategies, mainly in term of "lean manufacturing." We examine the implications of these processes on the evolution of the relationships between industry and distribution. The chapter addresses the repercussions of the development of lean methods on the development of other formulas having a significant impact on the relationships between industry and distribution, specifically in TA. We then discuss further developments that may be proposed in TA and its channel relationships by shifting from a perspective of supply to one of demand.*

### INTRODUCTION

This chapter examines the evolution of the relationships between manufacturers and retailers in the fashion system and its implications over time. More precisely, we focus on the manufacturer-retailer interdependencies (Ailawadi et al., 2010)

in the textile and apparel (TA) supply chain and distribution channel, which are analyzed as a retail-apparel-textile system (Abernathy et al., 1995). The aim is to provide a picture of these changes and possible future developments<sup>1</sup>.

The chapter is divided into two sections followed by conclusions. In the following section we address the repercussions of the development of lean methods on the development of other

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'formulas' having a significant impact on the relationships between industry and distribution, specifically in TA. The ability of retail actors to reduce risk and achieve low response times from their manufacturing suppliers has been a powerful driver of change in manufacturer-retailer relationships. In TA the retail strategies of seeking to reduce the risk of unsold stock and losses from breakage call for manufacturing suppliers to adopt new practices for fulfilling orders flexibly, rapidly and efficiently. It is in this context that the concept of 'lean retail' emerged, and hence the practices of 'lean retailing'. Lean retailing is a process that calls for adopting a whole interrelated series of channel practices, beginning at the retail level, with the goal of matching supply and demand, and minimizing the inherent forecasting errors associated with the management of product mixes (Hammond, 1990; Forza & Vinelli, 2000). The introduction of lean retailing began in TA where lead-times were dictated by the two seasonal change-overs (*a-w* autumn winter; *s-s* spring summer), whose importance lay essentially in operational aspects, that is, the lag times between the forwarding of an order and response-delivery (Hunter, 1990). Subsequently, the spread of lean retailing was to place significant stress on all aspects of company programming, including research, production and marketing of the chain-channel. This had effects on decision-making regarding not only product assortments, but also fashion trend offerings and the presentation of collections even at the level of manufacturers, including those in textiles (Agins, 1999). In fact, the adoption of lean retailing operations puts immediate pressure on manufacturers, who find themselves faced with the choice of either holding greater amounts of finished merchandise in reserve in order to meet potential customer demand, with the risk however of winding up with large surplus stock, or innovating production processes to meet the new demands of retailers and thereby reduce their own exposure to the risk of surpluses at the same time.

In the second section we then discuss the implications of adopting lean manufacturing strategies not only in clothing supplier production processes but also at other levels. The requirements of lean retailing process concern not only apparel producers, but textiles manufactures as well. At the same time, lean retailing put pressure on fashion-oriented businesses to adjust the organization of their creative cycle itself in order to satisfy the final demand.

Overall, the chapter highlights the ways in which retailers are able to reduce risk and propose more attractive offerings to consumers. Advances in IT have brought about significant reductions in the cost of information collection, processing and distribution. Already during the 1980s and 1990s, such innovations set the stage for the implementation of distribution strategies aimed at reducing retailers' exposure to the risks associated to the disparate, constantly changing nature of market demands. The ability to use real-time information from points of sales allowed for adjusting product offerings on a daily basis to best meet the level and profile of the effective demand (Stabell & Fjeldstad, 1998). Such strategies aim to reduce inventory levels as a whole. Trends in this direction were already cited in the literature of the 1980s and were destined to increase considerably over the following decade (Tyler, 2008).

It should however be noted that the information gap remains the weak point in both retailers and manufacturers' relationships with the market. Given the current state of affairs, struggling manufacturing companies need to take a more active role in dealing with their demand-chain, especially by anticipating demand, while retail companies has been able to take an active role in the supply chain. A number of success stories may serve as examples: some manufacturers have managed to thrive by establishing tight relationships with retailers who have developed the capacity to give them a competitive edge in this rapidly evolving sector.

An outline of this evolution and some conjectures about future trends are presented in the concluding section. The relevant issues are addressed through a review of the literature and discussion of the author's own research.

**Evolution of the Channel and 'Lean' Versus 'Outlet' Formulas**

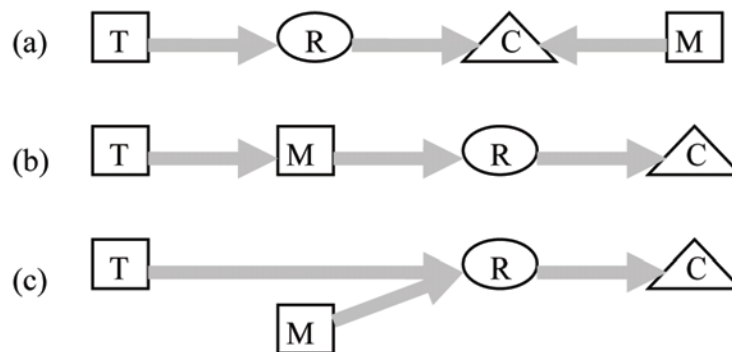
The spread of lean retailing processes over the last twenty years or so serves to highlight a return to the centrality of retail, in which the actors upstream from the chain-channel are in more direct contact with the distribution level. The sequence of traditionally recognized relationships between (1) textile enterprises and clothing enterprises, (2) apparel enterprises and retailers, (3) retailers and consumers has been interrupted, at least in part, by the new centrality of retail. This has translated into the emergence of relationships unaccounted for in traditional models, as retailers may be directly linked as clients to textile firms, and textile firms, in turn, may be direct customers of companies furnishing manufacturing services (Figure 1).

In the model illustrated in Figure 1(c), firms operating at the industry level put their production

capacity at the disposal of third parties, and thereby essentially act as contractors. Such enterprises may develop and promote a process of upstream integration of distribution firms, given that that these latter carry out roles typical of industry (sourcing raw materials and semi-finished products, product design, quality control, etc.), which are not carried out by contractors (Weiss, 1958).

In apparel channels characterized by predominately 'independent' relationships, clothing manufacturers interface with the suppliers of semi-finished textile products and retailers essentially through transactions between autonomous agents. Apparel producers operating in channels with largely 'interdependent' relationships have closer ties with subcontractors and retailers. This results in greater flexibility and a constant exchange of information (Uzzi, 1995). In this case, distribution can furnish information to the manufacturer, with whom it then coordinates actions to carry out merchandising and other marketing activities in their common interests (Sheridan et al., 2006). Such information exchange with the retailer can enable the manufacturing firm to better direct its short-term production, as well as its own design

Figure 1. Supplier-buyer links in the three models considered [Source: our elaboration]



T = textile firm; M = apparel manufacturer; R = apparel retailer; C = consumer:  
 (a) 'tailoring dominated' model: T(0,1), R(1,1), C(2,0), M(0,1)  
 (b) 'ready-made clothing' model: T(0,1), M(1,1), R(1,1), C(1,0)  
 (c) 'retail' dominated model: T(0,1), M(0,1), R(2,1), C(1,0)

activities. The distribution firm may however decide to take over these critical functions (production planning, design...), provided of course it has the means and resources to do so. Thus, it would not need to develop 'interdependent' channel relationships, but could maintain 'independent' relationships, by which it can make use solely of the manufacturer's production capacity, whose role thus tends towards that of a contractor.

Regarding the last type of distribution channel mentioned, that is, one characterized by '*integrated*' relationships, the roles of both apparel producer and retailer are taken on by a single agent, who carries out almost all management functions regarding both manufacturing and distribution operations. Such agents may be firms originating historically in the distribution sector, but who have taken on typically industrial functions, or conversely, they may originally have been involved solely in the manufacturing end and expanded downstream into retailing.

In TA industry-distribution relationships a role of increasing importance is being played by new out-of-town commercial sites called '*outlet centers*'. For manufacturers whose client retailers have adopted lean retailing, such centers can offer an alternative to adopting lean processes to satisfy such clients' needs. Implementing lean retail calls for quick response times on the part of the distribution network. Suppliers that adopt lean manufacturing to satisfy such demands are also able to reduce the negative effects of (1) unsold merchandise, (2) discount sales at cost, and (3) lost sales due to stock breakage, for both themselves and their client distributors. In contrast to this solution, outlet stores, and outlet centers in general, offer a direct sales channel that acts as a 'relief valve' for producers, that is, a means to dispose of excess production, generally through the formula of 'every day low price'. In this sense, the outlet channel can be viewed as an alternative solution to lean manufacturing, in the manufacturer's perspective, though (as we will see) it is potentially complementary to lean retailing in

fashion apparel distribution. Despite the higher risk of surplus associated with the higher inventory necessary to ensure rapid service, suppliers of 'lean' distribution firms can maintain their traditional planning because they can later dispose of any such surplus inventory through the direct channel represented by the outlets.

The 'outlet' distribution channel, however, presents at least one disadvantage with respect to the option of responding to lean retailing by implementing lean manufacturing. This is that lean manufacturing allows for the possibility of limiting lost revenues from stock breakage, while this cannot be counted, per se, among the benefits of an outlet channel.

Naturally, we can also envisage types of channels in which sales through outlet stores are combined with lean manufacturing practices, thus regarding the two processes as complementary. In such a scenario, manufacturing enterprises would also undertake a form of integration of the distribution process, albeit through a direct approach, which allows it to dispose of surplus inventory through a dedicated channel. In light of such considerations, it should be no surprise that the outlet channel developed rapidly, in parallel with the spread of lean retailing in the fashion apparel industry – in the United States up until the late 1990s and over the following decade in Europe.

The outlet channel represents a type of 'direct' distribution channel, which is essentially characterized by the presence of an agent, the promoter of the center, whose role is to carry out some of the functions typical of retail. In fact, the promoter may take on certain management functions characteristic of retail activities (hiring personnel, marketing, display management and merchandising), together with other roles that are instead typical of a site promoter, starting with determining tenant-mix strategies and generating traffic by promoting the outlet (Burrresi & Guercini, 2003).

The outlet form of direct channel is therefore particularly attractive for operators who are not

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committed to implementing lean manufacturing in response to the lean retailing adopted downstream by their clients in distribution. The agents that integrate processes of lean manufacturing and lean retailing are therefore by definition those less oriented towards the outlet channel, even though their positioning may in some cases be higher (Figure 2).

The results attainable through integration in channel relationships underlines how tight coordination, prompt information exchange, and risk sharing between industry and distribution are fundamental to providing a timely response to the changes of the final market (Richardson, 1996, p. 410). It seems that such integration need not necessarily be combined with forms of proprietary control. Besides such forms there are others in which integration between distribution and industry may be the result of a bias towards servicing the latter, which is amenable to the development of agreements and alliances with retail firms through channels dominated by ‘independent’ relationships.

The proliferation of items references (i.e., number of Stock Keeping Units to manage) is a long-term trend in TA, and suggests a series of implications for both producers and retailers, the first amongst which is the greater uncertainty over what product(s) will sell best (Abernathy et al., 1995, p. 192). After all, companies produce a variety of merchandise in order to gain a greater

market share (competitive logic), as well as to fulfill the wishes the final consumer (demand logic).

The greater the variety of merchandise, the greater the uncertainty for each single product. In order to furnish more service to clients without winding up with more surplus, retailers must be able to acquire needed goods without delay. Accordingly, this requires that manufacturers be able to fill orders promptly and efficiently. If manufacturers respond simply by increasing their own inventories, they will incur rising costs (especially from unsold stock) and they will, in the middle-to-long term, be less competitive. Sooner or later, at some point client distributors will be driven to seek a more efficient supplier (Blackwell, 1997). Thus, lean retailing inevitably appears to favor the development of lean manufacturing. Adopting lean retailing practices offers retailers a way to capitalize on advances in information technology and to minimize exposure to uncertainties in demand. The demands of clients with such preferences will bring pressure to bear on manufacturing suppliers, engendering substantial changes in the practices of the supply chain, and moreover with consequences on the entire business process (Milgrom & Roberts, 1988). Thus, at one extreme, manufacturers could simply opt to not innovate their internal routines and hold the necessary inventory to service lean retailers, thereby increasing their inventory costs. On the other extreme, manufacturers could upgrade their operations of internal planning and design,

*Figure 2. The relationships between unsold stock management and positioning [Source: our elaboration]*

		Positioning	
		lower	higher
Manufacturer unsold stock management strategy	lean	typical lean retailing and manufacturing	integrated outlet and lean
	outlet	integrated outlet and lean	typical brand manufacturer outlet services



provisioning, supply and production, to be able to rapidly respond to changes in demand, and thereby minimize the risks associated with surplus inventory, as much for themselves as for their clients. In an even more developed form, it could be the manufacturers themselves to impel retailers unwilling to follow such an approach to adopt lean forms of retailing, thereby leveraging their own quick response capacity as lean manufacturer to gain a competitive advantage over competitors (Guercini, 2001).

### **PERSPECTIVES IN THE NEW MANUFACTURER- RETAILER RELATIONSHIPS**

As we have seen, the introduction of lean retailing leads to significant transformation in both the standards of service expected and the interactions between industry and distribution, with a shift of manufacturers' investments in distribution centers and service systems towards the retail segment. The development of lean retailing entails the increasing dominance of retailers within channel relationships. The need for suppliers to adapt their behaviors to meet the demands of retailers does not necessarily imply symmetry in the flow, or even sharing, of information, given that retailers simply impose compliance to their standards and are not obliged to share data on demand beyond that information implicit in supply specifications (Hunt & Nevin, 1974).

Distribution practice has also undergone substantial progressive changes in terms of logistics. Traditionally, goods have always been transported from manufacturing plants to warehouses also owned by the manufacturer, whence they would then be transferred to retailers' storehouses. In lean retailing systems, the warehouse has been replaced by automated distribution centers, which interface directly with both industry and distributors (Hoover et al., 2001). Clothing suppliers can set up their distribution operations so as to increase

the information links between manufacturing enterprises and retailers, thereby enabling labeling or informing retailers of upcoming deliveries, for example. Thus manufacturers can provide retailers with new services, which may even involve advance price labeling, as well as general merchandising services (Park, 2004).

Innovations in the apparel channel also have effects upstream on the textile market. At times change arrives suddenly, at others it comes more gradually, but it looks a general trend, and it is always the retailers who represent the essential agents of change (Doyle et al., 2006). Retailers call for clothing suppliers to invest in the first, emergence stage of "lean retailing" strategies – a whole series of basic information technologies whose purpose is to meet the requirements of ever-more demanding retail service in terms of short lead-times and rapid fulfilling of orders (Palmer & Markus, 2000; Forza & Vinelli, 2000). Retailers do not care much about how suppliers satisfy such requirements, as long as they do (Geysken et al., 1999). We are now witnessing the ever-increasing emergence of practices that address the problems of interfacing retailers and manufacturers, rather than the purely manufacturing concerns of clothing enterprises. If clothing producers adapt their operations to face the new and rising demands of the channel, their suppliers must also become more prepared to respond with new offerings of finished and semi-finished fabrics, as well as other new products and services (Jones, 2002). Although purchase price has traditionally represented the basic reference element for assessing supply alternatives in the TA industry, the spread of lean retailing strategies has brought other criteria into play, in particular, supply lead time. Lead times are traditionally longer for the delivery of fashion fabrics than for basic ones. In particular, in the formulation of the early 1990's, lean retailing focused mainly on "basic" or "fashion-basic" goods, rather than "fashion oriented products" (Abernathy et al., 1995). The spread of lean retail strategies in the field of fashion becomes evident in

the second formulation of such strategies, widely adopted especially in the late 1990's, though their inception had come somewhat earlier<sup>2</sup>.

Lean retailing processes, in fact, underwent a second stage, whose peculiar features with respect to the preceding stage include: (1) greater involvement of textile suppliers in the adoption of lean retailing; (2) the spread of lean retailing also to the field of fashion-oriented products, which imposed a reorganization of the stages of planning and designing apparel. A number of other aspects are also interesting in this regard: (a) the retail-apparel-textile channel appears increasing driven by actors who take on the role of lean retailers or, when originating in the manufacturing sector, producers who take on the functions typical of retailers and assist their retail clientele in implementing lean practices; (b) increasing interdependencies arise within the channel, and are linked to the processes of organizational integration, which also promote processes of vertical integration in response to the increasing need for coordination; (c) there is an increasing service orientation in the exchanges within the channel; (d) although the prime movers of change come clearly from the retail level, other actors may also address the problems of interfacing with distribution and consumers; (e) since lean retail requires a "quick response" from the supplier, when dealing with fashion and fashion-basic products, local suppliers may enjoy a relative advantage due to their shorter reaction times (Christopher et al., 2004).

New information technologies, new production process management, the evolution of production costs abroad and new organizational solutions are all aspects that have contributed to transforming the relationships between distribution and industry in TA (Palmer & Markus, 2000). It seems that the close communication within such relationships have come to substitute for inventory reserves (Milgrom & Roberts, 1988). The emergence of lean retailing processes has progressively revolutionized the relationships between distribution and industry in TA. Within the broader context of

modern clothing distribution, such revolution may be invoked to partly explain the central importance attained by retailing among the various roles in the TA supply channel. Lean retailers differ from traditional clothing businesses in their greater exploitation of information technologies, an aspect that especially characterizes the first stage of lean retailing's development, and which has brought about a change in the demands on manufacturing suppliers for speed and reliability, thereby driving them to adopt lean manufacturing practices. The second stage of development of lean retailing therefore led to the involvement of other components of the value chain, generally within the manufacturing sector, and particularly affecting the areas of planning and design (Jackson, 2001; Sheridan et al., 2006). The consequent initial increase in the number of seasonal collections (from two up to four or even six) was quickly followed by a veritable explosion, even as far as the creation of weekly collections in fast fashion enterprises. Various critical factors account for the success of seasonal fashion-oriented products (Mattila et al., 2002), all linked to sourcing: *forecast accuracy*; *process lead-time*; *offshore-local sourcing mix*; and *up-front/replenishment buying mix*. In lean retailing forecast accuracy is less critical, because what is produced is tightly linked to the demands of direct customers (Mattila et al., 2002, p. 343).

Brand manufacturers who work with lean distribution clients may find themselves having to manage potentially unsold stock, if they themselves do not "go lean" in their own manufacturing processes, that is to say, adopt *lean manufacturing*. In the event that they do not, then the organization of the supply chain / distribution channel will see to it that any surplus stock is essentially left with manufacturers. Another way that this can happen is when the industry is integrated at the retail level, which however does not practice lean retailing. Thus, the reserve stock is functional – it is necessary in order to fully serve the sales sector and avoid stock-outs. These two situations are illustrated by "c" and "d2" in Figure 3. In both cases

industrial producers can manage these reserves through a direct outlet channel, offering “out of season” and/or “out of standard” products. It is interesting to note how lean manufacturers who interface closely with lean retailers, by limiting the amount of products released into the retail channel, should not need a presence in such outlet channels.

The relationships between industry and distribution in TA can be analyzed by comparing manufacturer management of the “supply chain” and retailer management of the “demand chain”<sup>3</sup>. As already seen, from the 1980’s until the 1990’s new technologies and new strategies and organizational models were progressively adopted to reduce lead times and limit surpluses due to market forecasting errors. This process has produced *quick response* times for lean retailer clients, but should per se be distinguished from the processes involved in *quick fashion* (Guercini, 2001, p. 70). This latter development represents a formula aiming not only to reduce leads times, but also to adjust organization of the creative cycle itself as a function of the requirements of final demand. In traditional “programmed” production management systems, the fashion chain leading up to a new season calls for an 18-month cycle (Irpel-Textrends, 1991). For instance, during the 1980’s the average lead time in the clothing industry, from raw material to final consumer, has been estimated at about 65-70 weeks, of which only 11 were for manufacturing, while nearly 40

were taken up by the processes of wholesaling and logistics. In recent years a rather general rule appears to have defined a 12-month cycle (thus 15-20 weeks less than in the 1980’s). The main benefit of this reduction in lead times has been to minimize forecasting errors and their effects. It has been estimated that, while traditional times can lead to forecasting errors of about 40% of overall production, reducing lead times from 12 to 9 months can cut this margin of error by half (Jacobs, 2006, p. 85). Further reductions in lead-times can bring about progressive reductions in forecast errors, with consequent improvements in the overall balance sheets of channel enterprises. It has been estimated that the pre-season forecasts currently suffer from an error of about 10% (Lowson et al., 1999, p. 44, p. 93 ff.).

In this regard, fashion designers conceive of new trends about one year before the target season. However, the decisions regarding semifinished textiles, beginning with the fabrics to employ, are made months before (Jackson, 2001, p. 127 ff). Nowadays, many successful firms have reduced lead times so drastically that they are no longer tied in the same way to the seasonal production management model. Vertically integrated firms such as Inditex-Zara and H&M can complete the entire cycle from design to distribution in only three to eight weeks, thereby effecting substantial changes in operating relationships within the channel.

Figure 3. Lean strategies in TA manufacturing and retail [Source: authors’ processing]

		Retailing	
		lean	non-lean
Manufacturing	lean	(a) limited reserves in channel	(b) retailers hold reserves
	non-lean	(c) manufacturer holds reserves	(d1) retailers hold reserves, or (d2) retail-integrated manufacturers hold reserves

The development of lean retailing aims to limit lead times and thereby avoid errors in forecasting and, consequently, the associated higher costs / lower profits. Two parts of the TA value chain can be distinguished: the “*supply oriented*” and the “*demand oriented*”, as per the well-known scheme proposed by Porter (1985, p. 35). This chain is normally represented with horizontal left-to-right arrows, which indicate the flow from raw materials to final consumers. Thus, we speak of “*demand and supply chain management*”, in which the flow of products are oriented in one direction (supply), and the information relevant to decision-making in the other (demand). According to Jacobs (2006, pp. 86-87), some components of the value chain can be represented as flowing from right to left in the “demand” perspective, in which the position of end consumers on the right-most side emphasizes their determining role in orienting and driving enterprise activities in the chain-channel. Because suppliers are clearly crucial to important segments of clothing firms’ value system, reducing lead times in the supply chain requires a concerted effort with these partners. Suppliers’ orientation or stance with respect to their specific “*demand chain*” is clearly important in this process. In fact, there are two ways suppliers may define such stance. The first way for suppliers to take such a demand stance is to assume that the requisites expressed by retailers is the true expression of demand. In this case, the directly relevant agents of demand for the manufacturing firms are their immediate retail clients. The second approach instead takes the demand stance in perhaps the strictest sense of the term, by equating it directly with end consumption. Consequently, cooperation with retail occurs through different means. In fact, in this case manufacturers may seek to integrate vertically, taking on distribution functions in an effort to bring themselves closer to end consumers.

Nowadays, the fact is that for manufacturers the demand side of industry-distribution relationships is still generally represented by retailers, who must plan their own product mix (“what”

to sell), manage their inventory (“how much” of each article and SKUs) and consequently decide on purchases (“where” and “who from”). Retailers make such decisions based on their knowledge and assessments of the needs and desires of consumers. Such assessments may however suffer from significant shortcomings, especially considering, as highlighted by some recent studies, that more than half of European fashion consumers fail to find what they are looking for at sales points (Stockert, 2004). The logical conclusion, already drawn by various authors, is that the state of information on consumption remains the “Achilles’ heel” of TA chain-channel management. The supply side of industry-distribution relationships is clearly of relevance to retailers, given that they must interface with manufacturers who combine or collect the inputs for production (sourcing), and must organize its various stages, including packaging and delivery of products to the distribution channel.

Analyzing the supply chain and the demand chain is also of considerable importance to the organization of integrated enterprises, as they do not necessarily require distinct, recognizable agents. When such vertical integration has not been implemented, it falls to the manufacturer to study the demand chain, just as it is up to the retailer to examine the supply chain, thereby giving rise to a distinction based on which the links between the two perspectives can be discussed with greater precision.

On the *demand side* the supply chain can be managed through purchasing policy, by seeking different types of links through which to interface with different areas in the typical supply chain of manufacturers (Hoover et al., 2001, pp. 74-76). These are represented by “distribution” (A), “packaging” (B) and production in its narrowest sense, i.e., “manufacturing” (C). Retailers can in fact look for contacts with manufacturers’ distribution divisions, with the aim of ensuring rapid delivery, as the supplier has probably invested in substantial amounts of inventory (scheme “A” in Figure 4).

In the second approach mentioned, retailers look for contacts with packagers and request assembled products from clothing suppliers in response to precise consumer demands. Such requests may include logistics management, dedicated packaging, adjustments to product specifications and/or private labeling (“B” in Figure 4). Lastly, in the third approach, retailers interface with suppliers’ manufacturing processes, from whom they can order custom production (*manufacture-to-order*), though this comes at the cost of lower efficiency and longer delivery times. Such solutions moreover generally involve accepting higher supply prices (“C” in Figure 4). Retailers therefore come to manage these alternative sourcing methods by operating on the demand side and carrying out “*supply chain management*”. On the industry side, manufacturers must cope with the requisites and constraints of production technologies. Moreover, they are often responsible for managing the more well-established, if not traditional, requirements of inter-organizational relationships along the TA chain / channel. Often producers who avoid such role, do so by taking on a more demand side approach, that is, they manage process so as to achieve high levels of distribution sell-out by favoring retail activities over direct relationships with final consumption.

On the *supply side*, industry can implement various different policies for managing the demand chain, thereby adopting so-called “*demand chain management*” (Baker, 2004). Four different forms can be distinguished (Hoover et al., 2001, pp. 76-80). The first form, interfacing producers’ distribution functions, essentially involves retailer purchasing. Such an approach to demand chain management is a mirror image of the first of the three types of supply chain management cited with regard to retailers (“A” in Figure 4). This first case therefore represents a form of cooperation that can provide suppliers with a quick response strategy to satisfy the requirements of lean retailers (Iyer & Bergen, 1997). A second form of demand chain management by manufac-

turers calls for joint effort in the operations of manufacturing, packaging and distribution, which may need to interface administratively with purchasing, but which, in any event, seeks to coordinate with retailer clients’ inventory management, thereby providing savings in inventory costs (“D” in Figure 4).

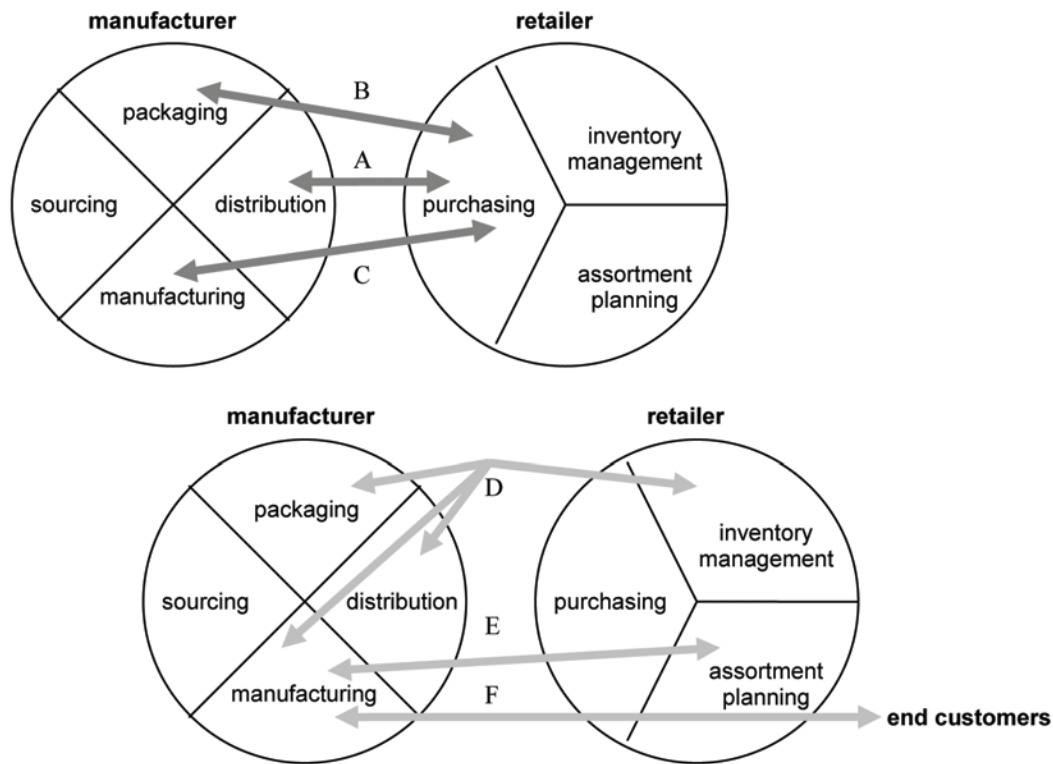
A third type of demand chain management involves establishing relationships between producers’ manufacturing divisions and retailer clients’ inventory management. In order to collaborate in defining retailers’ inventories (including merchandise assortments), manufacturers must, together with their direct clients, try to understand the consumer demand categories that both are seeking to satisfy (“E” in Figure 4). The fourth and last type of demand chain management presents some particular features. Here, manufacturers organize their demand chain management based not on their retail clients, but rather directly on indications from final consumers (“F” in Figure 4).

This last form of demand chain management appears particularly interesting. It has been likened to the strategies used to overcome retailing and achieve mass customization in other sectors, such as the case of Dell in the personal computer industry (Kerin et al., 2009). Such approach to the demand chain may be of as much interest to *manufacturer-retailers* (producer integrated in distribution) as to *retailer-manufacturers* (distributor integrated in production). This latter presumes an inverted perspective of the path: retailers try to achieve a more direct link between manufacturing and final consumers through their own distribution network. In both cases, the relationship between industry and distribution in TA merges the various resources in an integrated fashion to guarantee more direct contact between manufacturing processes and the downstream activities of the demand chain<sup>4</sup>.

In such a scenario, industry may also seek to set up new services of interest mainly to the retailer, so as to build up dynamic cooperation through which to improve economic results of

## Matching Manufacturing and Retailing Models in Fashion

Figure 4. Alternative relationships between manufacturer (supply perspective) and retailer (demand perspective) in TA [Source: authors' processing]



- A – interface distribution-sourcing (cooperation to obtain quick response)
- B – interface manufacturing/packaging/distribution range management (integrated range management)
- C – interface manufacturing-range planning (integrated planning)
- D – interface manufacturing-final customer (full demand chain orientation)

equal benefit to both. In the event retailers press excessively for price cuts, the manufacturer may try to establish direct relationships with consumers, following the approach outlined in the fourth and last form of demand management described above. Alternatively, it is sometimes retailers themselves, who by their close participation in typically manufacturing functions, take on the distinctive features of retailer-manufacturers (or industrial retailers), and adopt the fourth approach to demand chain management described, in order to respond more fully to the consumer demands they manage to perceive. In any event, both retailer-manufacturers and manufacturer-

retailers come to address the logic of both the supply chain and the demand chain in an at least partly integrated fashion within their enterprises. The understanding of consumer demand that can be gained solely from the information collected by conducting retail activities cannot however account for the so-called “unrealized sales” consequent to consumer dissatisfaction with the assortment offered. The traditional functions of the middleman do not include the developing of close contacts between manufacturers’ offerings and final demand. Managing the demand chain does not simply represent the mirror image of supply chain management by the retailer, given

the important role that this latter's orientation to final demand may have. This is an aspect that still requires further development, despite the meaningful impetus towards the vertical integration of fashion enterprises. Integration must go beyond the simple, partial forms that developed in the early stages of lean retailing, and broaden vertically to include interfacing with consumers downstream and with the design processes upstream.

With more complete vertical integration the drive to cooperation among actors within the same channel gives way to a greater impact of competition between channels involving vertically integrated enterprises. Even at the retail level, there seems to be little understanding of the causes of unrealized sales to actual customers (not to mention prospective clients), and to this end information technologies are of little use without the ability to relate to customers, draw nearer to them, gain greater understanding and learn through a relationship with them. The fourth type of supply chain management ("D" in Figure 4) therefore has the potential to bring about more radical innovation – not only in end consumer products and services, but also in the relationships between industry and distribution – than the two stages of development of lean retailing (Jacobs, 2006, p. 92). At the same time, there has been a shift from greater *vertical cooperation* toward one marked essentially by *horizontal competition*. This suggests that the evolution of industry-distribution relationships in TA is potentially destined to devote greater attention to the acquisition of knowledge on the prospective behaviors of the final customers of all businesses, that is, consumers. This comes about in the face of the continued standardization of service centers, as highlighted by the excessive uniformity in the various types of shopping centers, which in turn has stemmed from the pursuit of economy by the large fashion chains and the management and control systems of the promoters that have created them.

One important related aspect concerns the considerable difficulties involved with actually

using the data produced by distribution information systems (micro-marketing applied to apparel distribution). Such difficulties stem from the currently limited number of case studies on market segmentation based on the data collected by POS systems. Faced with such limitations in retail information technologies, fashion demand seems ever more difficult to predict, especially in light of the long-term increase in its diversity that began in the 1950's and 60's (Abernathy et al., 1995) and which has accelerated considerably in recent years. Cooperation between retailer and manufacturer does not appear enough to face such rapid development, either with regard to inventory and selection management alone, or at the level of planning product ranges and manufacturing. Moreover, the potential benefits of cooperation in terms of understanding prospective consumption do not seem extend beyond that which has been defined a generic advantage of two partners may possibly know more than one (Jacobs, 2006, p. 89).

## CONCLUSION

This paper has discussed how the evolution of the relationships between industry and distribution in TA seems to follow particular paths that are quite distinct from those developing in other fields of distribution. Such paths are shaped by the peculiarities of the manufacturing and distribution processes in the fashion industry and the TA production cycle. More specifically, what emerges from the analysis are at least three possible evolutionary patterns, which in historical terms define the last three decades, at least. However, such paths of evolution also take on a conceptual quality and therefore may be abstracted from any specific time period.

In a first stage of evolution the relationships between industry and distribution are characterized by the early success of lean retail formulas, which shape the operational processes of industry. This upsets the established order, in which both

industry and distribution organize their product offerings (textiles and apparel) based on two seasons (spring-summer and autumn-winter). Thus, with the rise of lean retailing, this first evolutionary stage allows for going beyond the traditional patterns of production cycle times, and brings about profound changes in retail enterprises' operations and their relationships to industry. In this stage, enterprises seek to minimize lead times through the collaboration between industry and distribution made possible by the introduction of technological innovations in information management. This stage reached its peak in the 1980's and was characterized by the development of business enterprises, such as Benetton, which represent models for analysis and emulation at the international level.

During the second stage of evolution of industry-distribution relationships the consequences of the adoption of lean formulas spread to involve industry, particularly in their interior functions upstream of logistic and commercial aspects. Once again, such trends are triggered at the level of retail functions and processes and, unlike the preceding stage, they not only tend to shape the operational activities of supply process management, but come to involve and profoundly modify the very creative processes of industry. Within this framework, some manufacturing processes can be integrated directly into enterprises whose prime concern is distribution. The spread of fast (or quick) fashion processes is symbolic of this stage. Not only are operative lead times reduced to a minimum, but conception and design times come to be defined by ever more frequent offerings as determined by the need to bring to market merchandise in a continuous "state of becoming" and hence able to stimulate demand. In this stage the lead times dictated by two fashion seasons have been definitively superseded by a large number of new offerings brought out at an ever more rapid pace. Firms such as Zara are emblematic of this stage of evolution of the relationships between industry and distribution in TA. Cooperation through

vertical relationships gives way to processes of true strategic and operational integration, accompanied by the heightening of horizontal competition. There is a full-blown trend toward market- and service-orientation, with a consequent shift from a supply chain in which the guiding principles for buyers-suppliers are defined by technology (upstream), to one in which the (downstream) processes of distribution and consumption play the central role.

This model seems to have reached full maturity in recent years. Enterprises that have adopted such practices have even achieved better performance than those gained through other strategic groups. Such market orientation has led to improvements in industry response times to customers' actual purchasing behaviors and moreover stimulates consumer interest by intensifying the pace of new, and therefore 'fresher', fashion offerings. Such model seeks to minimize the lag times between conception and production, on the one hand, and better respond to consumer purchasing behavior, on the other. However, it does not address the need for knowledge, for instance, on unrealized sales due to a consumer's failure to find the sought for product in stock. In other words, in both the evolutionary stages described, attention is devoted more to purchasing behavior than to actual consumption. This represents the "Achilles' heel" in the market orientation of TA firms. Both industry and distribution enterprises remain largely committed to marketing offers at an ever accelerating pace, with the aims of stimulating the market and reacting rapidly to its manifestations of interest. Even more so than in other fields, TA is still lacking the market research tools necessary to acquire direct knowledge of consumption. A greater understanding, for instance, of unrealized sales and their relations to what customers look for, could have significant implications for the strategy decisions of enterprises, which over the last years have often focused on points of sales and customer-experience aspects. Such an approach marks the third and last stage of evolution of the



relationships between industry and distribution, one which could lead to, or at least offer, alternative prospects to the trends that dominated the earlier stages.

For future research, it will be interesting to find analytical evidence to theoretically verify some critical insights revealed in this paper. For example, for channel coordination issues in different stages, the respective operational benefits and coordination mechanisms can be explored (see Eppen and Iyer 1997, Chen et al. 2006 for more details).

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## ENDNOTES

- <sup>1</sup> The study of the retail-apparel-textile system seems amenable to a functionalist approach: given its internal links to the supply channel, it can be analyzed as a whole (Bucklin, 1970). The sole fact that a number of different manufacturing agents are involved (in both textiles and apparel) does not by itself seem sufficient to compromise the application of some facets of functionalist analysis (after all, the distribution channel begins with manufacturers).
- <sup>2</sup> Good examples in this regard are the fashion-oriented product lines offered by Zara and H&M, or those of the Italian Liu Jo, Patrizia Pepe and Pinko.
- <sup>3</sup> The offer chain / distribution channel can be interpreted in both a “supply” and a “demand” perspective (Jacobs, 2006), as it presents aspects of both (Gipsrud, 2004, p. 202).
- <sup>4</sup> This may also represent an alternative response to the appeals of many retailers for ever lower prices for the manufacturing supplier's products (Guercini, 2008).

# Chapter 14

## A Mass Customisation Implementation Model for the Total Design Process of the Fashion System

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### **ABSTRACT**

*Global economic development has been increasingly segregating the design and manufacturing functions of industries both geographically and administratively. In response, fashion companies in advance economies have increasingly operated as brand houses that engage in design and marketing as their sole activities. The total design processes of the contemporary upstream fashion supply chain is therefore investigated and analysed as an integrated fashion system. A new conceptual model of mass customisation aligning the activities and interests of the collective fashion supply chain producers is subsequently developed with its associated implementation strategies. This model takes a consumer-centric approach, and places designers/brand houses as the instrument and channel for mass customisation. The objective is to enable the prospect for small medium fashion enterprises to deploy the vision and principles of mass customisation in a more coordinated, cost effective, and responsive way. The prospective benefits and practical issues of this new model are discussed.*

### **INTRODUCTION**

Fashion companies in advance economies have increasingly become brand houses performing the functions of design and marketing exclusively at two polarised ends of the lengthy and fragmented

fashion supply chain (FSC). This includes, firstly, functions of total design processes interacting with off-site manufacturers at the FSC up-stream. Secondly, it includes the functions of marketing and sales interacting (directly or indirectly) with end-consumers at the FSC down-stream.

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This chapter refers to end-consumers collectively as the fashion ‘Customers’. It refers to all participants of the FSC design and manufacturing functions collectively as the fashion ‘Producers’. This includes most critically, brand-houses/designers companies, textiles suppliers, and garment manufacturers. The “Fashion System” refers to all workings of the global fashion apparel industries.

Mass customisation (MC) has been recognised as an effective strategy in response to the contemporary climate of “the Fashion System” in an age of diverse Customers demand, product proliferation, global competition and information technology. This climate has been further challenged by the global economic downturn and the impact of currency fluctuations on trading supply and demand. However, MC implementation tends only to be deployed in the mass market sector by global corporations with large scales of economy and extensive technological investment capability, whilst more than 90% of the Producers in the Fashion System are small-medium enterprises (SMEs).

This chapter explores the strategic and practical possibilities of mass customisation for the total design processes (TDP) at the FSC upstream. This includes all processes from design conceptualisation (creative direction) and sourcing to design development and pre-production. The set time conditions of the seasonal calendar are established as the key parameter of the FSC. These time conditions are often neglected in studies of design processes, yet they provide a critical and competitive basis to all works of the Fashion System. The set components and definition of the fashion garment is established as the key output of the FSC. The garment components are what all efforts of the Fashion System ultimately work towards and generate revenues from.

A new model for a mass customised FSC is developed to enable a two-way balance between a consumer-centric demand and a design-led supply process. This balance is critical to the optimisation of the contemporary Fashion System. Due to the

process-based principles, the new model does not necessarily require large investment or substantial technological intervention for brand-houses or small medium designers companies to implement, but warrants the benefit of mass customisation.

## **BACKGROUND**

### **The Fashion Design Process: A Calendar of Prescribed Timing for Supply Push**

For fashion brand houses and apparel designers’ labels companies, the FSC design process generally includes all stages from ideas generation and creative direction to garment prototype development (Secor, 1992). Much published research explores the design and development process with respective diagrams devised to illustrate key sequential stages.

Carr and Pomeroy (1992) classified four phases with linear operative steps in each: 1) Origin of styles, comprising market research, design, concept, and market screening. 2) Sample development phase, including prototype pattern, sample, and range meeting. 3) Business objective refinement phase, encompassing pattern adaptation and testing, while production planning and scheduling is also carried out. 4) Attainment of commercial products. This takes the process from production pattern, grading, markers, production templates, specification, into two strands of feedback from manufacturing and marketplace. And while technological advances and geographical shifts of fashion design and development have evolved since the 1990s, the process stages and functional output of the FSC processes have remained largely unchanged.

Gaskill’s (1992) retail product development model splits activities after 1) Trend analysis and concept development, into three parallel areas of 2A) Fabrication selection, 2B) Palette selection and 2C) Fabric design. This is then followed by

3A) Silhouette and style direction on one hand, and 3B) Prototype construction and analysis on the other, before reemerging into a single final phase of 4) Line presentation. The internal factors of target market definition and merchandising process are pointed out, as are the external factors of domestic and foreign markets. However, they are not specified in terms of the stages or time table within which those activities take place.

Wickett *et al.*'s (1999) detailed activities guide for apparel product development, personnel and sources are identified in seven phases of 1) Trend analysis, 2) Concept evolution, 3) Palette selection, 4) Fabric selection, 5) Fabric design, 6) Silhouette and style directions, 7) Line presentation, with an additional category listing influential internal and external intervening factors.

Sinha's (2001) summarised the generic fashion design process in four phases of 1) research and analysis, 2) synthesis and selection, 3) manufacturing, and 4) distribution, and indicated key factors at each phase. Mc Kelvey and Munslow's (2003) design process flow chart is not dissimilar, though it is completed with an additional promotion phase following completion of range or collection. This would typically be a marketing function carried out or directed exclusively by the brand house, bearing no relation or responsibility to the manufacturers.

Forza and Vinelli's (2000) research describes sequential activities in the FSC and points out the substantial reliance design and production has on forecasting, however inaccurate. Information on customers is typically managed completely independent of activities in the FSC. Their production stage chart illustrates the occurrence of monthly activities on a larger scale from yarn to textile to apparel production and distribution, though does not address specific time factor or relationships between the activities and processes. Le Pechoux's (2001) on the other hand, explores the dynamics and processes of fashion industries as a complex system; addressing the non-linear nature of cyclical iteration processes involving external and internal factors.

Senanayake and Little (2001) reviewed various mechanisms for the textiles and apparel industry's new product development (NPD) measures, and referred to the merchandising calendar in the format of a scheduling Gantt chart, with a full list of 40 activities and respective timing in a total of 35 weeks from concept to production for one season's product range.

Pan's (2006) research addressed a full range of parallel functions in the FSC processes with reference to the fashion calendar timeframe and main interacting participants amongst the collective Producers. An Amalgamated Process Map was devised to show a typical 16-18 wks development period from concept to completion of a full range of up to 200/300 show prototypes for brand houses that produce 2 main seasonal collections per year. The 'Producers' selection point' and the 'Customers' choice point' for the critical total design processes of the FSC were identified.

All process models reviewed reveal that the lengthy total design processes carried out collectively by 'Producers' prior to launching products in the market place, involve a series of screening and selection of design options and combinations. These range from ideas, trends and moods to the palettes of fabrics, colours, silhouettes, and fabrication to the final merchandise stories, mix and timing. Judgment calls are made by Producers loosely according to the evaluation of trend forecasting, observation of market happenings, assessment of past sales, and availability of resources. With the exception of resources availability, all factors considered by the Producers in fact contribute towards a high-risk speculation of what Customers may want in months to come. In this sense, Producers act on behalf of Customers to pre-empt decisions on what they should want.

The cyclical pressures to achieve the right decisions mix occur at set calendar times (typically just before the deadline for the pressing commencement of each following process stage) at one polar end of the FSC upstream, some 6-12 months prior to fashion collection launches at the

market place. These decisions therefore directly impinge on the marketing and sales activities: affecting the responses from industry buyers and press at international trade shows, and eventually determining the Customer driven retail sales performance at various regional markets across the globe. It is therefore fair to categorise the contemporary Fashion System ultimately as one that exercises a strong “Producers” supply-push approach, with “Customers” well shut-out of the loop of its core design functions and processes.

## **THE MASS CUSTOMISATION TENET**

### **A Dilemma in the Power Struggle of Demand Pull**

Mass Customisation (MC) has since the 1980s been advocated as the prospective paradigm that combines the benefit of mass production efficiency and craft production individualization. The aim is to effectively respond to global turbulence in a market of ever-fickle desires of individual customers, ever faster moving trends, and ever finer segment differentiation, indeed a climate of today. Gilmore and Pine II who pioneered the theory of MC defined it as ‘markets of one’, whilst Davis defined it as ‘individual segmentation’ (Davis, 1996; Kara & Kaynak, 1997). Brannon (2000) defines in *Fashion Forecasting*, as the medium between mass production’s ‘one-size-fits-all’ and haute-couture’s ‘one-one-a-kind’, where traditional supply chain is inverted by making Customers an integral part of the initial stages of product development.

Kay declared as early as 1993 that it is possible for all aspects of production and delivery systems to be done effectively to meet Customers’ individual needs with the following formula: Mass customisation = custom-focused x lean production x continuous variety x short cycle development x flat and empowered management culture (Kay, 1993). Thackara (1998) further defines the

relationship between suppliers and customers in ‘*One-to-one on-line: fashion, the internet, and the role of design*’, outlining how mass customisation provides the platform on which the sales transaction is the beginning of an inter-dependent relationship between the seller and buyer as opposed to the end of a marketing process. This approach repositions functionality and quality as merely a starting point. In a contemporary market place where Customers are increasingly spoiled by the wide range of choices of more-or-less perfectly performing products, it is the logical response that service becomes part of product within a holistic concept for organisational design.

However, despite extensive academic and industry research providing conceptual and practical guidelines, benchmarks, and matrixes for MC, propelled by the challenging economic climate and maturing Customers’ behaviour that beckons MC (particularly in the notoriously fast-moving Fashion System), the paradigm is still far from a wide-reaching reality some two to three decades later. Tseng and Pillar (2003) believe the missing gap is the capacity and mentality within companies to put the demands and wishes of each single customer at the centre of the value chain. On the other hand, Blecker & Abdelkafit (2006) argues that there is still a lack of common framework concerning the effective implementation strategy to aid MC practice.

Six levels of mass customisation involving Customers at varying degrees in the Producers’ processes can be classified as below with respective contemporary fashion case examples. Level one has the most detached relationship between the Producers and Customers and level six has the most engaged. As the level of customisation increases, Customers involvement moves further upstream of the supply chain (Lampel & Mintzberg, 1996; Blecker & Abdelkafit, 2006).

1. The ‘Basic Customiser’ combines ‘push-through’ forces of strong market understanding with responsive manufacturing systems,

and expects customers to find what they want from a larger variety of product offering. This is typically an approach taken by large scale companies whom have the resources to develop, buy-in, and offer vast product assortments and design lines. Spanish retail giant Zara is a well-know case whose fast reaction towards seasonal fashion trends, effective use of sales information, and efficient manufacturing system stunned the global industries with its phenomenal success. Moreover, its impact forced other large retailers (particularly US ones) to re-examine their own processes.

Aggressive British large retailer Top Shop is another successful 'push-through' example, using effective marketing and buying strategies as well as exclusive design commissions to curate a wide variety of on-trend products and smaller designers' labels. It caters to the tastes and styling of a wide range of younger age-group Customers', yet fosters their loyalty to Top Shop as an umbrella brand and destination.

2. The 'Alteration Customiser' employs a third party between Producer and Customers to carry out the customisation or personalisation of standard products. Examples are commonly seen in up-scale department stores such as Harrods or Selfridges, where in-house tailors or seamstresses would be called in to make minor garment alterations necessary to fit the specific customer making the purchase.

A small number of designers' boutiques or menswear suiting retailers also have such function or have recommended subcontractors or suppliers whom provide such service to their customers. It is a 'reactive' and an expensive way of obtaining customization (for Customers in above case examples) as products are not designed for effective customisation (Tsigkas et. al., 2001).

3. The 'Cosmetic Customiser' deals only with packaging, distribution or point-of-sale changes. For instance, Thomas Pink shirting company is able to offer customers the service of embroidered personal initials on the cuffs of shirts purchased from its standard ready-to-wear range.

Growing high-end fashion internet retailer Net-a-Porter makes the simple gesture of a 'Cosmetic Customer' by providing 4 choices of packaging options of basic, discreet, signature, and wedding wrap during the check-out point on-line Customers' purchases.

4. The 'Transparent Customiser' provides unique products by monitoring customers and without necessarily making its customisation explicit (Anderson-Connell et. al, 2002), as opposed to a user making the request. The iconic internet retailer Amazon of the internet era is a pioneer and leader of such Customisers, where a full purchasing history of Customers are recorded in its database, and repeated customers are recommended a range of different products in similar styles or genre to what they had previously purchased.

Many internet retailers now employs this effective methodology and Koodos is a designers brand discount site which recommends complementing garment separates or accessories in similar price points or styles Customers shop on site.

5. The 'Self-Adaptive Customiser' produces products with features designed into them so that Customers can change aspects of it according to their individual preferences without aid from manufacturers or retailers. Common examples would be seen in a reversible jacket or a pair of cargo pants where leg parts can be removed and worn as shorts.



Elliot Rhodes takes the 'self-adaptive' principle to design and retails a wide range of fashion belts where Customers can select, self-assemble and interchange belt buckles and embellishment from a standard range to accessories for a variety of fashion and functions.

6. The 'Collaborative Customiser' (Pure Customiser) involves Customers into the product design process termed co-design (Fiore et. al, 2000, Anderson-Connell et. al, 2002). This is the most sophisticated level of mass customization, also known as core/pure customization. This approach nurtures a 'Prosumer' (Toffler, 1980; Piller, 2003) relationship between Producers and Consumers, involving Customers within the design development and/or manufacturing process. A Suit That Fits.Com deploys the classic made-to-measure technology to enable customers to select from their standard range of styles, cuts, fabrics, and finishes to assemble and deliver the product of Customers' personal choice.

DEPLOY demi-couture is a pioneering case in the high-end fashion sector, where Consumers' requests or feedback are incorporated into the design and merchandising processes at the FSC upstream. Garments are designed and constructed with multiple functions, styles, and/or specific customer requirements so that Customers can customise each outfit for numerous looks and occasions. Product life cycle is simultaneously increased as the Prosumer relationship is extended after-sale as loyal Customers build-up a much more versatile and creative personalised wardrobe.

Alford (2000) suggests that the MC concept is suitable for low-volume applications with customisation available at a cost premium from the standard product. Okonkwo (2007), however, argues that the rules for the fashion market place have changed and that customisation need not

necessarily be applied at a cost premium to the brand-houses. And in fact, Customers are increasingly expecting and not just desiring personalised attention from their goods/service providers in the following lateral areas: 1) Customising of standard products, 2) Customising point of delivery, 3) Customising of retail shopping experience, 4) Producing bespoke goods, 5) Customising of on-line shopping experience, 6) Allowing Customers to customise the process.

Whilst there is no shortage of concurrent views for key drivers and market suitability of mass customisation, namely: 1) heterogeneous demand, 2) short product life cycles, 3) mature markets and, 4) more conscious Customers (Kotler, 1989; Pine, 1993; Westbrook & Williams, 1993; Hart, 1995; Kotha, 1995; Feitzenger & Lee, 1997; Gilmore & Pine, 1997; Peppers & Rogers, 1997; Bardakci & Whitelock, 2003), mass customisation in its higher-level and purer forms, is yet to be substantially adapted by the Fashion System on a broader basis for a wider consumer base. More importantly, MC confronts the Fashion System with several of its inherent paradoxical attributes, particularly in the high-end fashion sector. It has thus has been met with skepticism and with substantial reluctance for experimentation and ultimate change. The reasons can be summarised through the following dilemmas that constantly thrusts the FSC towards mass customisation in concept, yet consistently drag it away from it in practice:

### **Perception Hindrance**

Whilst varied product ranges and features are now clearly crucial in meeting an increasingly knowledgeable contemporary Customers' demands; whilst individual tailoring is an elitist's luxury too expensive to sustain both for Producers and Customers, and whilst Customers' willingness to spend extra for additional individuality or personalised convenience has become well known (Taylor et.

al., 2003) – the attributes of mass customization would offer an attractive response.

Ironically however, even as the fashion Producers strive to gain greater market share and customer base ‘en-mass’ in a globalised economy, a remarkable proportion of the Fashion System practitioners are unable to reconcile the increased individuality afforded by mass customisation with warranted conformity offered by ‘exclusivity’ (e.g., luxury goods bearing the same look and logos sold in mass quantities globally). This is driven by a fear of losing their brand superiority and authority through enabling Customers to specify or personalise their own branded products (Okonkwo, 2007).

### **Resource Hindrance**

Whilst the fashion life cycles commanded by seasonal changes are naturally short, fierce global competition has further propelled ever changing trends and shifting niches, and thus ever shorter product life cycles and un-salvable product features through ‘planned obsolescence’ (Easey, 1995; Jones, 2002). In full view is the front end momentary glory of the latests, the newest and the musts-haves, fully aided by the contemporary fashion’s all powerful counterpart – the media.

This phenomenon would have logically beckoned the practice of mass customisations, as it has in many other industries. However, unlike most other industries, fashion brand houses and designs companies in advance economies by-and-large have very low entry barrier and require relatively low technological investment, particularly since shedding almost all of their manufacturing activities some two decades ago. This factor coupled with the apparent necessity to allocate hefty marketing budgets in order to succeed, means both financial and human resources for substantial back-end development, innovation or upgrade commands low or no priority.

### **Operation Hindrance**

In an inherently labour-intensive industry, where each production run of a product style was ultimately never long enough for even a mass retailer in its mass production hey-day to fully automate garment manufacturing (partially due to the nature of handling wide varieties of soft fabrics); where operational skills of individual workforce is heavily relied upon; where competition fierce, entry barrier low, and the need to distinguish one product from a vast array of others paramount; a shift to mass customized production would have seemed both natural and slight.

However, the ever compressed design-development time for the ‘new season’ revolving chains of cyclic deadlines up from Designers, Textiles Manufacturers, and Garment Manufacturers and down to trade and consumer press, marketing and sales, means that there is never the window or aspiration to reflect, review, or restructure for substantial or collective changes. In order to implement mass customisation effectively, a period of time would be required to coordinate supporting technology and methodology, and devise, update, improve or revise the relevant processes.

Nevertheless, early adapters of MC in the Fashion System, such as Levi’s made-to-measure jeans and Nike ID shoes, have maintained their leading positions and proven competitive advantage in the global market place a decade on. They have invested heavily in enabling technology (and marketing) in relation to Customers and Producers. However, studies on these cases have also concluded that success will depend on customers’ satisfaction level during early pre-manufacturing steps, and suggested that FSC may need specialised MC processes (Lee & Chen, 1999).

Alford’s research concluded that it is possible to transform the management of the customised supply chain by increasing involvement of suppliers and use of product data management systems to effectively combine resources and expertise in geographically dispersed areas. It will also help

cope with escalating complexities in managing the varieties and volume of data that mass customisation introduces into the supply chain (Alford et. al. 2000). However, it was identified that optimisation requires an effective and coordinated approach to inform and support relationships and management decisions in the design and production process.

Tseng and Piller (2003) further suggests that building a value chain that places individual Customers demands and wishes at the centre implies much more than investing in technologies. By presenting Customers' co-design prospects, process could be shortened and streamlined to focus on proving real value to Customers, thus increasing competitive advantage to Producers. All authors of MC research agree that industries will greatly benefit from knowledge and utilisation of Customers' information (i.e. real demand), and that much work is to be done throughout the supply chains in order to realise the true gains of MC. The how and where of this balance between Producers' supply push and Customers' demand pull in a new MC process specific to the Fashion System is therefore the central objective of this research.

## **THE PARAMETER AND OBJECT OF THE FASHION SYSTEM**

It is clear that the common objective of the FSC Producers is to produce clothes from conceptualisation to consumption speedily, profitably, and to the Customers' purchasing choice. This research therefore disassembles the current FSC design processes into the following factors with subsequent findings:

### **The 3 'Constants' of the Fashion Parameter**

The three key conditions of the Fashion System to which all Producers are subject to, are identified as: 1) the time line, 2) the communication plane,

and 3) the decisions points of the FSC total design process. This research therefore considers the three factors as 'constants' of the process model.

### **Time Line**

The parameter of time line is marked into two types of effective periods: 'processing time zone' and 'interacting time zone'. These definitions set the first parameter for the model, and two terminologies refer to the activities segments that must be carried out by the three key Producers of Designers/Brand houses, textiles suppliers, and garment manufacturers. The reference of calendar weeks in the fashion season is common to all parties. Processing time zone refers to the periods where the back-end supporting and preparatory works are carried out in order for the essential communication to take place between the three Producers parties. This typically occupies in a longer time span of calendar weeks. Interacting time zone occupies a shorter time span and refers to the periods where the actual contact and communication is made at the front-end between FSC parties. Zipkin (2001) refers to the activities of this 'interacting time zone' as the 'elicitation process', and categorised the key information as identification, selection from menu of alternatives, technical measurements, and reaction to prototypes.

The key steps of the FSC total design process are shown in the Amalgamated Process Map (Figure 1). All activities for embarking on a new season collection or range design begin officially with fabric selection at or around the major textiles and trend forecasting tradeshows in mid September for the following year's fall-winter fashion collection. The most notable leader for all mid to high-end fashion sector Producers is Premier Vision trend forecasting and textiles tradeshow in Paris. This calendar time to which this tradeshow takes place is thus denoted as week 1 of the Amalgamated Process Map. The same design process is repeated at a maximum

**A Mass Customisation Implementation Model for the Total Design Process of the Fashion System**

of once every 6 months (each ‘fashion season’), and starts again in February for spring summer collections for its following year.

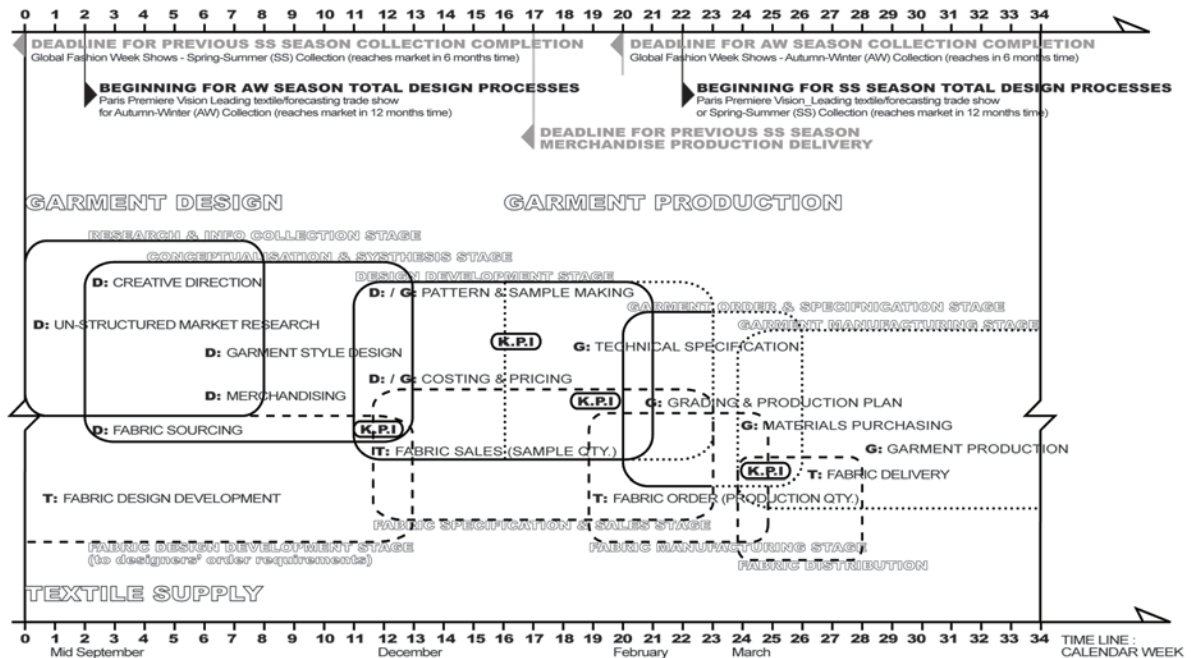
**Communication Interface**

The design and control of design development process is often ad-hoc based on individual managers’ experience without sufficient communication structure (Tsigkas *et. al.*, 2001). Field research analysis showed that smooth and accurate communication between the three key Producers parties carried out by their respective front-end teams in the ‘interacting time zone’, depends heavily on the correct design information

related to, and prepared by, the back-end support team in the ‘processing time zone’. It also shows that the nature, format, and to some extent, the content being communicated, are in fact the same season after season. These being: accurate and consistent samples and specification packages, and bill-of-materials for both fabrics articles and garments styles.

It is clear that the reduction of information duplication and repeated procedures can improve efficiency and effectiveness thus speeds up processing time for all parties in the FSC. Furthermore, sharing of correct information accelerates problem solving cycles and enables the anticipation of potential issues and obstacles dur-

Figure 1. The Amalgamated Process Map



**THE AMALGAMATED PROCESS MAP**

- D:** DESIGNERS/BRAND HOUSES PROCESSES
- T:** TEXTILES SUPPLIERS PROCESSES
- G:** GARMENT MANUFACTURERS PROCESSES
- (K.P.I)** KEY PRODUCERS' INTERFACE
- BEGINNING OF KEY FASHION SYSTEM PROCESSES
- DEADLINE FOR KEY FASHION SYSTEM PROCESSES

ing the design development processes (Muffato & Roveda, 1999). The communication interface (Figure 2) between specific operating teams of the three parties is therefore established as the second parameter for the model. The communication interface is defined by the unification of fabric and garment specifications in terms of the channels, format, and information content for interacting FSC parties, with reference to timing requirement and duration allowances set in the fashion system time line.

### Decision Integration

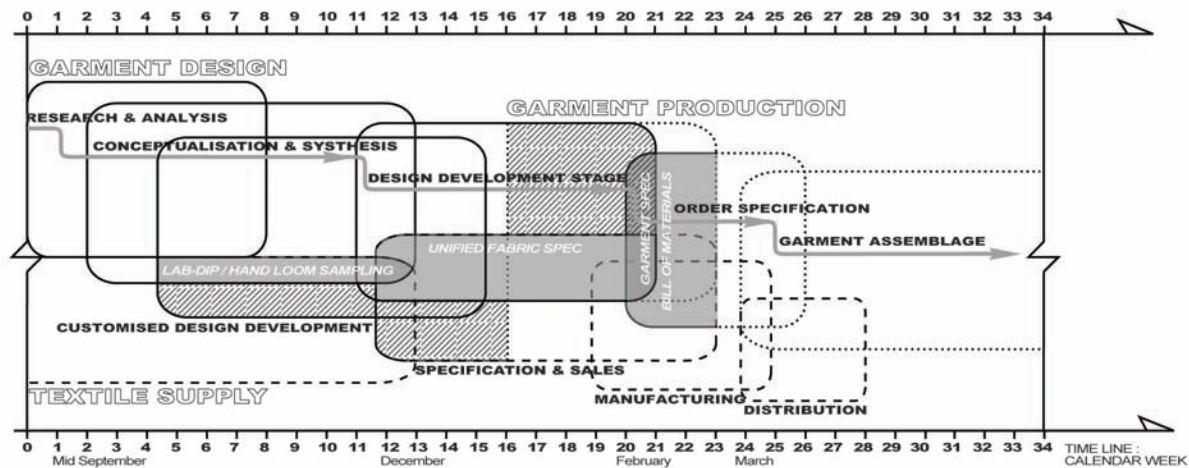
Key decisions for both the Producers' selection point and the Customers' choice point (PSP and CCP in Decision Point Map) are converged to become an 'Integrated decision point' (Figure 3). These are the points in time (between weeks 8 to 18) when the most critical decisions for the

fashion output of garments are made, from colour and fabric palettes to silhouettes and merchandise mix. They are therefore the specific points where information on Customers' preferences and requirements should be incorporated into Producers' decisions in the relevant FSC process stages.

### The 3 'Variables' of the Fashion Object

The 3 key components of the Fashion Object, i.e., the garment, to which all 'Producers' output ultimately go towards, are identified as 1) fabric, 2) colour, and 3) silhouette. It is through the incessant changes of these very factors that variety and newness of garments are created season after season to supply Customers. This research therefore considers these factors as 'variables' of the model.

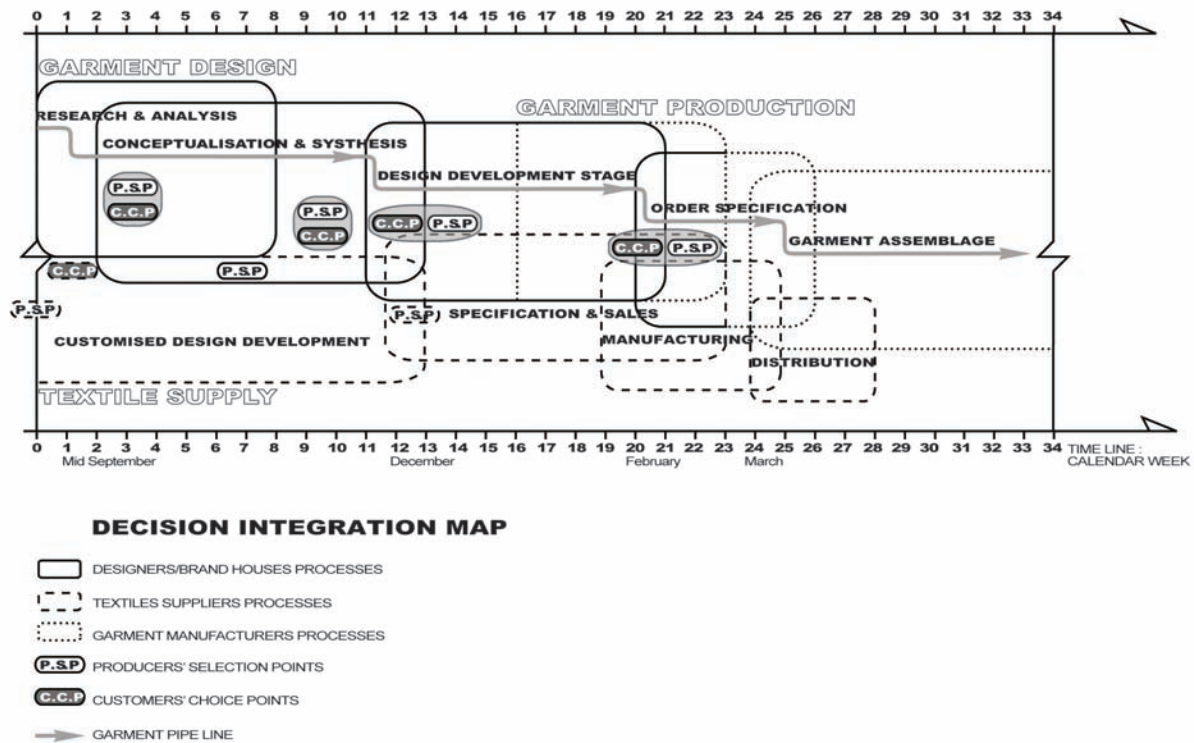
Figure 2. Communication Interface Map



#### COMMUNICATION INTERFACE MAP

- DESIGNERS/BRAND HOUSES PROCESSES
- TEXTILES SUPPLIERS PROCESSES
- GARMENT MANUFACTURERS PROCESSES
- COMMUNICATION INTERFACE (INTERACTING TIME ZONE)
- COMMUNICATION INTERFACE (PROCESSING TIME ZONE)
- GARMENT PIPE LINE

Figure 3. Decision Integration Map



## Fabrics

Fabric is undoubtedly one of the first key components of a garment. Fabric selection in the total design process typically entails the pooling of all sample swatches collected from trade shows and individual suppliers' presentations or from Designers' own sourcing and market research. Designers then decide on a palette of desirable fabric appearance, construction, hand-feel, and special features or functions to compile a creative direction 'mood board' and/or start silhouette designs with.

In the field research conducted, a range of fabric specifications sent from high-profile, international sample Designers/Brand houses to textiles suppliers were collected and analysed. The specifications showed a wide variety of formats and quality of information. Some were with fragmented hand-written descriptions accompanied

by photocopied art work and sample texture of fabric requirement. Others saw formulaic files of large retailers containing lengthy technical lists stretching up to 3 pages, yet with large areas or information irrelevant or not-applicable to most fabrics commonly used, hence barely filled in. Researcher therefore identified information common to all companies and crucial to textiles suppliers' proceedings for fabric production, with references to the following: 1) literature on textiles manufacturing processes, 2) field research on textiles suppliers' order processing and production steps, and 3) key sample textiles suppliers' fabric library cataloguing systems and information referencing methods.

A proposed 'unified fabric specification' with clear information on purchase order, fabric construction and end-use (garment) requirements was subsequently devised in order to assist designers/brand-houses to accurately and efficiently commu-

nicate their requirements to their textiles suppliers. Relevant personnel at the textiles manufactures responsible for fabric order processing, as well as industry experts in textiles development were consulted to verify the validity and practicality of the 'unified fabric specification' as a communication interface.

## **Colours**

Colour is a most critical factor in garment design that dictates and reflects the changing seasons and trends in the Fashion System. Whilst Customers may not be fixed on fabric or silhouette (cut) when shopping, most have instinctive and clear ideas on colours, particularly when choosing apparel goods set against their own complexion (Wilson *et. al.* 2001). Field research on consumer's clothes shopping preference showed that 63% surveyed women find colour to be the first thing that catches their attention.

The lengthy series of Producers' 'pre' selection and screening processes for colours take place prior or in parallel to fabric palette selection. They are carried out first by global trend forecasting agencies and fibre, yarn, textile manufacturers, then by Designers/Brand houses, industry buyers, followed by media/press. However it is the final purchasing decision of Customers that determine the success of a colour choice.

From the Designers/Brand houses' point of view, consequences of getting the colour palette wrong could result in costly retention of unsold garment units and loosing market shares to competitors (Wilson *et. al.* 2001). Instrumental in designer's process in arriving at the final colour choice is the Textiles Suppliers' responsiveness and capability of providing custom physical colour lab-dip match samples or hand-loom swatches as accurately and quickly as possible.

From the textiles suppliers' point of view, the colour specification issue is a complex and costly one and the chances of not getting the colour 'right' in the eyes of the client (Designers/Brand houses)

are extremely high. This is due to the following: 1) the subtle differences and subjective preferences in match colour acceptance level, 2) the same chemical colour formula will result differently on different types of yarn, construction, and finishing, and 3) discrepancy in light sources between Textiles Suppliers and their clients'. Even when high-quality textiles suppliers typically provide 3-4 derivatives for one colour match in each lab-dip package, research shows that more than 70% of the colour match samples are approved only after 3 tries of lab-dips (with an average turnaround time of 2-3 week for each 'try'). In addition, Designers/Brand-houses often take up to 2 weeks to reply with approval or request for further lab-dips, due to in-house communication and decision between relevant design or management personnel. It is therefore clear how these reiterative processes lead to an in-efficient 8-10 week period to conclude on fabric development and lengthens the FSC total design process, as marked in the Amalgamated Process Map (Figure 1).

## **Silhouettes**

Silhouette is referred to as the three dimensional cut, overall shape and volume of the design (Mc Kelvy & Munslow, 2003). For the ease of description, Researchers refer to the silhouette factor in the garment design process as a term which comprises the aspects of garment cut; shape; style; construction; proportion, specified through pattern-making and garment specification.

During the period of the fabric and colour selections and decisions, the total creative directions and styling for the seasonal collection/range are conceptualised. The actual designs (drawings) of garment silhouettes (styles) typically begin 2-3 weeks later by Designers. This opens up some 4-6 weeks of garment designing and is carried out concurrently with the continuation of fabric and colour development screening and selection aforementioned. Pattern makers on or off-site then translate drawings with descriptive



notation for detailing, finishes and measurement requirements into flat patterns for on or off-site garment sampling.

## **Design Synthesis**

At the end of the parallel processes described in 3.2.1-3.2.3, a set of composite decisions based on three variables above are made on behalf of end Customers by Designers alone in SMEs, or collectively with their in-house textiles and merchandise managers, their company executives in larger fashion corporations. This takes place at the 'collection presentation' process step during weeks 14-18. The collective Producers' aim is that at first sight (of physical retail garment or marketing campaign imagery), the colours, textures, and shapes will attract Customers enough for them to want to buy.

As observed from all sample Designers/Brand houses, a fair percentage of garment silhouette in each company's season collections are repeated designs or consist of similar core shapes from previous collections. This may not always be immediately apparent due to different usages of fabric, colours, and embellishing details. However, further research on the design development processes showed two key evidences for common occurrence of silhouette design repetition.

Firstly, styles in new season collection development are often referred to as a certain previous season style name and/or number with the new addition of a certain detail, both in Designers' verbal descriptions and sketch notations. At times descriptions of such nature replace formal drawings or initial specification altogether. Secondly, certain key pattern blocks are frequently re-used for different garments with minor alteration or addition of lines and details to generate new season silhouettes. This was seen particularly often in the work of Designers/Brand house with in-house pattern makers, where archive patterns were frequently accessed for referencing purposes during the construction of new styles.

However, the practice of silhouette repeats and moderate alteration is dependent upon individual Designers'/Brand-houses' preferences and work methods, and this practice is not carried out in a systematic or consistent approach in any of the sample companies observed.

The main reasons that the design of garment silhouettes often repeat from season to season, as widely seen in the market place in general, are as following: A) Long-term over-arching trends on silhouettes last for several years and through the seasons (Jackson, 2001). B) Each designer/brand house develops certain garment cut and fits typical to its products that are recognised by their clientele and thus maintained as classic items carried over the seasons. C) Although there are countless looks and styles to which the Fashion System generates constantly, between the variety of fabrics and colour palettes, there are arguably a finite number of key silhouettes amongst each garment type that would be accepted by a wider clientele. For instance, there is a limit to which the silhouette of a pair of full length trousers can vary, before its potential buyer group is dramatically reduced (irrespective of price points), and sales prospect compromised.

Nevertheless, repetition in garment silhouettes, wholly or partially, is by no means a lesser expression of creative design, for it is the combination of the three variables of fabric, colour, and silhouette that generates desired value and newness for Customers. The example of the famous Burberry checks print used on typical swimwear fabric for a basic bikini silhouette illustrates that high value can be re-created by altering just one variable of a design. In fact, when closely examined, most garment silhouettes consist of some elements where aspects are not created completely from scratch and have not or could not form parts of another garment silhouette.

This dissected view of the garment object highlights the significance of systemic repetition in the contexts of design process. That is, if within in each garment silhouette there is always some portion



of it re-produced from parts of another garment previously designed, it takes no great leap towards two possible prospects. Firstly, the generating and communicating of largely the same information of garment pattern and specification can be logically organised for frequent access and cross-referencing. This would reduce the common occurrence of repeat information and/or process duplications as widely observed in the FSC processes, thus allow for a more streamlined and sustainable process saving both time and resources. Secondly, components for repeatedly designing garments with partially shared silhouettes, (e.g. jacket of same bodice cut yet different lapels and sleeves shapes), can be methodically rationalised and utilised – thereby capitalising on the natural existence and characteristics of silhouette repetition as a design variable, without compromising the creative totality of a garment.

## **CONCLUSION AND DISCUSSION**

### **Proposed New Process Model and Implementation Strategy**

The Collective Activity Model (Figure 4) which maps out the total design process emerges as a new prospective model of mass customisation for the FSC. The new model is characterised by the following attributes: firstly, the rationalised and directional flow between Producers and Customers is cross-referenced against the calendar time line of the existing Fashion System. Secondly, Designers/Brand houses are positioned in the critical role of integrating Producers' design-development processes at the back-end and Customers' real choices collated directly from the market retail front end. Thirdly, the Customers' information is incorporated into 4 key points in the FSC upstream process; points 1 and 2 are 'opinion-based' information that aid Producers' final colour, fabric, and silhouette selections. Points 3 and 4 are 'decision-based' information that aid Producers' sizing and quantity order. Fourthly, the moderate changes to the collective FSC upstream

processes do not require all participants of the fragmented FSC to radically re-engineer their existing functions and processes. Finally, the model allows for further compression of MC delivery lead-time by systemising aforementioned communication interfaces and design synthesis.

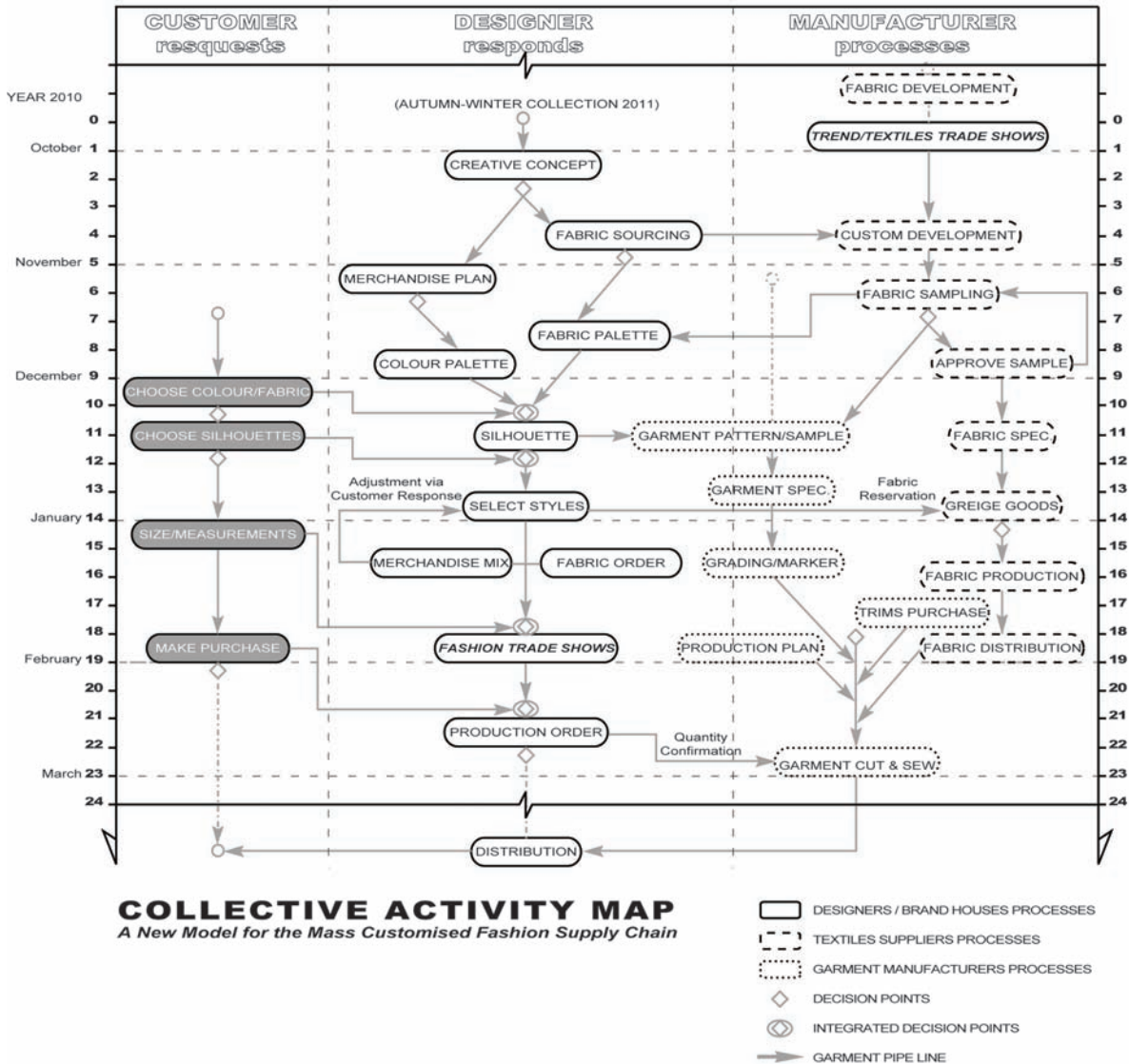
The new model therefore offers the potential for Producers to supply the garment in a more accurate manner, and for Customers to demand the garment in a more personalised fashion. However, it does not require significant organisational re-structure and technological investment, nor presents the high risks that would prevent fashion SMEs from experimenting with this new model for mass customisation whilst constantly under the seasonal time pressures. Three key implementation strategies are discussed in the following sections with reference to Customers and Producers. In this new model Producers are differentiated into Manufacturers, and Designers for clarity of the strategic propositions.

### **On Consumption: Customer Requests**

With a central focus on mass customisation, the field research survey and analysis on sample female shoppers in central London investigated what and how the fashion Customers demand, and what their unfilled demands are. The results cast light upon its reciprocal relationship with supply. From the Customers' point of view, most Producers are unresponsive and insensitive towards their precise needs and wants, despite the enormous investment to attract Customers through Designers/Brand-houses marketing efforts. The survey showed that 64% of respondents wished they could easily access customised garments, and a total of 63% of respondents have clothing alteration needs 'frequently' or 'all the time'.

This unresponsiveness to Customers (from garment style, to colours, fit, availability and price) translates directly into lost sales on a significant scale and in turn results in loss of market share

*Figure 4. Collective Activity Model -- a Mass Customised FSC*



for the Producers. The consequences account for two facts: firstly, in a stiffly competitive, densely populated, yet marginally differentiated fashion system, customers can find easy substitutes for most fashion trends and merchandise. Secondly, due to widespread information technology, customers are fast becoming knowledgeable about fashion trends and products. They are thus increasingly able to declare what they like and dislike, and to even specify what they need and want.

This illustrates their full readiness for all levels of mass customisation offering.

### New Model Strategy 1: Customers' Information Input Built-In

Whilst theories of postponement and modularisation for mass customisation have previously separated the production-driven push system and the customer-driven pull system, and identified the

'decoupling point' in the value chain (Blecker & Abdelkafi, 2006) from which standardised and customised products are separated in the pipeline, this research emphasizes the importance of a combination of supply-push and demand-pull approach for the FSC. 'Integration Decision Points' are identified in the total design process with the precise timing and contents necessary. Customers' feedback and general preferences or wish-lists (particularly that of repeat Customers) on product attributes such as fabrics, colours, and silhouettes can be continuously collected by Designers/Brand houses, stored in its central data-system such as electric point of sales systems (EPoS) or others generic database or spreadsheet softwares, and regularly updated, analysed, and utilised. Data can then be incorporated at the key 'integrated decision points' as illustrated in the 4 points of the Collective Activity Model (Figure 4). Furthermore, this information can be shared with long-term supply chain partners (e.g. textiles and garment manufacturers) as basis for new product development and/or quality performance improvement.

This intervention aids Designers/Brand houses' capability to anticipate the real and customised demand of the Customers, fine-tune their decision making for merchandise plan and make it more closely aligned with the Customers' needs and wants. It also in turn helps to reduce the errors associated with predicting some 12 months in advance and 'ordering in the dark', which often results in slow sell-through, costly mark-downs en mass, or large stock keeping. Furthermore, it creates a continuous 'feedback chain' for the collective processes between Producers and Customers through the FSC process, which is much more effective and timely than a long 'feedback loop'. It thus presents a direct contrast to the long feedback loop of the existing Fashion System practice, where information on customers is typically not gathered until the end of each season's sell-through cycle, and not incorporated into Producers designs until a minimum 3-4 months

later, if at all. The new model therefore enhances the optimal balance between Producers' supply push and Customers' demand pull, by activating a MC implementation strategy at the heart of the FSC upstream processes.

### **On Production: Manufacturer Processes**

Given that a) The prospect of mass customisation is indeed highly sought-after by the fashion Customers; and b) the validity and precision of design information passed through the FSC pipeline is of paramount importance in order to achieve the garment, as intended by the Producer and desired by the Customer; the field research investigated what and how textiles and garment manufacturers currently supply, and how they may re-organise existing processes in order to capitalise on this demand. The high occurrence and high cost of process reiteration, information duplication, and ad-hoc communication was identified throughout the FSC upstream processes, and is therefore a key area in the existing FSC practice that beckons streamlining.

### **New Model Strategy 2: Producers' Information Flow Re-Channeled**

Fabric and garment specifications are identified as the critical design information generated by Designers and processed by Manufacturers all the way through the FSC pipeline to affect and/or determine the final garment sale to Customers. A set of unified fabric and garment specifications and their accompanying bill of material are thus proposed for designated functions between the FSC Producers, at particular communication interfaces in the total design process in the FSC upstream as illustrated in Figure 2. This ensures the correct content share at the right calendar time and between the right parties, and reduces the large margins for human error whiles reducing process delays thus streamlines process efficiency.

## **On Design: Designer Responds**

On surveying international brand houses/designers companies, field research found that sample Designer/Brand-houses produce an average of some 800 garment styles per company per year, irrespective of the finer differences in each company's sub-season merchandising. The figures total the number of garment styles that actually sailed through the series of Producers' screening and selection processes in the lengthy FSC pipeline and end-up on the retail shelves. In other words, plenty more styles are designed, partially or fully developed, but dropped somewhere along the FSC pipeline. According to Eckert's research on ratio of design ideas to samples, only an approximate 30% of garment styles make it through as final merchandise (Eckert, 1999).

## **New Model Strategy 3: Designers' Information Creation Managed**

As fabric, colour, and silhouettes are identified as the three key components of the garment object that repeatedly change in response to the parameters of a cyclical fashion system, it follows that using combinations and permutations of these three variables would offer an efficient strategy for the creation of new garment styles. A clear organisational and management structure of information classification and referencing can be devised to generate assembling options for the fashion garment, both in terms of design and production. This provides the creative and economic advantage for mass customised fashion garments and dramatically reduces complexity, time and resources wasted through repetitive process reiteration. Furthermore, it provides Producers with the ready capabilities to combine different design components, whilst presenting Customers with a far more enticing product offering in the form of relevant options incorporating their individual requirements. The result is a far more mutually beneficial Prosumer relationship increasing both

Customers' satisfaction and Producers' brand loyalty.

## **FURTHER RESEARCH**

The proposal of this new model as an MC implementation strategy suitable for SMEs in the FSC, opens up new opportunities and possibilities for both Producers and Consumers with enhanced prospect for the synergy of 'Prosumers' co-design. It is noted that Burberry, amongst a handful high-end brand houses, has since this year taken the lead to take direct orders from Customers at the fashion week catwalk trade shows for goods delivery in 3-4 months time. DEPLOY demi-couture has also been pioneering in holding loyal Customers previews during collection design development processes, in order to collate Customers feedback for new season design finalisation and merchandising decisions. These new scenarios demonstrate that for worthy, desired fashion goods, Customers are indeed interested to engage in certain FSC processes and willing to wait for the necessary delivery lead time.

However, further study and testing remains to be done in this new arena of a mass customised design process, beyond the more widely explored aspects of sizing, made-to-measure, and enabling technology. Areas of key relevance are highlighted: 1) The in-depth investigation on the total design processes of FSC companies that have already adapted various types of MC strategies, 2) the precise content, mechanism, and system for translating Customer demands into sophisticated garment designs, and 3) the prospect of modularisation as a design management strategy for a mass customised FSC. Continuous research is also carried out on the optimisation matrix for collection design and development using mathematic permutations and combinations of the garment components. And whilst a challenging global economic conditions and market turbulence is faced by all, this climate will only

serve to intensify the potential and necessity for variety and customisation (Pine, 1993; Harts, 1994), in order for Producers to fulfill Customers' demand more precisely.

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# Chapter 15

## An Exploratory Study on Product Lifecycle Management in the Fashion Chain: Evidences from the Italian Leather Luxury Industry

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### ABSTRACT

*New Product Development (NPD) in most manufacturing sectors is stressed by an increasing global competition and pressure to improve product quality and innovation, reduce product cost and time-to-market (TTM), and rapidly respond to changing customer needs and shortened product lifecycles. These requirements are increasingly fulfilled by applying the PLM (Product Lifecycle Management) approach, a widely accepted concept that generally defines the adoption of a large number of ICT (Information and Communication Technology) solutions for managing product data along the product lifecycle. This contribution shows the results of research concerning the application of PLM within the luxury fashion supply chain, conducted in 2009 in Italy, with the analysis of 20 companies of the leather market. The research shows some of the differences that exist between the luxury industry and other more PLM-oriented sectors (e.g. automotive) in terms of adopted ICT tools, criticalities, problems, and benefits expected and realized.*

### INTRODUCTION

New Product Development (NPD) in most manufacturing sectors is stressed by an increasing global competition and pressure to improve product quality and innovation, reduce product cost and time-

to-market (TTM), and rapidly respond to changing customer needs and shortened product lifecycles. These requirements are fulfilled by applying the PLM (Product Lifecycle Management) approach, a widely accepted concept that generally defines the adoption of a large number of ICT (Information and Communication Technology) solutions

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in order to support collaborative and coordinated environments, managing product data along the product lifecycle (from the cradle to the grave), and mainly focuses on the NPD process.

PLM has been extensively studied and analyzed in recent years, with different authors highlighting the holistic meaning of such acronym (e.g. Stark, Saaskvuori and Immonem, Grieves). For example, according to Stark (Stark, 2005), it brings together products, services, structures, activities, processes, people, skills, application systems, data, information, knowledge, techniques, practices and standards. Saaskvuori and Immonem (Saaskvuori and Immonem, 2005) define it as a comprehensive approach, entailing: (i) a strategic management perspective, wherein the product is the enterprise value creator; (ii) the application of a collaborative approach to better use the enterprise competences distributed amongst diverse business actors; and (iii) the adoption of plenty of ICT solutions in order to practically establish a coordinated, integrated and access-safe product information management environment in the extended context. Grieves (Grieves, 2006) identifies in PLM everything which deals with the management of the product data that are created, stored, and managed along the lifecycle of a product, from the design to end of life. Ma and Fuh (2008) state that PLM is a technical term to describe a comprehensive, systematic and scientific approach in managing enterprise performance based on a coherently and consistently integrated computer system that can effectively and efficiently fulfill the product and process information requirements within a dynamic, collaborative and networked environment.

PLM is one of the most recent evolutions of the enterprise ICT applications, characterized by an increasing integration and interoperability into and between tools and supported processes, both in design and management activities. In the last 30 years, CAx (Computer Aided, where x stands for Design, Styling, Manufacturing, Engineering, Process Planning, etc.) tools have successfully evolved from 2D to 3D modeling techniques,

enabling a list of knowledge-based engineering approaches, generally addressed as Virtual Prototyping, Digital Mock-Up and Virtual Reality. Since the 1990's, collaboration in product design, development, and delivery has been enabled in integrated software platforms (alternatively addressed with new acronyms, like TDM Technical Data Management, EDM Engineering Data Management, PDM Product Data Management, PIM Product Information Management, etc.) where product data can be safely stored, retrieved, and reused. Since 2000, PLM has been used to define a comprehensive ICT market, nowadays composed of two main segments: (i) one constituted by a galaxy of design tools (i.e. CAx and engineering tools) and (ii) a second one composed by a plethora of Collaborative Product Definition/Development and Management platforms (CPDM). The first segment is dominated by ICT players historically dedicated to product design, like Autodesk, Dassault Systèmes, PTC, SIEMENS, while in the second these vendors compete with many other players coming from other backgrounds such as Oracle, SAP, etc.

PLM market is one of the most booming ICT markets irrespective of the global crisis, as many analysts (e.g. AMR Research, CIMdata, Daratech, Gartner) are continuously declaring, and PLM projects are considered as strategic investments, to be financed for surviving and preparing companies "for the next economy up-cycle" (Cimdata, 2008). It has been widely applied in capital intensive industries such as aerospace and automotive. In such industries, the same PLM concept has been defined and it is still evolving, (Sapuan et al, 2006), (Tang and Qian, 2008), (Alemanni et al, 2008) becoming a comprehensive system supporting the information needs regarding products "from cradle to grave". This system involves many engineering stages such as industrial design, conceptual design, detailed design, process planning, manufacturing, assembly, sales, maintenance, and recycle or destroy (Ma and Fuh, 2008).



Today, aerospace, automotive, and similar mechanical-based sectors are considered traditional and conventional PLM markets in which PLM solutions (both CAx and CPDM) are well known and applied. In recent years, analysts and consulting companies have dedicated their attention to unconventional PLM sectors such as food, pharmaceutical, telecommunications, textiles, footwear, and apparel. Among these, the so-called “fashion luxury sector” has been addressed repeatedly as one of “the next” PLM sectors (Barret et al, 2007), (Sulesky et al, 2007), (Hojlo and Suleski, 2008).

Italy is commonly considered to be one of the most important “fashion and luxury” countries of the world (Brun et al, 2008), particularly with regard to the Italian leather industry. Within this context, the present contribution aims to investigate the declination of the PLM approach in the unconventional “fashion luxury sector”, focusing on the application of PLM within the niche of the Italian leather sector, in order to understand the main commonalities and differences with more conventional PLM sectors.

Before presenting the results of the Italian-based research conducted by the authors in 2009, a brief description of this particular sector is reported. For supporting the reader, the Table 1 synthesizes the list of the acronyms adopted in the chapter.

## **BACKGROUND**

The term “fashion” is used by practitioners and academics to generally refer to an industry which widely includes several sectors: textile, clothing, leather, knitwear, accessories, sunglasses, cosmetics, and jewelry. Each of these sectors show distinctive characteristics and may be further divided into different competitive segments characterized by a company’s dimensions such as the served customers and markets, and applied technologies. Authors Saviolo and Testa (Saviolo

*Table 1. List of used acronyms*

<b>Definition</b>	<b>Acronym</b>
Bill Of Material	BOM
Collaborative Product Definition / Development and Management	CPDM
Computer Aided Design	CAD
Computer Aided Manufacturing	CAM
Computer Aided x (where x stays for Technology, Design, Engineering, etc.)	CAx
Carry Over	CO
Engineering Data Management	EDM
Information and Communication Technology	ICT
New Product Development	NPD
Product Data Management	PDM
Product Information Management	PIM
Product Lifecycle Management	PLM
Small and Medium Enterprise	SME
Stock Keeping Units	SKU
Technical Data Management	TDM
Time To Market	TTM

and Testa, 2005) classify the fashion markets using the price and the number of sold units as variables that discriminate the type of the product, thus defining five main market segments: *couture*, *prêt-à-porter*, *diffusion*, *bridge*, and *mass*. From the last segment (*mass*) to the first one (*couture*) (i) the prize of the sold product increases, (ii) the number of sold units decreases, (iii) the perceived and the real quality increases, (iv) the product differentiation and variety increases (from *mass* to *custom*) and (v) the demand predictability and stability generally decreases.

Each market segment has an impact in the structure of the fashion value chain in terms of TTM, lot dimensions, and number of sold units per product type. The value chain of the fashion industry has been studied by several researchers in the past years, and numerous publications can be found on such topic. Most of them are related to the fashion industry as general market (Brun et al, 2008) (Caniato et al, 2007), while some others

are focused on textile and clothing (Burrelli and Ravagni, 2006) (La Marca and Palamara, 2005) (Gereffi and Memedovic, 2003) (Richardson, 1996) (Bruce et al, 2004) (De Toni and Meneghetti, 2000). There are other papers as well focused on the description of specific value chain such as Zara (Ghemawat and Nueno, 2003) and (Vona, 2004), Burberry (Moore and Birtwistle, 2004) and Armani (Fernie et al, 1997). Saviolo and Testa (Saviolo and Testa, 2005) identify four types of fashion value chain according to the existing level of integration:

- i. Integrated Griffe (e.g. Gucci, Prada, Ferragamo) companies which own and control nearly their entire value chains - from the design, to the production plants, until their branded shops.
- ii. Industrial Integrated Groups (e.g. Tod's and Ermenegildo Zegna) which design, own their plants, and sometimes manage part of the distribution chain.
- iii. Pure Brand Owners (e.g. Roberto Cavalli) which are generally small companies focused purely on design without involvement in the production, distribution, and selling processes.
- iv. Industrial Players (e.g. Sergio Rossi) which provide their specific production and distribution competences and facilities (e.g. in the shoes making) to other brand owners.

Traditionally, a polarization can be observed in the fashion industry (Brun et al, 2008). Some companies choose to operate in the mass market, selling low-cost products that are available to a large number of consumers, whilst on the other hand other companies provide exclusive and expensive products to an elitist segment of consumers. The latter type composes the "luxury" segment. Companies which belong to both markets are not common. Like fashion, luxury itself is a transversal concept which dominates a plethora

of manufacturing sectors including clothing, jewelry, furniture, wine making, automotive, and the yacht industries. Luxury is "a way of live" in which the customers search for elitist emotions. In the last decade, different authors (Fernie et al, 1997), (Silverstein et al, 2003) and (Sen, 2008) analyzed the intangible sense of elitism and desirability which pervade the luxury segment. For example, D'Arpizio (D'Arpizio, 2008) defines the 3A's of luxury (Absolute, Aspirational, and Accessible) which constitutes sub-segments of the whole luxury market. In the Absolute luxury, the products must be elitist, represent an icon, and include characteristics of tradition and uniqueness. In the Aspirational luxury, the main value for the customer is represented by aspiration, recognizability, and diversification. The Accessible luxury is characterized by a higher economic accessibility, where the sense of membership and status symbol plays a relevant role.

Within the luxury apparel fashion markets, style and design excellence are achieved by keeping the design activities in-house while collaborating with experienced external designers and stylists (Brun, 2008). The process of New Product Development (NPD) is characterized by a large number of product revisions, in which the continuous interactions between designers, stylists and marketing functions take a long time and iterations (Sen, 2008). Revisions and modifications are realized also when the final product is already in the market, in order to align the production to the customer demand (e.g. change colors for a model).

NPD is characterized by high seasonal demand, which depends on the seasonal nature of fashion products. The whole NPD process is managed at least four times per year - one time for each season - with a short TTM (15 months in the apparel industry, 12 months in the leather industry)

In the luxury fashion market, NPD is a comprehensive process which includes the following five stages:

- i. Design
- ii. Modeling/prototyping (for realizing the demonstration products to be shown at the fashion fairs)
- iii. Detailed engineering: Many companies complete the engineering phase at the same time as the sourcing phase. For example, in most cases, the generation of the final Bill of Material (BOM) takes place when orders have already been launched. Once the company confirms the order decisions, the BOM and the raw material purchase orders must be completed quickly. Moreover, the production quantities and decisions may continue to change very rapidly during the fashion shows seasons (i.e. the appearance of a Hollywood star with a particular bag can completely change the prevision regarding the sold units of that product, and this can happen also the last day of the last fashion fair). In some companies, the engineering phase is completed for all the products before the beginning of the fashion fairs. Although this strategy permits quick management of the sourcing activities, it likely overloads the engineering staff with less valued activities, as the actual goods produced are usually a small percentage of the all items presented at the fashion shows.
- iv. Material sourcing: The sourcing phase is very peculiar, as its duration can fluctuate from 2 weeks up to one and a half months depending on the duration of the commercial launch, which generally takes place in conjunction with the fashion shows and fairs (e.g. Pitti Florence fair, Milan and Paris fashion weeks, etc.). At the beginning of the sourcing phase, a provisional and generic order of raw material is submitted to the suppliers. The confirmation of the raw material quantity is given at the end of this phase, with a 20-30% maximum difference in quantity from the provisional order to the final order. During this very short period, the company board receives information on the number of sold units for the current season and must quickly decide which products will be produced for the upcoming season, thus defining the raw material order needs.
- v. Production and distribution: The production phase usually lasts 3-4 months, beginning when material sourcing is completed.

## **PRODUCT LIFECYCLE MANAGEMENT IN THE FASHION CHAIN**

### **The Italian Luxury Leather Industry**

“Made in Italy” is synonymous with quality, fashion and luxury. In previous years, Italian companies (most of them Small and Medium Enterprises, SMEs) of the fashion market have concentrated their activities in the highest value added luxury segments, guaranteeing the success of the national industry. Still today, despite the global crisis, luxury is still supporting the economic development of Italy (Brun et al, 2008), (AIMPES, 2009).

In the luxury fashion segment, the leather industry is one of the most active compartments. Pushed by an increasing global demand, the first decade of the Twenty-First century was a time for many fashion brands to introduce leather products in their product lines. Leather treatment has a long history in Italy, particularly in the region of Tuscany where many craft laboratories have existed for more than one century. The Italian leather industry is composed of shoe-making, suitcase and baggage making, and tanning treatment. The luxury leather market may be used as a reference market for the entire luxury fashion market, as addressed below.

This research has been conducted through an empirical, explorative research. It was carried out through personal interviews which were supported by a reference questionnaire. The reference

questionnaire, adopted as an interview guideline, is a mix of open and closed-ended questions, composed of the following three sections:

- i. General data about the company and the market.
- ii. Details about CAx and CPDM tools adopted in the NPD process.
- iii. Information about the deployment of PLM (CAx and CPDM) projects.

In this way, the data has been explicated through the analysis of the level of application of PLM, in terms of CAx and CPDM installed solutions, with the tentative purpose to make a comparison between unconventional PLM-oriented industries and more traditional PLM-oriented contexts.

The research has been limited to the luxury leather sector, with companies producing only finished leather goods (i.e. bags, suitcases, shoes, wallets and belts). According to the national leather association, AIMPES, (Associazione Nazionale Pellettieri) this sector is composed of 54 firms in Italy, including transnational companies belonging to the luxury sector with at least one business unit and at least one production plant in the country. All these companies are very well known international luxury names such as Burberry, Roberto Cavalli, Dolce & Gabbana, Dior, Fendi, Ferragamo, Etro, Furla, Gucci, Missoni, Montblanc, Prada, Sergio Rossi, Tod's, Trussardi, Versace and Ermenegildo Zegna - just to name a few. All of the 54 companies have been contacted and 20 of them (37% response rate) agreed to be interviewed and anonymously surveyed. Interviews have been conducted with product managers of the leather business units and/or to the responsible party of the relative technical departments. In some cases, the questionnaire has been submitted also to the responsible party of the ICT departments, when existing (less than the 25% in the sample). The data of the survey have been analyzed through qualitative instruments, hereafter presented and discussed.

All the surveyed companies operate in the luxury leather market, at the top of the fashion pyramid (Couture). According to the classification (D'Arpizio, 2008), 60% of the sample operates in the Absolute luxury segment and the remaining 40% in the Aspirational segment, and they serve global markets, typically within single brand shops.

The sector is composed of international companies, most of which are fully integrated and multi-product, belonging to multi-brand groups, with considerable amounts of capital available. Using the definition of value chain of (Saviolo and Testa, 2005), 10 companies are well known Integrated Griffe, 6 are part of Industrial Integrated Groups and 4 are Pure Brand Owners. Most of them (70%) are Italian owned companies, while 30% are business units of international transnational companies (25% based in Europe, 5% based in the US). In all the cases, the leather segment is just one of the luxury segments served by the companies. 90% of the sample companies are located in central Italy's region of Tuscany, while the remaining 10% are located in Northern Italy.

In terms of products, 70% of the sample produces only leather bags and suitcases, while the remaining 30% make leather shoes too. The majority of the sampled companies (55%) identify their core business in the leather sector (35% leather accessories, 20% leather footwear), while the remaining 45% companies report that clothing is their core business, and leather is just a slice of it.

An interesting "volume" parameter is the number of different Stock Keeping Units (SKUs) processed during the fashion season by the companies. A SKU is a single product code realized and sold during a fashion season (a "collection") and encompasses all the possible factors, such as color. For example, if the same model of a bag is produced blue and brown, then two different SKUs might be defined, one for the blue bag and one for the brown bag. More than 50% of the companies realize collections of more than 500 SKUs per season. Among them, 20% of the sampled com-

panies define more than 2,000 SKUs per season. Only 3 companies show fewer than 100 SKUs per season. In the new SKUs per season, some of them are directly related to SKUs of the previous season (e.g. just a new color – black – for an old model bag) and they are defined as Carry Over (CO) units - items produced continuously every year. More than 70% of the companies have a reduced CO (less than 30% on the total SKU per season), highlighting the constant innovation of the companies to continuously look for new fashion trends-waves for satisfying their customers.

It is widely recognized (Brun et al, 2008) that the fashion sector widely applies outsourcing strategies (Table 2). In more than 90% of the sample, production is partly outsourced to external production laboratories, generally located near the main plant and primarily based in Tuscany. On average, a company has more than 35 external small and medium laboratories working in its supply chain. Moreover, almost 50% of the companies design their products with the support of external designers.

### **ICT in the Leather Industry**

In terms of ICT tools, all the companies have an ERP (Enterprise Resource Planning) suite installed in order to manage their active and passive order cycle. In the NPD process, a significant difference has been observed between CAx and CPDM tools, for instance, 80% normally apply CAx tools (80% CAD, 45% also CAM), while only 40% of them have installed a CPDM solution.

45 percent of the companies adopt a CAD 2D, 30% adopt both CAD 2D and 3D, while 5% apply only a CAD 3D, and 20% of the cases do not have a CAx suite in their design departments. These companies just agree on the concept of the product and then totally outsource the detailed design and engineering to external professional designers. The leather sector calls for a CAD tool specifically designed for the leather/textile activities. Fewer than 20 percent of the sampled companies apply

a multipurpose CAD (i.e. SolidWorks by Dassault Systèmes, ThinkDesign by Think3), while the majority of the sample uses a list of dedicated tools, most of them created in Italy (i.e. Mozart CAD, Romans CAD, Naxos, AIMPEs CAD, Bitron CAD, etc.). Generally, when it exists, the installed CAM is provided by the same vendor of the CAD system. Furthermore, 40 percent of the companies have installed a CPDM solution.

Collaborative platforms enable cooperation among functions and business processes, generally proving a common data warehouse (vault) for sharing data, metadata and information. CPDM platforms can be implemented with different degrees of functionalities, supporting knowledge sharing in unstructured (e.g. simple file sharing email-based) or structured ways (e.g. automatic workflow). Further, CPDM platforms are used within small working groups (e.g. only the technical department) or larger teams (e.g. involving key actors of other phases, like marketing, production, etc.). In the analysed sample, 5 companies installed a CPDM solution (a traditional PDM platform) in the technical department, just for storing and sharing product data (i.e. drawing and 3D models) and managing NPD projects. In fewer than 5% of the companies, commercial web-based CPDM platforms have been installed for enabling collaboration along the NPD process, supporting product data (e.g. models and drawings) and metadata (e.g. BOM and configuration rules) sharing among the different phases (design, sourcing and production). In most of the cases, a deep customisation of CPDM commercial platforms was needed to

*Table 2. Percentage of outsourced activities*

<b>Outsourced activities</b>	<b>%</b>
Production	95%
Prototyping	70%
Product development	50%
After sales	30%
Logistic	30%

adapt the available solution to the peculiarity of the industrial context.

Most of the benefits reported by the companies regarding CAD application are the reduction of TTM and process quality improvements. The former is given more appreciation, since it enables faster realization of models and easier re-use of produced parts. The concept of process quality has been explained by the interviewees as better management, better storage of models, more security, and increased control on stage. Regarding CAD 3D, it was evident that, in this sector, solid modelers are used mostly for marketing purpose (i.e. display of 3D models that could replace, in some cases, the real prototype), while CAD 2D is still enough for the objectives of the designers. The main registered benefits related to the implementation of CAM application are time reduction (cutting speed), quality improvement (more precision and less errors) and costs reduction (reduced waste materials and use of unskilled manpower). In summary, CAD and CAM tools contribute to increase the efficiency in the NPD process.

With regard to problems encountered by the companies during the introduction process of a PLM system, the resistance of people to change is reported as the most critical one - as stated by more than 50% of the cases. This evidence confirms that, in most cases, the deployment of the PLM approach in a company (in particular in the CPDM segment) is linked to a process or organizational innovation, as happens in other more PLM-oriented sectors. This behavior is often explained in terms of "political resistance", apprehension of managerial control, evading personal initiatives and so on. Other criticisms indicated by companies' managers are related to technical issues and software specifications, even if none of these problems were considered as reasons for any particular project failure.

Pertaining to difficulties met by the companies after the introduction of a PLM tool, certain problems existed. In half of the analyzed projects, the introduction of the system do not reduced the

employee's resistance, which felt their benefits during the start-up of the projects. In more than half of the projects technical problems have been detected, during the introduction's phase, because PLM tools needed users dexterity and involves high personalization and integration (in particular CPDM platforms) in this industry. At the end of the project, most of the surveyed companies were satisfied by the introduction of the new software products. Only 10% of the companies reported the PLM introduction project as a failure.

Two cases of failures are analyzed in this research, both related to the introduction of basic CPDM platform. In the first case, the causes were related to technical issues (the proposed solution did not meet company's needs), while in the second case the resistance of the business units and less of a commitment of the company managements have to be considered as the main reasons for the projects failure. These two cases confirm a common thinking widely debated in literature and common to ICT projects: during the introduction of ICT tools, human elements are the critical factors in determining the success or the failure of the projects. Furthermore, a good management and a strong commitment are needed to guarantee the success of implemented projects.

Software specification is another crucial aspect to ponder. In the first part of a project, an important step is the definition of how a commercial tool has to be personalized in order to full fill a company's particular needs. In many cases, the effort needed to support this part of a project was underestimated by managers, causing problems and delays.

Other causes reported by the companies as possible criticalities in the introduction of CPDM systems often had to do with the dimension of a company. One common thought is that, if the collections are made of fewer SKUs, or a division has fewer personnel, it does not seem relevant to introduce this kind of collaborative systems. On the other hand, the commitment coming for a corporate strategy, even if not supported by real

company's needs, is more effective for adopting CPDM software, rather than for CAx tools. In fact, CPDM systems enable collaboration among departments, functions and sites. In a small context normal communication could be enough to foster collaboration, while in big contexts (like corporations and transnational companies) collaboration might be pushed and physically supported by using dedicated ICT CPDM platforms. CAx tools are directly related to the activities which they are designed for, so their adoption is independent by a company structure and dimension.

Despite the criticalities mentioned above, CPDM systems can offer many benefits to companies. CPDM platforms generally permit a better cost control of a product, beginning from the design phase, and provide the opportunity to increase cross-functional collaboration and establish a better control on internal processes. CPDM systems guarantee to the user that he/she can assess a structured and shared archive where he/she can easily find the right product information (i.e. the right version of the SKU), thus enabling a more efficient use of time, a reduction of the risks and errors in the management of the BOM. A typical benefit achieved with a CPDM system in traditional PLM-oriented sectors is a general improvement in the component and part reuse and management. In this particular industry, because of the peculiarities of the fashion sector itself, in which market demands for new products, forms, and materials, such kind of benefit was not considered useful by the companies.

## **ANALYSIS AND DISCUSSION**

Within the sample, those companies with the most advanced and integrated CAx solutions (i.e. CAD 2D and 3D integrated and also directly connected with CAM) are managing more SKUs per year, with more products are being designed continuously using sophisticated ICT solutions.

In order to evaluate and classify the attitude of a company in the adoption of PLM tools, a proxy variable has been created and named as ICT Maturity Degree. This variable has been defined considering the interaction between the degree of functional coverage and the existing integration among the software of the company, where functional coverage is a parameter linked to the internal processes supported by ICT tools, and integration means the system capability to share information and to communicate inwards and outwards the company. Regarding the integration, the levels have been defined as:

- None: companies without any CAx and CPDM systems.
- Low: in case of isolated CAx tools and/or CPDM systems.
- Medium: when CAx tools and/or CPDM systems are partially integrated among themselves or with other ICT suites.
- High: in case of fully integrated ICT solutions.

In a similar way, four levels of functional coverage, with increasing complexity, have been defined as:

- A zero level, in which companies without any CAx and CPDM systems have been included and classified with "Inexistent" functional coverage.
- A first level (Low), in which takes place a simple transaction of drawings and data sheets among business functions, implemented with an extemporaneous use of e-mail or data warehouse. Companies without a CPDM system belong to this level.
- A second level (Medium), where there is a more complex management of data and metadata among company's functions; at this level is required the existence of a relational database and a data warehouse system, able to manage controlled and re-

stricted access, without using automated workflow. Companies with traditional commercial PDM belong to this group.

- A third level (High), with an intensive use of automated workflow among functions, data warehouse systems able to manage of product data and other complex information. In the present study, this level represents the highest definition of PLM-oriented ICT system.

Crossing functional coverage and integration (Table 3), it is possible to define four levels of ICT Maturity Degree, which are:

- Group 1 (None): in case where both functional coverage and integration are absent.
- Group 2 (Low): with a low level of functional coverage associated to low and/or medium integration level.
- Group 3 (Medium): when both parameters are medium.
- Group 4 (High): in the following cases: high functional coverage and a medium and/or high integration level; medium functional coverage and high integration level.

The 40 percent of the sample have a low maturity degree, generally due to a limited use of collaborative software. The remaining 60% of the sample is equally divided among the other three levels. The highest level corresponds to the application of a comprehensive PLM approach.

Some of the most interesting results of the survey come from the comparison of the ICT Maturity Degree variable with other companies' parameters, as the number of SKU and the percentage of CO. Table 4 and Figure 1 map the ICT Maturity Degree with the number of SKU, in Figure 1 the bullets represent the companies. Even if the nature of the research cannot demonstrate this sentence, a direct relation between the number of SKUs (then the dimension of the seasonal collection) and the ICT Maturity Degree seem to exist. That is, the bigger is the collection, a more sophisticated and integrated ICT infrastructure is needed. In Figure 1 there are two outliers (i.e. two companies with high SKU, but without a CPDM system). The empirical nature of the research does not explain this phenomenon, but the possible causes are the budget constraints and a general mistrust of ICT solutions which still exist in some companies of the fashion market.

Table 5 crosses ICT Maturity Degree with CO percentage. From these results, two possible relationships can be supposed:

- A small CO percentage could indicate high variability in the collection, which calls for more sophisticated ICT tools.
- A high CO percentage could indicate a relevant continuity among collections, which could call for sophisticated CAx for enabling a better design reuse.

As mentioned, NPD process (or part of it) is often outsourced in the leather industry. Table 6

*Table 3. Analysis of the ICT Maturity Degree*

Level of functional coverage	Inexistent	I (Low)	II (Medium)	III (High)
Level of Integration				
None	20%	-	-	-
Low	-	25%	-	-
Medium	-	15%	20%	5%
High	-	-	5%	10%



Table 4. SKU classes and ICT Maturity Degree

ICT Maturity Degree	Group 1	Group 2	Group 3	Group 4
SKU classes				
< 100	25,0%	25,0%	-	-
100 - 200	25,0%	12,5%	-	-
200 - 500	25,0%	25,0%	25,0%	-
500 - 1000	-	25,0%	50,0%	-
1000 - 2000	25,0%	12,5%	25,0%	-
> 2000	-	-	-	100%

Figure 1. SKU versus ICT Maturity Degree

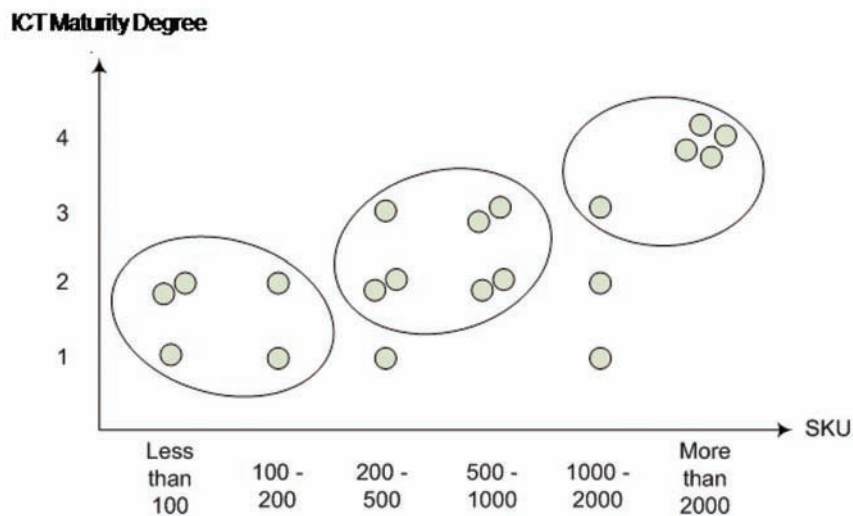


Table 5. CO percentage versus ICT Maturity Degree

ICT Maturity Degree	Group 1	Group 2	Group 3	Group 4
CO percentage				
0-15%	-	25,0%	16,7%	50,0%
15-30%	50,0%	37,5%	83,3%	-
30-45%	-	-	-	50,0%
> 45%	50,0%	37,5%	-	-

maps ICT Maturity Degree with NPD outsourcing. Obviously, 100 percent of the companies of Group 1 operate in outsourcing, even if in many other cases (with a higher ICT Maturity Degree) part of the NPD process is realized externally. Evidently, PLM (CAx and CPDM) systems enable for a better management of the relationship with

suppliers (e.g. for CAD models display, collaborative management of technical data, etc). However, it might be said that in most of the sample cases unstructured traditional web-based technologies (like e-mail and FTP) are used to exchange product data with outsourcers, while structured solutions (e.g. CPDM workflows) are not so well diffused.

*Table 6. Outsourcing of the NPD process versus ICT Maturity Degree*

ICT Maturity Degree	Group 1	Group 2	Group 3	Group 4
<b>Outsourcing NPD</b>				
NO	-	63%	50%	75%
YES	100%	38%	50%	25%

*Table 7. Leather Business Unit Personnel versus ICT Maturity Degree*

ICT Maturity Degree	Group 1	Group 2	Group 3	Group 4	Total Companies
<b>Leather BU Personnel</b>					
< 50	100,0%	62,5%	16,7%	-	50%
50-100	-	25,0%	16,7%	-	15%
101- 250	-	12,5%	33,3%	-	15%
251- 500	-	-	16,7%	50,0%	10%
> 500	-	-	16,7%	50,0%	10%

*Table 8. Number of Business Unit Designers versus ICT Maturity Degree*

ICT Maturity Degree	Group 1	Group 2	Group 3	Group 4	Total Companies
<b>Number of BU Designers</b>					
< 50	100%	62,50%	-	-	50%
50-100	-	25,0%	16,7%	-	15%
100-250	-	12,5%	33,3%	-	15%
250-500	-	-	16,7%	50,0%	10%
> 500	-	-	16,7%	50,0%	10%

Analyzing the relationship between the size of the leather business unit – measured as the number of people belonging to the business unit and ICT Maturity Degree, it appears that all the cases without any ICT tool, and 87.5% of those who have only CAx tools, have a staff under 100 employees (Table 7). Moreover, in all the cases with CPDM systems installed have more than 100 people. These cases can be further divided into two groups, one with basic CPDM systems (66.7% of the companies), and the other with advanced CPDM solutions (100% of the companies). The data seem to show a link between the size of the business unit and the presence of PLM solutions despite their level of complexity. The same results have been reached by evaluating through the number of people dedicated to the NPD process. The implementation of CPDM systems seems to

be linked also with the dimensions of the design and technical department (Table 8). Having more designers and engineers involved in the leather business unit, the higher the ICT Maturity Degree appears. Due to the explorative nature of the survey, however it is not possible to confirm this hypothesis, even if many indicators seem to confirm this thesis. Such a relation (i.e. company dimensions versus ICT Maturity Degree) represents one of the biggest limits of PLM in this sector. The available PLM technologies seem to be still dedicated to big companies, while SMEs are excluded from this market.

Others possible correlations have been sought e.g. the core business of the brand and the ICT Maturity Degree, but any relevant connection regarding adopted tools has come out. It appears that 100% of the companies without any tools

have clothing as their core business: this evidence could partially explain small ICT investments in the leather sector, but it doesn't provide any information about a possible higher ICT Maturity Degree of the core division.

One of the objectives of the research was the identification of possible trends in adopting CAx systems and CPDM solutions in fashion sectors. In this way, during the research, past and future ICT projects regarding the NPD process have been also investigated. Regarding past projects (Table 9), results show that the last tool introduced by the companies belonging to Group 2, having only CAx tools, in 75% is the CAD system itself, percentage equally divided among 2D and 3D. Companies owning basic CPDM solutions, in 25% of the cases have recently introduced 2D CAD tools, as substitutions of obsolete software or as integrated system to CAM (system implemented in 25% of these companies). The remaining 25% have recently adopted their current CPDM solutions. The results of Group 4 is interesting too: in this case, for 75% of the companies, the last implemented system is the CPDM solution, while in the remaining part, the last tool is a CAD 3D, as a renewal or extension of an existing structure.

These results show that, in the luxury leather sector, the introduction of collaborative solutions is recent and currently in progress, while CAD systems have been adopted since several years in most of the cases. For that matter, CAD 2D tools are still sufficient for the industrial needs and substitution with CAD 3D seems to be still far away.

A specific set of questions were related with the investigation of ICT projects planned by the companies in the next 3 years, the results are interesting and can be summarized in the following statements:

- 75% of companies without any tools in their NPD are not planning to introduce them in the next years. This evidence can be justified in some cases with the presence of other ICT projects currently in progress, or due to budget and/or human resources limitation for a new project, or because they are considered not strategic for the firm by the management. The remaining 25% have planned the introduction of basic CPDM systems.
- All the companies with only CAx tools are preparing new projects. Where in 30% of the cases extension of CAD or CAM tools are considered in order to cover additional functionalities. While in the remaining 70%, they consist of projects for the introduction of CPDM solutions. In the end, it is important to underline that the cost of these projects, due to their extension, is always considered significant by the management of the companies.
- Companies belonging to the third group, which own a CPDM system, 75% of them have projects regarding these tools. These projects are mainly related to the extension of functionalities or to improve the integration level, and in most of cases changing

*Table 9. Last ICT tool installed by the company (within the four groups of ICT Maturity Degree)*

ICT Maturity Degree	Last ICT tool installed						
	ERP	CAD 2D	CAD 3D	CAM	Basic CPDM	Advanced CPDM	Other
1	100%	-	-	-	-	-	-
2	-	37,5%	37,5%	-	-	-	25%
3	25%	25%	-	25%	25%	-	-
4	-	-	25%	-	-	75%	-

their own basic solution into a most advanced one.

- Focusing on companies with advanced CPDM solutions (only 3), despite the common thinking, results that all of them have already planned projects of functional coverage extension or improvement of the integration level. In authors' opinion, this evidence confirms that the benefits obtained by the companies are the main incentive to promote a full implementation of the PLM business model. Obviously these kinds of projects, such as those of the previous paragraph, consisting of extensions of solutions already implemented, will be lower than the size of those introduced from scratch.

Moreover, in most professional literature, dominated by vendors and consultants publications, there is a recurrent interest on the application of PLM (in particular in its CPDM segment) in fashion sectors. Some contributions ((e.g. (Barret, 2007), (Hojlo and Suleski, 2008), (Suleski et al, 2007)) state that fashion will be the next PLM market. This exploratory research partly confirms such an interest, though PLM is at the fledging stage in these sectors. However, it might be noticed how in the last five years many companies in the luxury leather industry have changed their CAx tools and have introduced their first CPDM systems, and many others plan to introduce a CPDM solution in the next years. This means that PLM is certainly gaining growing interest across these companies.

## **CONCLUSION**

In this contribution the main results of an empirical research concerning the application of PLM solutions for supporting the NPD process in the luxury leather sector are reported. Even if the luxury leather sector is a niche market of the

largest fashion sector, it can be considered well representative of the criticalities and features of all the other sectors. Despite this, obviously, the analysis of such a specific market is one of the most relevant limits of the research, which has an explorative purpose and can't be considered as exhaustive.

However, in its limitations the research underlined the main peculiarities of PLM projects in the fashion industry, identifying some commonalities and differences that characterized this sector in comparison with more PLM-oriented sectors, like the mechanical one.

From this preliminary analysis some interesting new research items have been identified. For example, it is interesting to notice how after sale service is not considered at all in the ICT strategies of the analysed companies. A common thought widespread among the interviewees is that the non-durable nature of products implies a short lifecycle. This evidence moves companies to have "lack of memory" on themselves. Thus after sales, in spite of other sectors where maintenance is a strategic phase of the lifecycle, in the luxury fashion sector is currently a marginal phase of the process, where no resources focus on it. In this sector, after sales is still considered as a service that the companies as to provide, and not as a source of further earnings or competitive benefits (e.g. aerospace). The adoption of a "complete PLM approach" is still too far to be implemented in fashion contexts as in more PLM-oriented sectors such as aerospace (Tang et al, 2008) and automotive (Alemanni et al, 2008).

Finally, it is evident that the fashion context has a particular NPD process, which urges for a specific adaptation of PLM solutions. Such a peculiarity needs a new reference model different from the traditional mechanical NPD process. It will thus be interesting to conduct more in-depth analysis on the topic. For instance, more samples can be collected and rigorous statistical analysis can be conducted to reveal more important academic and managerial insights. Moreover, as motivated by the

findings of this exploratory research, mathematical models can be constructed for further studies.

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## Chapter 16

# Consumer Perceptions of Online Apparel Customization: An Exploratory Study

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### ABSTRACT

*This study was conducted to identify a variety of consumer perceptions of apparel customization in the context of e-retailing. Consumer surveys were performed by email invitations through a marketing firm. The survey participants visited apparel customization websites, which were developed for this study, to customize a pair of jeans before answering open-ended questions. The respondents were 213 female college students in the U.S. Their statements were analyzed and categorized into eight dimensions representing the benefits (usefulness, convenience, and fun/enjoyment) and costs (risk, limitation, self-assurance, time consumption, and unappealing) of online apparel customization. Two discussion topics were drawn from the findings: why people are willing or unwilling to customize apparel online. Insights are generated and future research directions are discussed.*

### INTRODUCTION

Customization is an important part of modern supply chain management, and the business strategy such as mass customization (Lee, Kunz, Fiore, & Campbell, 2002) has been well-established in practice. Undoubtedly, customization reflects

the shifting marketing focus from sellers to buyers (Wind, 2001). In the past, buyers passively chose standardized products offered by sellers, but, increasingly, buyers are actively participating in the production process to create products that meet their own values (Meuter, Bitner, Ostrom, & Brown, 2005). As a consequence, the traditionally separate roles of companies and consumers are not clear anymore; consumers participate in the

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value creation process as “co-producers” or “customizing consumers.” Therefore, companies are continuously adopting new strategies to respond to their individual customers. The environment of abundant information in today’s society makes consumers more knowledgeable; they know what they need and want and have confidence in their product choices (Moynagh & Worsley, 2002).

The efforts of marketers to meet individual needs and wants were initiated in off-line contexts, but such efforts are now offered by many e-retailers, as well. Since Dell.com began providing customized computers, other e-retailers have begun to offer customized medicine, food, home furnishings, and apparel. In particular, apparel products have a great potential in online customization since apparel is one of the most popularly selling categories in online shopping and customers have identified apparel as one of the most appropriate items for customization (Goldsmith & Freiden, 2004). Although e-retailers are adopting customization as a strategy for managing and building long-term relationships with their customers, not all companies look to continue to use the strategy. One reason for the failure of online customization could be the lack of a company’s understanding of its customers; how customers perceive online customization may influence their behavioral attitudes and the success of the business. Thus, the goal of this study is to explore different aspects of consumer perceptions of online apparel customization and to provide implications to academics and practitioners.

## **BACKGROUND**

In a modern concept, apparel customization involves the use of certain technology that can be used to reduce the costs of producing personalized items. A US company, Levi Strauss, was the pioneer of apparel customization in this modern concept. To meet the needs of customers, the company adopted body-scanning technology to

offer customized jeans at its flagship store in San Francisco. The use of customization capabilities among the top 100 apparel companies in the year 2000 increased 120% compared with the previous year (Kelly, 2000). Similarly, e-retailers began to feature customization on their websites at that time. LandsEnd.com started to offer customized apparel in 2001 with men’s and women’s khaki pants, and has since expanded its product assortment to include jeans, outerwear, chinos, dress pants, and other items (Scardino, 2004). For companies, online customization is a way to provide additional benefits to their customers. By choosing their own color, fabric, design, size, and fit, customers can create a unique value or style. During the process, e-retailers collect a customer’s information, such as design preferences. The information can be saved and used for the customer’s next online visit. In that way, customers can conveniently shop at the store and also have a feeling of personal service and care.

In spite of these advantages, not all the companies look successful in their customization offerings. IC3D.com provided customized jeans via online orders, but has currently stopped its business. LandsEnd.com has limited its customized offerings and now takes customization orders for only men’s dress shirts. Previously, some researchers had suggested that adopting customization would be an effective strategy for e-retailers for managing and building long-term relationships with their customers. (Ribbink, Van Riel, Liljander, & Streukens, 2004). However, not all researchers were positive toward online customization. Lee and Lin (2005) examined the influence of e-retailers’ use of customization on consumer satisfaction, but did not find any significant results. In explanation of these disparate findings, perhaps online shoppers perceive not only the benefits of customization, but also the disadvantages that negatively influence satisfaction and repetitive behavioral intention. Furthermore, very limited studies regarding online apparel customization exist (e.g., Choy & Loker, 2004), and these existing studies suggested



the overall positive consumer responses toward apparel customization in online shopping but did not identify the exact factors influencing positive consumer responses. Thus, the current study was intended to discover how consumers perceive online apparel customization and to discuss the implications. For this purpose, the previous literature was reviewed and a consumer survey was designed for empirical research. The study is thus presented as follows: first, the unique nature of apparel customization is reviewed by discussing consumer involvement in the customization procedure, which is followed by the introduction of the determinants of consumers' behavioral intentions to online customization; next, the methodology of the consumer survey and the findings are reported; and finally, a discussion of the findings is presented, which leads to suggestions for future research directions and a general conclusion.

### **CONSUMER INVOLVEMENT IN APPAREL CUSTOMIZATION**

Apparel customization can be accomplished by allowing consumer involvement at several points in the apparel production process (Kamali & Loker, 2002). Consumers might be involved in the pattern making stage by developing a custom fit or design; in the designing stage by selecting sizes, styles, and fabrics; in the production planning stage by forecasting the future needs of individual consumers; in the manufacturing stage by asking for small orders; in the delivery stage by utilizing point-of-purchase data and finding the best delivery option for individuals; and in the post purchase stage by asking for personal adjustments. Among all the potential possibilities, the most common approach used by e-retailers for consumer involvement is at the designing stage, as shown in many online apparel retailers such as Nike.com or LandsEnd.com. This involvement is essential for customization, and the amount of involvement may vary depending on the level of customization. That is,

a higher level of customization is possible when consumer involvement is greater. For example, in order to create highly customized jeans, customers have to go through longer shopping procedures that include their choices in design options and also data collection for their body sizes. Some companies require less consumer involvement for a lower level of customization, and the shopping procedures are less complex. Anderson-Connell, Ulrich, and Brannon (2002) identified four types of apparel customization while conducting focus group interviews with females ages 20 to 50. One of the customization types was totally customizing orders, which may require a great amount of consumer involvement because the company may need more extensive and detailed information to create the garment. Other types of apparel customization can be achieved by a consumer's choices of design options or through interaction between the consumer and a service provider. These types of apparel customization may require less consumer involvement than totally customizing orders. Finally, copying one's own clothing is another means of customizing apparel that may require a limited amount of consumer involvement.

In all cases, though, consumer involvement is an integral part of customization. By being involved in the production process, customers can be co-producers to satisfy their own values. During this co-production procedure, consumers may have differing perceptions of online customization and subsequent behavioral intentions.

### **DETERMINANTS OF BEHAVIORAL INTENTION TO ONLINE APPAREL CUSTOMIZATION**

Previous studies have suggested that consumers would be highly interested in apparel customization and would willingly accept the technology (e.g., body scanners) to customize their garments (Fiore, Lee, & Kunz, 2003; Loker, Cowie, Ashdown, & Lewis, 2004). Other researchers (Choy &

Loker, 2004) also indicated that consumers would have high intentions to be involved in customizing wedding gowns online. These studies made implications about consumers' general interests toward apparel customization but failed to provide clear explanations, particularly in online contexts. In fact, the actual motivation of adopting apparel customization may depend on the perceived benefits and costs to gain those benefits. Marketing literature suggests that both parties in an exchange relationship expect some benefits (rewards) and costs (investment) (Houston & Gassenheimer, 1987), and the ratio of the benefits and costs will influence both individuals' intentions to engage in the relationship (Burnstein & Karz, 1972). In the context of apparel customization, individuals may willingly become involved in a customizing procedure when the rewards justify the investment.

Securing a unique product is the most important benefit a customer can expect in customization, but online shoppers will evaluate not just the benefits, but also the expenses they have to pay to gain the benefits. Compared with a typical shopping procedure, customization shopping will be longer and require more psychological/physical effort. The procedure may include an information collection process, which can cause concern for privacy. For example, in order to customize jeans on IC3D.com (this company has temporarily ceased business), customers chose options for the design in 11 categories (fabric, fit, leg, ankle, waist band, front pockets, back pockets, fly, trim, label, and thread) and provided 11 body measurements (waist, widest, waist to widest, front rise, back rise, mid crotch, full crotch, thigh, inseam, knee length, and bent knee).

The process of providing personal information about one's body can be a tiring procedure and also an uncomfortable procedure for a consumer, particularly for females, who may be more sensitive in revealing their size information. One study showed that consumers are very sensitive toward the information collection process online, regardless of the degree of personal identification

requested (Chellappa & Sin, 2005). This previous study showed consumers' concerns over the data collection process for even anonymous and personally unidentifiable information.

Therefore, despite the benefits, costs can be a significant hindrance to accepting customization. In the context of relationship marketing, Noble and Phillips (2004) wondered why people are reluctant to use a company's relationship marketing program (e.g., loyalty cards) even though they perceive the benefits of the program. With focus group interviews, they found two dimensions that hinder consumers' engagement in relationship marketing programs. One dimension was "perceived efforts," which reflected the investment of time and efforts to obtain the benefits of the relationship programs. The other dimension was "perceived loss," which represented the consumers' sense of time spent, privacy concerns, and unsatisfactory benefits.

In sum, the previous literature has suggested that consumers' willingness to be involved in apparel production is determined by the benefits and costs that consumers perceive. Cho and Fiorito (2009) developed a research model to examine consumer acceptance of online customization. While testing the model, they suggested perceived usefulness, perceived ease of use, and perceived security as the major indicators of trusting the websites or forming positive attitudes toward online customization. This previous study provided significant insights on consumer intentions to online customization, but enriched contexts of the theme may be needed. Therefore, a consumer survey was designed in order to investigate a variety of aspects of online apparel customization.

## **METHODOLOGY**

### **Development of Customization Websites**

To survey participants, this study developed customization websites to provide the experience

of customizing jeans. Jeans were selected as the focus item because of their potential in the apparel customization market (Lee, et al., 2002). Prior to the survey website development, existing websites for customizing jeans were investigated to identify content. This investigation showed that a typical procedure for customizing jeans included different levels of information collection, depending on the level of customization. Given this market practice, the survey websites provided three customization offerings, low, medium, and high levels of customization (see Table 1). A low level of customization (Website A) provided limited design options and asked for limited size information. Medium and high levels of customization (Websites B and C, respectively) offered more extensive design options, but also required more input, such as extensive body size and body shape information. A high level of customization, compared with a medium level, was designed to gather more extensive and detailed size and shape information. All three websites had the same shopping procedure: first, choose the design options; second, provide the size and/or shape information; third, confirm and check out the item(s). These websites were created based on one selected commercial website that requires an extensive procedure for design options and information gathering; thus, modification of the website for the survey purposes was easy. In order to create a professional look, the original layouts, colors, and text information were duplicated into the developed websites. Furthermore, the developed websites used additional graphics and text from other commercial websites.

### **Survey Procedure and Data Analysis**

This study was conducted through online surveys. Each survey included an embedded website (A, B, or C) and was emailed to a member of a consumer panel in a marketing firm. Each participant started the survey by clicking the linked website in the email. At first, the participant was directed

to experience a shopping procedure to customize jeans for her own use by using the embedded website in the survey. Then, each participant was asked to answer open-ended questions such as “Do you have any comments on the website you just explored?” The collected data for website A was 73 responses, for website B was 66, and for website C was 74. Data was analyzed by two different coding methods. First, open coding broke down the data for conceptualization and categorization. Next, an axial coding technique identified the connection between the categories that were grouped and organized by the hierarchical relationship (when it was applicable). When a participant provided multiple statements that contained different contexts, the statements were divided and each piece of the statement was coded separately. Consequently, the numbers of the statements used for the data analysis were 88 for website A, 73 for website B, and 80 for website C.

### **Characteristics of Sample**

The target audience was 100% female college students. Lee et al. (2002) found that college students are a potential target for apparel customization because of their interest in the customization processes, body scanning, and co-design. Also, female college students are more interested in customization than are male students. Regarding age, the largest sector was 20 to 29 (65%) and the second largest was 18 to 19 (27%). In area distribution, the northeast region and the west region of the United States had the most respondents, each of which accounted for 19.5%. White/Caucasian was indicated by the majority of respondents (74%), followed by Black/African American (19%), Asian (10%), and Hispanic/Latino (6%). More than half of the sample (52%) majored in Arts and Sciences. Health and Science (15%) and Marketing and Business (14%) majors were similarly distributed. Parents' annual income was surveyed and income in the range of \$35,000 - \$74,999 accounted for 20% of the respondents;

## Consumer Perceptions of Online Apparel Customization

Table 1. Procedure and Category of Apparel Customization Websites

Procedure	Category	Websites A (Low)	Websites B (Medium)	Websites C (High)
<b>Step 1</b> Fabric & Features (Design Option)	Color	O (3)	O (6)	O (9)
	Fit	O (3)	O (3)	O (3)
	Waistband	O (3)	O (3)	O (3)
	Front Pocket	O (2)	O (2)	O (2)
	Back Pocket	O (2)	O (3)	O (6)
	Ankle	O (3)	O (4)	O (4)
	Closure	X	X	O (3)
	Thread	X	X	O (7)
<b>Step 2(a)</b> Fit (Body Measurement)	Waist	O	O	O
	Hip	X	X	O
	Inseam	O	O	O
	Height	X	O	O
	Weight	X	O	O
	Bra Band Size	X	O	O
	Bra Cup Size	X	O	O
	Shoe Size	X	X	O
	Body Proportion	X	X	O
	Petite, Regular, Tall	O	O	O
	Pants Size	O	O	O
	Fluctuation	X	X	O
<b>Step 2(b)</b> Fit (Body Shape)	Hip	X	X	O
	Seat	X	O	O
	Tummy	X	O	O
	Thigh	X	O	O
	Body Shape	X	X	O
<b>Step 3</b> Finish	Confirm Order	O	O	O

O: Included; X: Excluded; () : Number of Options

many of the respondents (42.5%) answered they did not know their parents' annual income.

## FINDINGS

The survey responses were analyzed and clustered into eight categories. The categories were organized under benefits- and costs-related perceptions representing the positive and negative

aspects of online apparel customization. Table 2 lists selected statements in each category for websites A, B, and C.

## Benefits-Related Perceptions

The categories under positive perceptions were usefulness, convenience, and fun/enjoyment. No sub-categories were identified. *Usefulness* indicated the functional aspects of the websites for

Table 2. Selected Statements for Benefit/Cost-Related Categories

Categories		Frequency (%)			Selected Statements	
		Websites A 88 (100%)	Websites B 73 (100%)	Websites C 80 (100%)		
Benefits related	Usefulness	14 (16.01%)	21 (28.77%)	15 (18.75%)	"I think customization of jeans is a great idea because it is difficult to find in the store jeans that fit well all over (A)." "I think that this idea would be very helpful for individuals with non-standard body shapes (B)." "It was very helpful to find the right size of pants I wear (C)."	
	Convenience	14 (16.01%)	4 (5.48%)	4 (5.00%)	"Much easier than trying on a bunch of jeans to see what fits (A)." "It was easy to follow (B)." "I think the website was set up well and easy to use... (C)."	
	Fun/Enjoyment	3 (3.41%)	4 (5.48%)	0	"I really enjoyed the experience (A)." "It is a very interesting concept (B)." "I enjoyed the many options offered the selection process (B)."	
Costs Related	Limitations	Option	15 (17.05%)	4 (5.48%)	5 (6.25%)	"They just need a bigger variety of sizes in jeans (A)." "Needs more options-more embroidery options... (B)." "Need more options when it comes to color options (C)."
		Features	9 (10.23%)	8 (11.00%)	11 (13.75%)	"A picture of some finished products would be helpful in decision making (A)." "Where/who makes the jeans (B)?" "It never said anything about the cost or the shipping options (C)."
		Direction	3 (3.41%)	5 (6.85%)	2 (2.50%)	"I would need instructions on how to take measurements (A)." "A size guide with size suggestions based on height /weight would be wonderful, because I am not sure of my inseam (B)." "Need directions on how to measure your hips, inseam, etc. (C)."
	Risks	Product	15 (17.05%)	6 (8.22%)	16 (20.00%)	"Clothing, especially jeans are hard to shop for online because of the fit of each pair of jeans (A)." "Buying jeans online doesn't seem to be as effective for me because I feel more comfortable trying them on first (B)." "I might buy shirts or other items if this site offered them but not jeans (C)."
		Privacy	0	16 (21.92%)	18 (22.50%)	"I DID NOT like the questions about bra/cup size that were unrelated to my customization of jeans. I felt that severely detracted from my opinion of the company and I would not buy from a place that collected unnecessary information such as that when I am looking at JEANS!!! (B)." "Should not have asked for bra measurements and weight (C)."
	Assurance	8 (9.09%)	1 (1.37%)	3 (3.75%)	"I worry that I would make a mistake on my measurements, even with the detailed how-to-measure instructions (A)." "I was confused on my measurements and I didn't have the right tools to measure myself with (B)." "I guess some measurements because I don't know them, and don't have a tape measure, which made the whole process unsettling (C)."	
	Time Consumption	0	2 (2.74%)	1 (1.25%)	"It takes too much work to calculate actual inseam and waist size in inches (B)." "I don't know my inseam or waists, and I would be disinclined to measure when I can just go buy jeans at a store (B)" "I didn't know right off the bat what all my measurements are, so it was a pain to have to figure that out (C)."	
	Unappealing	7 (8.00%)	2 (2.74%)	5 (6.25%)	"The website needs to be more appealing. It's too dull (A)." "It looked a little clunky, not as well designed as it could be (B)." "Only people with nonstandard figures might be interested in this websites (C)."	

customizing jeans. Respondents commented that the websites were useful and convenient to use in shopping for jeans with the right fit and size, especially for people with non-standardized body shapes. Convenience included the perceptions of

the websites as fast, easy, and user-friendly shopping tools for customizing jeans. Fun/Enjoyment included statements referring to respondents' fun and enjoyable experiences while shopping on the websites.

## Costs-Related Perceptions

The categories used presented a broader array of negative perceptions of online apparel customization: risk, limitation, assurance, time consumption, and unappealing. Risk and limitation were composed of multiple sub-categories. Risk consisted of two sub-categories, Risk of Products and Risk of Privacy. *Risk of Products* reflected respondents' concerns regarding the product (i.e., jeans) carried on the websites. Many respondents worried about fit problems and thus wanted to try on the customized jeans before they decided to purchase them. *Risk of Privacy* was related to consumer concerns about the safety of personal information input during the customization process. Respondents expressed uncomfortable feelings or strong resistance to the request for personal body size information.

**Limitation** was delineated into three sub-categories: Limited Options, Limited Features, and Limited Directions. *Limited Options* referred to few options in colors, sizes, and/or styles in customizing jeans on the websites. Some respondents remarked the websites should provide more options, especially in size categories, because accurate measurements might be important in customizing jeans. *Limited Features* focused on the lack of supporting services or information to ensure the customization procedure. Major statements in this category were about the need for presenting the finished product. Other comments had to do with price and manufacturer information that was not provided on the websites. Some respondents were concerned that the price would be very high. Others wanted to know the manufacturer of the customized jeans to ensure quality. *Limited Directions* indicated the lack of guidelines regarding measurements. Respondents noted that they needed directions on how to measure specific parts of the body, such as waist and inseam.

The other three categories, Assurance, Time Consumption, and Unappealing, did not have sub-categories. Assurance was related to respondents'

perceptions of the website features that failed to give confidence in completing the shopping. The main reason for lack of confidence was related to requested measurements. Respondents remarked that they did not understand some terms (e.g., inseam) used on the sites. Furthermore, respondents were not sure if they could provide accurate measurements. Time Consumption referred to consumers' concerns for the time investment to customize jeans. In the Unappealing category, some respondents commented that the visual presentation of the websites was unattractive. Other respondents commented that only people with nonstandard figures might be interested in the websites.

## Comparison of the Three Websites

In order to examine whether consumer perception of the customization website is different as the involvement level increases, the three websites were compared in terms of the benefits- and costs-related categories that were identified in the previous analysis. This comparison was based primarily on the inspection of the frequency and percentage of the statement in each perception category.

For benefits-related perceptions, usefulness appeared in the perception of all three websites. The other two benefits-related perceptions presented differences between websites. That is, convenience was more often perceived at the low involvement website (website A) than at the medium and high involvement websites (websites B and C, respectively). Fun/Enjoyment was identified at websites A and B, but not at website C.

The major differences of costs-related perceptions were observed in three categories. One was from limitation of options; the statements referring to this category more frequently appeared regarding website A than for websites B and C. Reversely, risk of privacy was observed for websites B and C, but not for website A. Finally, assurance seemed to associate more highly with

website A rather than with websites B and C. Little noticeable difference was found for limitation of features and directions, risks of product, time consumption, and unappealing.

## **DISCUSSION AND IMPLICATIONS**

Customized offerings are adopted by apparel e-retailers who want to meet their individual customers' needs and wants. The success of the business will be based on positive consumer behavioral intentions. Previous studies on this topic were rare, and the few existing studies failed to focus on the variety of the aspects of online apparel customization that positively or negatively affect consumer behaviors. A successful strategy can be planned when marketers understand not only the attractiveness, but also the hindrance, of a marketing program.

In literature, the positive aspects of online apparel customization were emphasized, but the negative sides were not. Noting this issue, the current researcher attempted to identify diverse aspects of online apparel customization from consumer perspectives. For this purpose, consumer surveys were performed using three customization websites developed for this study. These websites reflected different levels of consumer involvement in the customization procedure. In analyzing the data by a qualitative method, the current researcher found different consumer perceptions of online apparel customization. Participants' statements from the survey were listed and clustered into eight categories. The finding of the study implies that consumers may become involved in online apparel customization for different reasons, but they may also be reluctant to engage in this type of shopping for various reasons. Thus, two discussion themes were drawn from the finding.

***Why people might be interested in online apparel customization.*** Consumers may want to engage in online apparel customization when they perceive the advantages. The categories of

positive aspects in online apparel customization represented the perceived benefits of customizing jeans in online shopping. Thus, people may want to customize their jeans online perceiving the usefulness, convenience, or fun/enjoyment in the shopping. These benefit related categories are comparable to the ones suggested by the Technology Acceptance Model (TAM). The TAM was developed by Davis (1989) and has been applied by many researchers to explain the acceptance of information technology or the innovative processes or services based on a technology (e.g., Gefen, Karahanna, & Straub, 2003; Wang, Lin, & Luarn, 2006; Yu, Ha, Choi, & Rho, 2005). In the model, usefulness and ease of use of the technology are the determinants of the acceptance of the technology. Those two determinants are comparable to the usefulness and convenience categories from this study. Usefulness in this study reflected the utilitarian aspects of online customization as similarly shown in the TAM. Convenience referred to consumer perception of online customization as a fast, easy, and user-friendly shopping tool. Thus, convenience in this study does not just mean easy operation of a system, but it has a broader concept. The effects of usefulness and ease of use from the TAM were tested by Cho and Fiorito (2009) who applied the model to study the acceptance of online customization for apparel shopping among female adults in the U.S. In this previous study, usefulness had a direct impact on consumers' positive attitudes, but ease of use did not. Although ease of use may be one potential component that increases the convenience perception, this current study suggested that consumers might value more the overall shopping convenience. In addition, online customization may provide benefits of positive emotions, such as fun and enjoyment. Fun/enjoyment is related to a hedonic value, which is an important factor of consumers' purchase intentions (To, Liao, & Lin, 2007). The consumer involvement level may influence the perception of these benefits in terms of the degree. Usefulness of the websites

will be the most important benefit, regardless of the level of consumer involvement. However, the perceptions of the other two benefits may vary as consumer involvement levels increase or decrease. Higher consumer involvement means the consumer should provide more information and go through a longer shopping procedure. This shopping experience may be perceived as less convenient and less enjoyable because of the feelings of the delayed and complicated shopping procedure. That is, the shopping may not be as fast and simple as the shopping for customized apparel that requires less consumer involvement. However, although the degree of the perceived benefits varies, it should be noted that convenience and fun/enjoyment can be important values at any level of online apparel customization. Therefore, in sum, online apparel customization can offer useful, convenient, and enjoyable shopping experiences to consumers. These benefits may motivate people to use or reuse online customization as a shopping method to purchase apparel.

**Why people are reluctant to customize apparel online.** From the finding, we can also discuss the potential reasons for avoiding online apparel customization. One reason that people are reluctant to use online customization is the costs. Here, costs mean psychological or physical efforts that should be invested to gain the benefits. Three of the categories among the negative perceptions represented these types of costs. One was perceived risk. In particular, this study identified the risks of products and privacy. Regarding product risks, respondents expressed their concerns about purchasing jeans through online customization. Interestingly, though, jeans were identified as the most appropriate item for customization among college students (Lee et al., 2002). A good fit is one of the most important attributes for jeans, which could be the reason for these contradictory findings. That is, customization can be a way of meeting an individual's needs (e.g., the correct fit for an individual). However, the users may not want to become involved in the shopping

procedure until they are sure of a satisfactory outcome. The privacy issue is another type of cost related to risk perception in online apparel customization. The customization procedure includes the essential data collection stage, and a high level of consumer involvement for a high level of customization means that the shopping procedure includes extensive data collection. This data collection can increase the perception of privacy risk. For example, in order to make highly customized jeans, a customer has to input extensive body measurements (e.g., waist, hip, etc.). This information collection may be uncomfortable to customers, particularly to females. In addition, e-retailers often save this information for shoppers and let them reuse it on their next visit to the site. This retained information can provide for a convenient shopping experience, but it can also increase privacy concerns. Consumers tend to be negative toward online data collection, even when their personal information is collected anonymously (Chellappa & Sin, 2005). Cho and Fiorito (2009) found that perceived security of a customization website has a significant impact on positive attitudes toward apparel customization online. In addition, this study found risk perception is higher when consumers feel the data collection is not reasonable or necessary.

Limitation is another reason consumers may be reluctant to become involved in online apparel customization. Limited design options, a lack of supporting services or information, and a lack of directions to complete the customization could become costs that increase the psychological and physical efforts involved in customization shopping. A certain level of limitation in customization is necessary to control the complexity of the shopping procedure. While this limitation can reduce customer confusion, which is often referred as a problem in customization (Huffman & Kahn, 1998), it can also cause the opposite problem. While a company may provides a certain number of colors, textures, or fabric choices, depending on their level of customization, a customer may have



difficulty finding the right design option within the choices. Similarly, when a company decides to provide only the essential support to assist customers in shopping, customers' expectations for the service could be greater.

Another costs category is related to time. This study found that consumers might be concerned about the time investment needed to customize jeans. A similar suggestion was provided by Noble and Phillips (2004), who found that consumers were unwilling to invest time to be involved in a company's customer benefit program. The customization procedure may require a longer shopping time mainly because of the information input procedure. Therefore, for some people, shopping in a traditional way is more convenient.

Next, assurance is about consumer concerns related to a lack of confidence in their choices. Moynagh and Worsley (2002) suggested that current consumers are confident in their product selections because of the knowledge they have gained through various information technologies, such as the Internet. This observation could be applied only to general shopping. In the case of shopping for customized apparel, consumers may not always be confident in their purchasing. When people are not sure what they want, choosing design details and customizing their styles is not easy and is considered work. Finally, customization websites will not be appealing to all people. One of the two major reasons these websites are unappealing is the lack of visual attractiveness in website design. The other reason is that some people may feel customization is just for people with non-standard sizes.

Parts of these cost-related factors may be perceived differently as consumer involvement levels change. In particular, higher consumer involvement may increase the perception of privacy risks because higher involvement actually means revealing more personal information. On the contrary, limited options and lack of assurance may be more serious problems for the lower levels of customization, which require less

consumer involvement. In general, the costs of online apparel customization reflect the diverse reasons why people do not want to customize apparel online. The problems of privacy issues, extensiveness of options, and assurance for the customization should gain more attention as the level of customization varies.

**Managerial Implications.** Since the benefits and costs of online apparel customization are trade-offs, marketers may be not able to eliminate the cost aspects completely. However, marketers can make the customization shopping experience more attractive when they consider the general problems consumers may face while shopping. Existing companies provide an image of the finished product, which may reduce consumer risk perception of products. Another tactic could focus on increasing the use experience of online apparel customization. For example, a free trial or half-price promotion might increase consumer traffic on the websites and the number of experienced consumers. Through experience, consumers gain confidence in their choices and feel the shopping is less risky. In addition, those customers who have experienced the shopping procedure once may take less time and have less difficulty in completing the shopping procedure at the next visit.

Although the costs are considered the negative factors, marketers should understand that some consumers may be willing to take the disadvantage of the costs to secure highly customized shopping experiences. Customization invites consumers to be involved in the production procedure. As an individual becomes more involved in the customization procedure, a higher level of customization will be expected. This higher level of customization means more benefits, but costs will also be increased. For example, customization for tailored jeans for an individual may be perceived as a useful and convenient way to purchase a personalized fit and design, but this individualized product, highly customized jeans, may require extensive consumer involvement. The procedure can be enjoyable to the individual, but it can also be a burden because

of the potential product and privacy risks, limited supporting services, consumption of time and efforts, etc. However, if a consumer feels the products from the website greatly satisfy his/her unique needs, the usefulness of the website may outweigh all negative aspects and the consumer may want to use the website continuously as a shopping destination. Thus, identifying consumers' needs for customization will determine the success of this business. A person with an irregular size may have difficulty finding the right size or fit in a market. When the usefulness of online customization is perceived positively, the shopper will be less reluctant to provide extensive personal information. Similarly, those people who have a strong desire for unique, custom items will greatly appreciate the usefulness of the websites and enjoy the shopping experience. Companies can focus on this group of people in the operation of online apparel customization.

## **FUTURE RESEARCH DIRECTIONS**

While today's market generally offers homogeneous products, customization can be a way of differentiating one company from others. Considering the shifting trend of the marketing focus to individual consumers, customization will be soon an essential part of the apparel business. An arising issue will be how to make the companies' adoption of customization more approachable and sustainable. Understanding consumers will be the first matter. This current exploratory study attempted to identify the advantages and concerns related to customizing apparel through online shopping. The advantages reflected the benefits, while some of the concerns were related to the costs to gain the benefits. This study found "what" the benefits and costs are in online apparel customization, but it did not examine "how" the benefits and costs work together. The benefits may be appealing to consumers to use customization, but the unavoidable costs may work as a hindrance. According

to exchange theory, consumers may willingly accept the costs when they feel the benefits are greater. While a previous study (Cho & Fiorito, 2009) found the effect of some of the benefits- and costs-related variables on consumer attitude to online apparel customization, further studies need to consider a greater variety of variables as implied in this study and to focus on the intervening effects of the benefits and costs.

Possible research inquiries can include which specific benefit or cost category will more significantly influence consumer behavior and how the significant perceptions will be different based on apparel items or shopping situations (e.g., shopping under time pressure). For example, risk could be a more serious issue to customization for jeans than for t-shirts. Compared to t-shirts, jeans customization may require more information of body measurements but provide a less secured outcome for the anticipation (i.e., a perfect fit). Similarly, a longer shopping procedure or a procedure that is time consuming could be a more bothersome issue for shoppers who are already under time pressures. These assumptions can be empirically tested through consumer surveys.

Additionally, the level of consumer involvement can influence the perception of online apparel customization and thus we may want to know how to balance the benefits and costs as customization levels are increased. By examining perceptions of different levels of online apparel customization that require different levels of consumer involvement, we can trace changes in the perceived benefits and costs as the consumer involvement increases; this will provide valuable information to suggest the optimal balance between benefits and costs. While this current study examined the relationships between consumer perceptions and change of consumer involvement in a qualitative approach, the relationship can be further investigated with statistics-based (e.g., Merle, Chandon, Roux, & Alizon, 2010) or mathematical modeling (e.g., Cattani, Dahan, & Schmidt, 2010) methods. Finally, we can consider cross-cultural studies to

understand cultural influences in the perceptions of online customization and the subsequent behaviors. In order to understand cultural differences and/or similarities, we need to perform further studies in diverse cultural contexts.

One limitation of this study may be the use of developed websites for the empirical study. Although the websites provided a direct experience of online apparel customization, there is the potential that the sample was not familiar with such customization sites. As the population of experienced users of online apparel customization increases, further studies may want to select these individuals as the research sample. Moreover, due to the exploratory nature of this study, sophisticated statistical methods were not employed in the analysis.

In addition to the issue of understanding consumers, companies may have other problems. One concern may be about the expenses to adopt customization. In addition to the initial costs, companies will need to continue spending to maintain the business of customized offerings. Therefore, the price of customized apparel is usually higher than that of regular products. As consumers may be willing to take risks to enjoy the advantages, they may be willing to pay higher price for the benefits. Companies may choose the maximum price they can offer to make profits or they may decide to keep a moderately high price level until the market is fully matured. While the first approach may reduce consumer interest in purchasing customized apparel, the latter can impact companies' finances. Another problem may be with returned items. Since an item is initially customized for an individual, there may be limitations on liquidating it if it is returned. These issues will be challenges to companies and further studies should concentrate on the development of sustainable strategies from the companies' perspectives.

## CONCLUSION

Adoption of online customization provides a strategic advantage to online apparel companies that want to move forward in a competitive environment. This study found various consumer perceptions of online customization for apparel shopping and suggested the reasons for why people are attracted to or avoid online apparel customization. While online customization may be an attractive shopping method for apparel consumers, unfavorable factors that hinder consumer acceptance also exist. The marketing focus is shifting to individuals, and customization can provide more opportunities for e-retailers. In order to be successful in the business, however, marketers need to understand how consumers perceive online customization so that they cultivate positive consumer intentions and find ways to overcome challenges. This topic opens rich research opportunities in academics.

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## **KEY TERMS AND DEFINITIONS**

**Apparel Customization:** Creation of apparel based on consumer involvement in the apparel production process.

**Consumer Involvement:** Participation by the consumer in the value production process.

**Co-Production:** Simultaneous customer and company involvement in production.

**Online Customization:** E-retailers' offerings to meet the needs and wants of individuals.

**Perceived Benefits:** Perceived rewards expected by engaging in a relationship.

**Perceived Costs:** Perceived psychological/physical efforts to be invested to gain the benefits in a relationship.

**Technology Acceptance Model (TAM):** A model developed by Davis (1989) and applied by subsequent researchers to explain the acceptance of information technology or innovative processes or services based on a technology.

# Chapter 17

## RFID Technology in the Fashion Supply Chain: An Exploratory Analysis

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### ABSTRACT

*Radio Frequency Identification (RFID) is a new technology that has received considerable attention from academics and practitioners due to its large scope of application, advantages and potentialities. This chapter aims to highlight the potentialities associated with RFID in fast moving Fashion Supply Chain Management (FSCM). The research emphasizes the technological contribution to the Fashion Supply Chain (FSC) such as speed up logistics activities, increased quality, reduced prices, and more responsive improvements for customer satisfaction. The chapter reviews the RFID technology, presents the benefits, disadvantages, and barriers associated with it. To explore the deployment of the RFID technology in the Fashion Supply Chain (FSC), a case study investigation of companies in different FSCM nodes was carried out. A cross-case analysis it is also presented to achieve a deeper understanding about this technology in a fast moving FSCM context.*

### INTRODUCTION

The Radio Frequency Identification (RFID) is the generic name of technologies that use radio waves (Jones, Clarke-Hill, & Hiller, 2005) for automatic identification of objects, positions or persons through electromagnet reception in con-

siderable distances” (So & Liu, 2006). Therefore, RFID is an automatic identification technology, which identifies and gathers data on items without human intervention or data entry (Wyld, 2006).

Although commercial applications of RFID date back to the 1960s, the use of RFID in supply chain management is relatively new. The RFID applications are diverse and are growing in various

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sectors for different purposes. In Europe and USA, RFID has been adopted by some major retailers. In 2003, the world's leading retailers, including Metro Group in Germany, Marks & Spencer in the UK, and Wal-Mart in the USA, mandated the use of RFID in tracking supplies (Cover Pages, 2003; Roberti, 2003). Since then, many other retailers in the world have announced adoption plans, including Tesco in the UK, Coles Myer in Australia and Mitsukoshi in Japan (Roussos, 2006). The rapid increase in the number of RFID users suggests a major research opportunity in the retail industry (Sethuraman & Parasuraman, 2005). This technology it is now at a stage, in which there are potentially larger benefits for a wider application, yet barriers remain including a necessary policy framework for enhancing business and consumer benefits while effectively addressing security and privacy issues (OECD, 2006).

The RFID has improved many processes in the supply chain such as handling materials with better efficiency, management of assets more effectively and improving products availability (Reyes & Jaska, 2006). The tracking of items (e.g. assets, containers, reusable bins) has become automated by the extensive use of RFID throughout the supply chain (Tajima, 2007).

The value of RFID technology is particularly visible in fast moving Fashion Supply Chains (FSC's), as the fashion business is characterized by a wide assortment of products, short life-cycles, high seasonality, high volatility, high-impulse purchasing and complicated distribution and logistics operations (Christopher, Lawson, & Peck, 2004). Peterson, Chang, Wong and Lawrence (2010) used the term "fast fashion" to describe a new business model where the tendencies are fresh products, shorter life cycles and faster production. This business model puts significant pressure for rapid delivery, high quality products, and low prices for each supply chain segment. In the highly competitive retail environment, the availability for a certain product category (or a specific item) is a relevant source of value to customers, since

there are huge penalties due to out of stock of the current season "must-have" advertised items (Brun & Castelli, 2008). To respond to customer needs, "time compression" and flexibility should be developed along the whole supply chain. Castelli and Brun (2010) also stress the need to align operations of different FSC members along the supply chain to enhance information exchange, through the use of new communication tools and process coordination practices. Despite the potential value of RFID technology in FSCM, Loebbecke (2007) stress that 'the actual examination of the influences and impacts of RFID has been less well documented.' Moreover, prior works does not have a holist perspective of the RFID deployment in FSC, only provide some insights about particular issues of RFID deployment in FSC, like, potential benefits (Kwok & Wu, 2009), implementation issues (Kwok & Wu, 2009; Loebbecke, 2007), RFID technology economic value (Bottani, Ferretti, Montanari, & Rizz, 2009), cost-benefit sharing issues (Bensel, Gunther, Tribowski, & Vogeler, 2008) or do it only at the retailer level (Moon & Ngai, 2008). The present work objective is to present a holistic perspective on RFID value in FSC using empirical examples from case studies related to the RFID deployment by companies belonging to FSC.

This Chapter aims to explore the deployment of RFID technology in fast moving Fashion Supply Chain Management (FSCM). It intends to investigate the real benefits, disadvantages and barriers felt by companies belonging to a fast moving FSC with the RFID technology deployment.

The chapter is organized as follows: an introduction to RFID with a brief explanation of the main characteristics of technology is presented, and then the benefits, disadvantages and barriers associated to the RFID deployment in supply chain are illustrated. After this, a deeper analysis on the RFID deployment in FSC logistics activities is described, followed by a case studies section to demonstrate the RFID deployment in fast moving

FSCM. Finally some discussion and conclusions are drawn.

## **BACKGROUND**

### **The RFID Technology Characterization**

RFID technology can be expressed as a wireless identification method, which does not require visual contact in order to be read or written. It improves communication capabilities of electronic information associated with physical items (Modrak, Knuth & Novak-Marc, 2010). This technology is composed by several elements: readers, tags, software, and security programs for the readers (Atkinson, 2004a). Tags can be classified into active and passive. Active tags use a small battery, a microchip and a small antenna built into them. Active tags with a read/write range have a longer frequency, while passive tags have shorter range. Antennas are used in tags and readers, having a diverse range of forms and technical factors. Readers are available in four types: handheld, vehicle-mount, post-mount, and hybrid (Meyerson, 2007). The first three are dedicated to reading active or passive tags. The fourth type has the active/passive mode allowing it to switch from the passive to active mode and vice versa.

The technology works by attaching an RFID tag to the item to be tracked. Each tag has a unique identification and a small radio transmitter. The tag informs RFID radio receivers within range of the unique identifier. Readers read or interrogate the tags. In reading, the signal is sent out continually by the (active) tag whereas in interrogation, the reader sends a signal to the tag. To read passive tags, the reader sends radio waves to them, which energise them and start broadcasting their data (Azevedo and Ferreira, 2009b). The reader reads all the tags within its read range in a quick succession. This automatic process reduces read times. In a field test, Marks & Spencer, UK,

tagged 3,5 million bins with RFID tags. While it is necessary 17,4 minutes to read 25 trays with bar codes on 36 dollies, RFID reduced the reading time to just three minutes, representing an 83 percent reduction in reading time for each tagged dolly (Wilding & Delgado, 2004).

### **Benefits, Disadvantages and Barriers Associated with RFID Deployment in Supply Chain Context**

There is a high investment in RFID systems development and improvement because of the important advantages that companies and supply chains can reach with it when compared to barcode tags. These advantages derive from the identification process automation, elimination of manual work to scan items and the continuous updating of data. This last factor it is important to provide a comprehensive inventory visibility throughout the entire supply chain (Derakhshan et al., 2007). Therefore the tagged items that are moving around a business can be monitored from supplier warehouse to the shelves. This comprehensive view of the supply chain allows businesses to trim inventory, streamline logistics, and optimize the efficiency of their workforces reaching by this way important competitive advantages (Lee et al., 2005).

Gaukler and Seifert (2007) explain that the RFID economies are fundamentally different from the economies of bar-coding: with barcodes, the label cost is low, but the incremental cost of each scan is high, since it typically involves human labour and material flow stoppages; with the RFID technology, the tag and system cost is high, but positive returns are obtained from the continuous material flow.

RFID could become an important source of competitive advantage in the logistics field. The system presents the ability for rigorous and simultaneous reading with increased data capacity contributing to efficiency improvements in material movement (So & Liu, 2006). For example,

efficiency improvements in loading and unloading of cargo can be reached, since warehouse operators do not need to manipulate optical readers to collect data about the products that are being loaded or unloaded.

RFID tags are read via radio frequencies therefore it is not mandatory to place the items in a particular position to read it. This could be helpful for effective warehouse management. Also the RFID-tagged products allow stores to track locations and count inventories in real time. This will better monitor demand for certain products supporting automatically orders to prevent an out-of-stock situation (Lager, 2005). On the retailing side, RFID technology at the point-of-sale (POS) can be used to monitor demand trends or to build a probabilistic pattern of demand (Kim & Gariso, 2010). This application could be useful for apparel industry which exhibits high levels of dynamism in trends. If RFID systems are used for information collection, accurate and real time information on product sale can be captured and used for decision making. This will also help to reduce overall bullwhip effect. So, RFID systems gives a total visibility of product movement in the supply chain (Chang *et al.*, 2010). This may help to make early decisions about inventory management in case there is any interruption in materials supply.

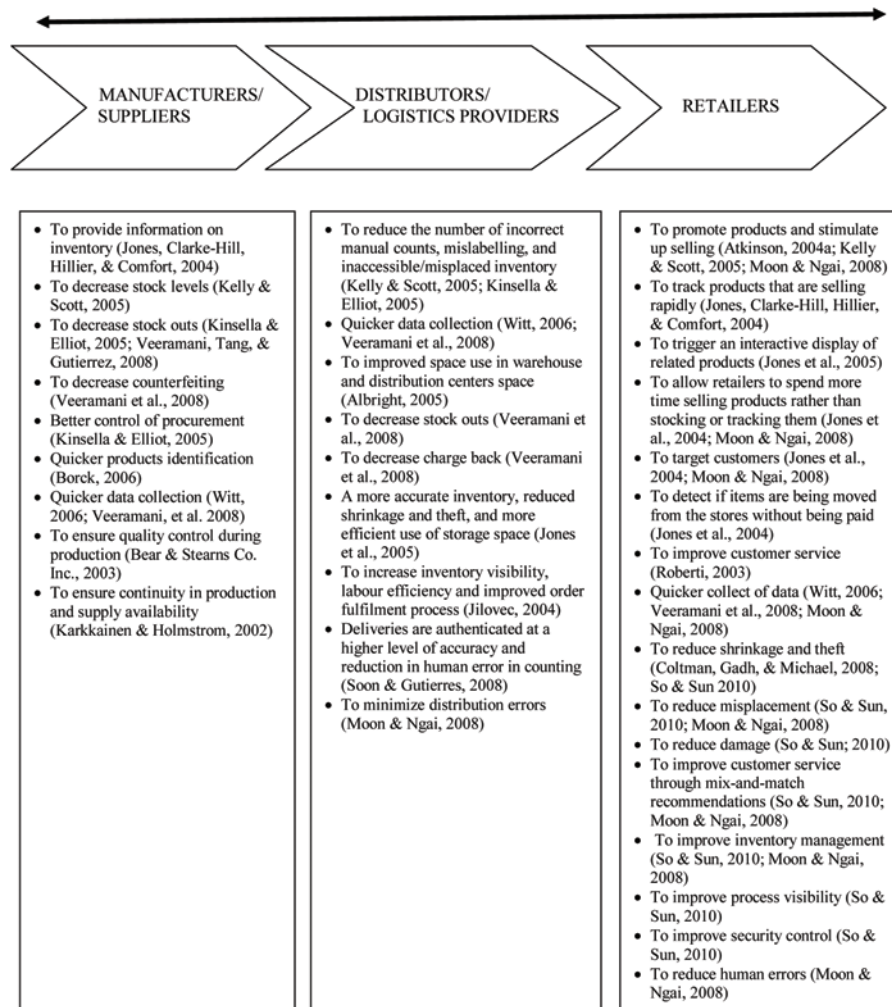
Moreover, this technology allows collecting information from objects in movement (Knill, 2002; Bange, 2006), creating visibility on material flows and a better coordination between supply chain entities. To Gaukler and Seifert (2007) the main advantages resulting from the RFID deployment in supply chains are associated to labour and time savings and also to benefits from increased visibility. Besides these benefits others are identified in Figure 1.

As observed, the RFID technology application in a supply chain context brings many benefits for optimisation and efficiency. However, the RFID system implementation also brings some

disadvantages. Kapoor, Zhou and Piramuthu (2009) had identified technical issues (e.g. privacy and security violations, computer systems bottleneck, and read error) and economic issues (e.g. cost and obsolescence) that RFID implementations in supply chain management must overcome. Figure 2 contains the main disadvantages of RFID deployment in the supply chain.

Besides these disadvantages, there are some potential obstacles related to the deployment of this new technology. Firstly, it involves a big investment (Borck, 2006) and the return of this is only recovered in the long term (Kinsella & Elliot, 2005). According to Trunick and Williams (2005), this type of technology presents a great level of obsolescence and innovation, therefore if a short return-on-investment (ROI) is verified less motivated will be the companies to invest in the RFID. The high costs, the lack of standardisation and know-how are some of the obstacles referred by companies for not using the RFID technology (Albright, 2005). Given that RFID technology is deployed across the company's boundaries and goes out to others supply chain partners, the cultural and behavioural barriers also play an important role. Kapoor, Zhou and Piramuthu (2009) referred security and trust issues, because when RFID tags are embedded in the sold item, the previous owner can indefinitely maintain radio-frequency item-level access to it. Trust, commitment, information transparency and focusing on the overall supply chain represents special challenges for managers (Spekman and Sweeney, 2006). These critical issues can be overcome by implementing effective collaboration practices among supply chain members. According to Spekman and Sweeney (2006) the RFID deployment is as effective as the level of collaboration achieved across the full supply chain. The following factors in Figure 3 are frequently cited as barriers for a widespread RFID deployment.

*Figure 1. RFID benefits across the supply chain*



**RFID IN Fashion Supply Chain Logistics Activities**

The fashion industry is characterized by a high level of competitiveness and market turbulence. It consists of notoriously labour-intensive multi-faceted processes with relative technological simplicity (Azuma, Fernie, & Higashi, 2009). The goal of supply chain management in the fast moving fashion industry is delivering the fashion trends at the right time in the right place, with increased variety, affordability and customization,

thus satisfying both the existing and the potential customers needs (Azuma et al., 2009).

To maintain competitiveness in the global market, fast moving fashion manufacturers should increase the speed in delivering new products to customers and in responding to market changes, using approaches and tools to automate logistics processes (thus reducing the time to market) and improving the information availability (Bottani et al., 2009). Additionally the FSC members have to deal with the following product characteristics (Christopher et al., 2004): i) short life cycles; ii) high volatility; iii) low predictability; and iv) high

Figure 2. Disadvantages of the RFID in a supply chain context

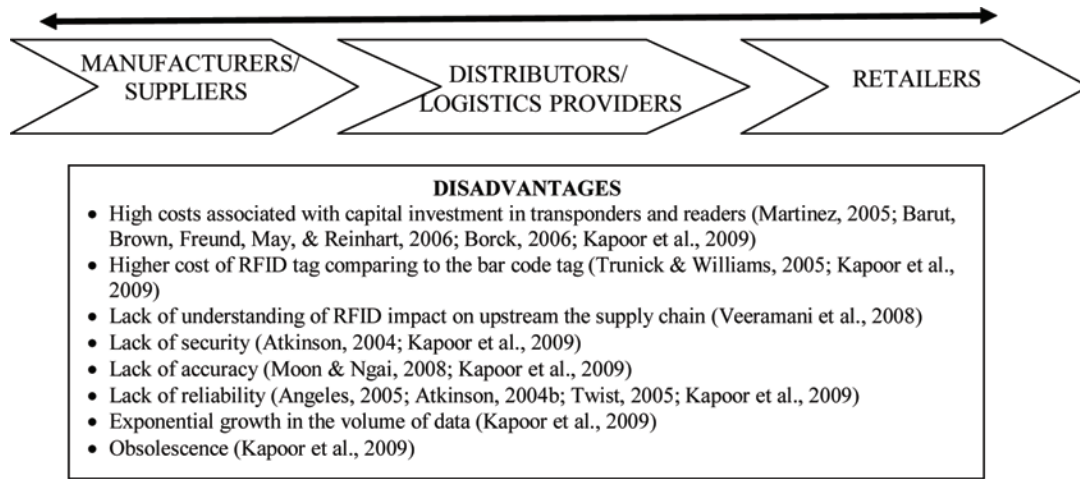
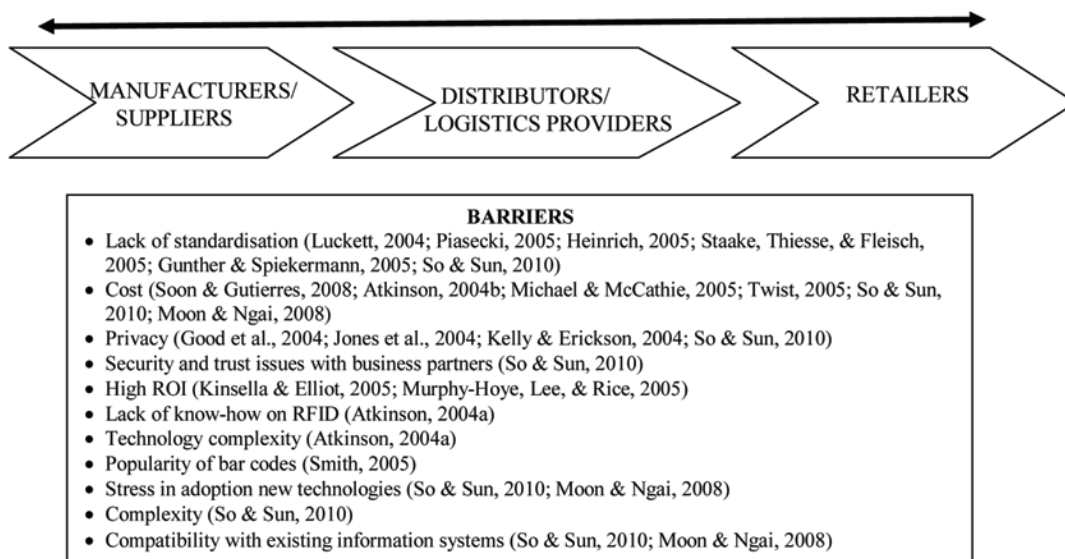


Figure 3. Barriers to the RFID deployment



impulse purchasing. These FSC characteristics and markets requirements have been considered as enablers to the RFID technology employment in this sector. Through real time data generation RFID provides capabilities to track and trace items and consequently to improve the efficiency of many activities along the FSC. The availability of real time data related to inventory levels also allows a better inventory management and con-

sequently a decrease on related costs. Forward the supply chain, the real data gathered from the end customers using, for example a RFID-based customer cards, enables retailers to record the consumer buying behaviour, interact with products and make purchase decisions (Moon and Ngai, 2008). So, the RFID deployment at the end of the supply chain contributes to improve its responsiveness to new tastes, needs and customers

requirements (Reynolds et al. 2006). Additionally, it makes possible to use a pull strategy among all the FSCM partners not only to speed the products delivery to the stores but also to adopt a products customization strategy.

The RFID deployment in FSC enables the access to real time item information anywhere along the network supporting the supply chain management objectives in this challenging context.

Hinkka, Rahkonen, Holmström and Främling (2010) also discuss the FSC characteristics that makes adequate the RFID utilization. First, the product variety is high and consequently the workers have difficulties to quickly differentiate and identify items of different sizes and models.

Another issue in FSC is the different needs of each supply chain member. The fast moving fashion retailers face the challenge of adapting quickly and frequently to keep up with product changes and buying trends to meet customer needs (Bottani et al., 2009). From the manufacture point of view, since fast moving fashion items product life cycle is very short, it is vital to ensure that the product is delivered to the stores as quickly as possible (Bottani et al., 2009). In this regard, the RFID capability to track and trace items, can streamline many activities along the supply chain. However, Hinkka et al. (2010) state that RFID solutions are mainly designed for retailers' purposes even though the same tag could be used upstream in the supply chain. If the tag is attached early in the manufacturing phase, other supply chain members can also make use of these tags, increasing supply chain visibility and potentially reduces handling errors and confusions.

However the RFID technology deployment in fast moving FSCM is not limited to items tracking applications. So and Sun (2010) refer that the next step in the RFID technology in FSC is to combine RFID tags with other pervasive computing technologies to realise ambient intelligence (AmI) in real life. AmI is developed to enrich people's lives and enhance customer experience in shopping and commerce, it involves integrat-

ing tiny microelectronic processors and sensors into everyday objects to make them smart. One of the latest smart AmI applications in retail is the intelligent mix-and-match of clothing items. This application helps users to choose desired colours and patterns that most closely resemble the style that one would like to portray, while on the other hand, it helps fast moving fashion retailers to manage more efficiently the product items in the stores and inventory in the back store. Ambient Intelligence includes also aspects of Human Computer Interaction and Artificial Intelligence. The designer label Prada made tests with an RFID based sales and promotion application in its flagship store, in order to increase the shopping experience and customer consultation (Reda, 2004).

### **Logistics Activities in Fashion Supply Chain**

The FSC covers different stages from the raw materials manufactures (e.g. cotton), accessories manufactures (e.g. zippers), textile manufactures, garment manufactures, distribution and fashion retailers. To reduce operations cost supply chains are extending across countries, and even continents, with productions facilities located in different geographic regions. This globalisation trend creates the need for data accuracy enhancement and visibility for real-time information at each FSC stage, especially for some partners located in other parts of the world (Kwok & Wu, 2009). Despite the RFID technology seems to be more suitable to supporting the garments logistics activities, it has great impacts when deployed in the whole supply chain. Gaukler and Seifert (2007) discuss the usefulness of RFID in logistics activities across the supply chain, namely in reducing the bottlenecks, enabling a faster and less costly product movement, and in improving inventory accuracy. There are benefits if the supply chain members have access to real-time information on how products are moving, increasing the supply

chain visibility and coordination. Kwok and Wu (2009) also discusses that RFID helps partners to collect real-time data at each point-of-sale. Being effective in visualizing actual sales of new collections and predict market trends, it supports overall lead time reductions and it increases supply chain responsiveness. The RFID deployment in FSCM is expected also to increase the efficiency, effectiveness and accuracy along the chain.

At the upstream level, Gaukler and Seifert (2007) referred that assembly and manufacturing are activities that could benefit from the use of RFID: tags can be used in a manufacturing setting to identify the product that is being assembled, as well as the component parts that will be installed into the product, allowing savings in labour cost and rework cost (due to fewer assembler errors). The RFID benefits may also be realised in the activities of receiving shipments, goods issue as well as in picking and packing processes (Bensel et al., 2008). In transportation and warehousing, the RFID deployment enables primary efficiency improvements through less labour, higher accuracy and higher performance.

Also, in retailing improvements in on-shelf availability of goods are expected through redesigning the shelf replenishment process, creating transparency on the actual inventory in store and improving the inventory control (Bensel et al., 2008). Moon and Ngai (2008) explained that the use of RFID technology in retail can streamline stocktaking operations, strengthen customer relationships, facilitating promotional activities and allowing retailers to allocate resources more effectively.

However, these benefits are dependent on the supply chain level where the RFID tags could be attached and the places where tracking can start. Hinkka et al. (2010) propose a framework to analyse four different options to attach RFID tags and start tracking: i) in the retailer's facilities, ii) outgoing from the distribution center (DC); iii)

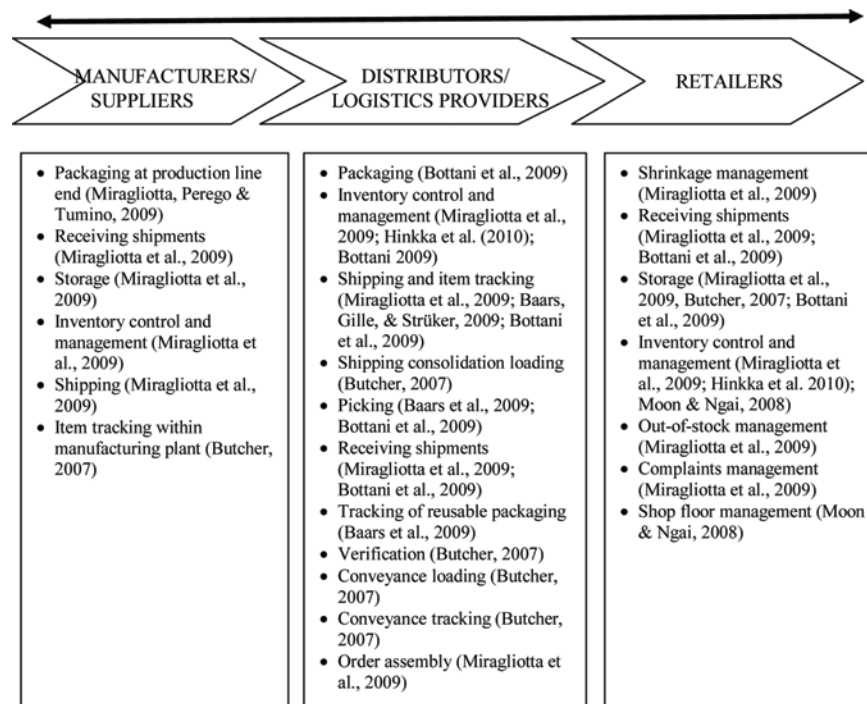
incoming to the DC; and iv) in the manufacturing phase. These tracking options will condition the logistics activities and entities involved in the RFID deployment. Figure 4 illustrates the logistics activities considered in the RFID deployment along the supply chain members.

As illustrated in Figure 4 in a multi-echelon FSC, the players engage in such different functions that the potential benefits of RFID deployment will not be distributed equally among all members (Bensel et al. 2008). Manufacturers are generally most interested in tracking cases or pallets of their products via the transportation channel up to the retail, whereas retailers typically gain most benefit from individual product tracking on their shelves (Gaukler and Seifert, 2007). Therefore, the retailer seeks for item level tagging to achieve maximum benefits, but this is the more costly solution for the manufacturer who needs to put on the tags. In this way, upstream suppliers generally feel they are transferring the benefits to their retail customers since they have a limited sense of how to take advantage of RFID within their own processes (Miragliotta et al. 2009). To overcome this situation Bensel et al. (2008) propose a compensation system where different measures can be applied namely financial payments, tangible and intangible measures.

## **CASE STUDIES**

The main objective of this section is to illustrate the RFID deployment in FSCM. To attain this, a set of illustrative case studies, from companies belonging to different nodes of fast moving FSC's, is analysed. The two criteria used to choose the companies to make part of this research were: first to belong to a fast moving FSC and second to deploy the RFID technology. The case studies are composed by three companies representing a second tier (manufacturers), one first tier (dis-

*Figure 4. Logistics activities considered in the RFID deployment in FSCM*



tributor/logistics providers) and also four focal companies (fashion retailers). The experience of these companies in deploying the RFID system is reviewed to identify: main architectural characteristics of the RFID system used, benefits, disadvantages, and barriers found during the RFID implementation.

Data for this research study was gathered from secondary data analysis of published literature based on a broad range of sources including newspapers, conference proceedings, industry reports, white papers, press releases and books. Electronic searches of journal databases including Emerald, EBSCO, Proquest, and ScienceDirect were also undertaken. In addition, specialized magazines on RFID, such as RFID Journal and Logistics Today were used. Selected articles describing case studies were also analyzed. Selected aspects are briefly described in the form of a table by focusing on benefits and disadvantages and also barriers of RFID technology application in FSCM.

### **Case Studies Profile**

In this section the main characteristics of the case studies are presented. As the references given in Table 1 indicate, all 8 cases are already published in detail. Hence, the objective is not to offer further insight into the single cases, but to bring them together to get a wider picture and learn from the cross-case analyses. To represent the manufacturing companies, the VF Corporation, the Lawsgroup, and the Gerry Weber were analyzed. To represent a logistics provider the Jobstl Warehousing & Fashion was analyzed. To represent fashion retailers, the Charles Vogele Group, the Trottlemann, the Kaufhof and the American apparel companies were chosen. In the Table 1 the research companies profile is presented.

As showed in Table 1 this study focused in companies that are based on different continents and in different countries. This makes possible a widespread comparison and a better understand-



Table 1. Companies Profile

	Company	Reference	Based	No. of Employees	Brands	Infrastructures
Manufacturers/Suppliers	VF Corporation	Collins (2004) Jackson (2006)	USA	44,000	Lee, Wrangler, Nautica, Eastpak and The North Face	50 U.S. distribution centers, 1,000 owned/contracted factories
	Lawsgroup	O'Connor (2006) Law (2006)	Hong Kong	18,000	Gap, Old Navy and J.C. Penney	15 production sites, in Asia
	Gerry Weber	Bensel et al. (2008) Loebbecke (2007)	German	2,160	Gerry Weber, Taifun-Collection and Samoon	Several production facilities, 340 houses of Gerry Weber, over 1,480 shop-inshop areas throughout the world and successful online shops.
Distributor/Logistics Provider	Jöbstl Warehousing & Fashion	WhereNet Corp (2007) Swedberg (2006)	Austria	150	Charles Vögele Group (Vögele)	A warehouse space of more than 60,000 m <sup>2</sup> and a fleet of 40 trucks for distribution in Austria, Slovenia, the Czech Republic, the Slovak Republic, Croatia, Hungary and Romania.
Fashion Retailers	Charles Vögele Group	Swedberg (2009)	Switzerland	7,800	Vögele, plus a selection of brands	851 stores throughout Europe, including Switzerland, as well as Poland, Germany and the Czech Republic
	Kaufhof	Loebbecke (2007) Loebbecke and Huyskens (2008)	German	19,000	Kaufhof	145 stores
	Trottleman	TAGSYS (2007)	Portugal	201-500	Throttleman	113 stores in Portugal and 3 in Spain
	American Apparel	Microsoft (2009)	USA	10,000	American Apparel	260 stores in North America, Europe, and Asia.

ing of the RFID deployment in fast moving FSC around the world.

### RFID' Architectural Characteristics

As point out in the section 2 there are many different architectural characteristics that the RFID technology could adopt. A brief description of the ones deployed by the focused case studies is shown in Table 2.

As can be seen in Table 2 besides the technology to be the same (this is, RFID), the architectural characteristics are little different according to the kind of product, organization position in the supply chain and also expected objectives to reach with its deployment.

### RFID Deployment in FSC Logistics Activities

In the world of fast moving fashion retailing, the start up processes of a collection increasingly assumes a determinant role in what concerns the determination of invoicing. When the number of pieces begin to increase, it is indispensable that companies find new forms to allow their processes to become more agile in order to avoid delays of orders reception and bottlenecks in the launch phase of a collection. This is possible through the supply chain members' synchronization by the deployment of the RFID technology. In the research case studies several factors are highlighted as main enablers for the RFID deployment: from the necessity to meet RFID shipping mandates

*Table 2. Architectural Characteristics of the RFID deployment*

	<i>Company</i>	<i>RFID' Architectural Characteristics</i>
<b>Manufacturers/Suppliers</b>	VF Corporation	<ul style="list-style-type: none"> <li>• 5 million tags used annually</li> <li>• To deploy two to four RFID readers at each of its distribution centers during the next few years</li> <li>• Multiple reads per carton on conveyors moving up to 300 feet/ minute</li> <li>• Strategic migration to item level tagging</li> </ul>
	Lawsgroup	<ul style="list-style-type: none"> <li>• High-frequency tags</li> <li>• Interrogators are located at each workstation to read the smart cards, and also scan a smart card assigned to each worker as an ID badge</li> <li>• IT department developed the RFID system in-house and has integrated it with its Enterprise Resource Planning (ERP) system</li> </ul>
	Gerry Weber	<ul style="list-style-type: none"> <li>• RFID is used to track all tagged objects on their way to two dedicated department stores via a distribution center</li> <li>• All sites involved, including the stores, are equipped with mobile or stationary RFID readers.</li> <li>• Reusable tags which combine UHF EPC gen 2 transponder with EAS (Electronic Article Surveillance) functionality are use to track the merchandise into the stores where the tag will be removed at the check-out</li> </ul>
<b>Distributor/ Logistics Provider</b>	Jobstl Warehousing & Fashion	<ul style="list-style-type: none"> <li>• A hybrid solution that uses automated real-time locating system to data in local areas such as warehouses and customer sites, and semiautomatic wide area “on the road” event notification to ensure complete, closed-loop supply chain visibility</li> <li>• The solution consists of active RFID tags transmitters attached to every container in the fleet; magnetic “exciters” positioned at client dock doors; and a local infrastructure of wireless sensors covering more than 20,000 square meters</li> </ul>
<b>Fashion Retailers</b>	Charles Vogele Group	<ul style="list-style-type: none"> <li>• At the stores are installed Checkpoint’s RFID readers on shelves (to track which items are available in the store front), as well as in fitting room (to monitor how many items customers bring in with them, and how many are purchased)</li> </ul>
	Throttleman	<ul style="list-style-type: none"> <li>• The garments with the RFID tags attached are packed in boxes and shipped from the manufacturer in India to the Distribution Center (DC) in Portugal</li> <li>• When the boxed garments arrive at DC are placed on a conveyor and sent through the tunnel interrogator that captures the tag ID numbers with an accuracy of 99.9 percent, and sends that data through a wired LAN connection to the retailer’s software system. The software then matches those numbers with the advance shipping notice, confirming that the correct items have been received.</li> <li>• Actually the Throttleman uses the Smart labels in 80 percent of its collection</li> </ul>
	American Apparel	<ul style="list-style-type: none"> <li>• The RFID will be deployed from the company’s manufacturing facility to all 31 of its retail locations in North America</li> <li>• The solution consists of four RFID reading stations at each of the stores, along with hardware including RFID scanners and fixed scanners</li> </ul>
	Kaufhof	<ul style="list-style-type: none"> <li>• A system high frequency for RFID at the unit and item level was selected</li> <li>• A combination of the standardized European Article Number (EAN) and proprietary product codes is used</li> <li>• The frequency range of 13.56MHz is used for logistic units and items</li> <li>• Credit card sized RFID transponders and readers were used at a reading range of approximately 1.5 meters</li> </ul>

from customers (VF Corporation), improvement of quality and logistics efficiency, and also, information quality (Gerry Weber), to the replacement of manual data-capture processes (Lawsgroup).

The RFID technology has been deployed in different ways and contexts. With regard to the case studies focused in this research, it has been used in a wide variety of logistics activities (Table

3). Although the tagging process can be made in different phases (pick-and-pack process of assembling orders, production and transportation), the majority of the case studies refers the tag attachment in garment production process. Also, the tags are read mainly at the distribution centers and stores levels.

Table 3. RFID deployment in FSC logistics activities

		Manufacturers/Suppliers			Distributors/ Logistics providers	Retailers			
		VF Corporation	Lawsgroup	Gerry Weber	Jöbstl Warehousing & Fashion	Charles Vögele Group	Kaufhof	Trottleman	American Apparel
Logistics activities	Packing operations	X							
	Shipping operations	X						X	
	Tracking of raw materials, semi-finished components and finished garments		X						
	Collect the finished goods		X						
	Handling process			X					
	Tracking containers					X			
	Tracking products from factory to store					X			
	Receiving operations						X	X	
	Monitoring, and sorting of merchandise						X		
	Inventory replenishment								X
Tag attachment	Pick-and-pack process of assembling orders	X							
	Production		X	X				X	X
	Transportation				X				
Tag Reading	Production		X						
	Distribution center	X		X	X			X	
	Stores			X		X		X	X

### Benefits of the RFID Deployment in FSC

Regarding the benefits associated to the RFID technology, as can be seen in the Table 4, the one recognized by almost all companies is the internal inventory control which is closely associated with stock outs minimisation. This benefit is pointed out by all the manufacturers companies and almost all the fashion retailers. This benefit was recognized as the most visible and important, because as known an effective inventory management depends upon consolidating, integrating, and analyzing data col-

lected from many sources such as, manufacturers, distribution centers and warehouses. Conventional tracking systems require manual intervention, which is labor intensive, time consuming and error-prone. On the other hand, the use of RFID technology has significant advantages over the conventional methods. In a replenishment-based system, whenever the total inventory at a warehouse or distribution center drops below a certain level, the RFID enabled system could place an automatic order. In warehouse, the sorting/picking is the most time consuming and subjected to errors activity. RFID systems ease the sorting and

**RFID Technology in the Fashion Supply Chain**

*Table 4. Benefits of the RFID in FSCM*

		<i>Manufacturers/Suppliers</i>			<i>Distributors/Logistics providers</i>	<i>Fashion retailers</i>			
		VF Corporation	Lawsgroup	Gerry Weber	Jöbstl Warehousing & Fashion	Charles Vögele Group	Kaufhof	Trottleman	American Apparel
<i>Benefits</i>	Cost savings	X		X	X			X	X
	Error reduction	X				X			
	Internal inventory control (less stock outs)	X	X	X		X	X	X	
	To reduce shrinkage						X		X
	To reduce lead time		X	X	X		X	X	
	To increase visibility		X	X	X	X			
	Responsiveness		X					X	
	Raw material control		X						
	Production status		X						
	Traceability		X						
	Delivery quality			X					
	Flexibility			X					
	Workflow improvement				X				
	Reduced inventory				X				
	Enhanced customer service				X		X		
	Shorter order-to-cash cycle times				X				
	Employee satisfaction				X				
	Inventory-related labor					X	X		X
	Improve shelf management						X	X	
	Increasing sales							X	X
Reduce the time spent in counting inventory					X	X			

picking operations, as it captures real time, accurate information about product availability in host computer database without physical movement.

This same benefit could be found in the Figure 1 but with different designations: “to decrease

stock levels”, “to decrease stock outs” and “to improve inventory management”. Combating stock outs is one of the key perceived benefits of using RFID. Retailers and their suppliers forfeit billions every year losing sales when customers

are unable to buy a desired product because it is out of stock; it also drives business to competitors and deteriorates customer satisfaction overall. The RFID deployment allows tracking automatically garments' locations, assisting the garment expedition to retailers avoiding out-of-stocks; also retailers can order items electronically. In Charles Vögele case study the RFID deployment allows to reduce stock-outs and the amount of time spent cutting inventory by 50 percent.

The logistics provider (Jöbstl Warehousing & Fashion) does not refer the benefits related to stock-out reduction, maybe because it does not make part of its preoccupations, but of their customers.

Another benefit that deserves a special highlight is the cost savings. Besides the high cost of investment needed and some doubts about its ROI, the RFID technology makes possible to attain a considerable cost savings. The Jöbstl Warehousing & Fashion recognises a 20 percent cost savings resulting from increased container utilization after the RFID deployment (WhereNet Corp, 2007). American Apparel reduced also costs spent on handling inventory by 35 percent (Microsoft 2009).

Other benefits described include: reduced lead time and increased visibility. The case of Throttleman could be analysed to illustrate deeply the lead time reduction. The Portuguese fashion retailer has reduced the time items spend in the supply chain by seven to five days. A quick identification of items as they arrive from the manufacturer in India ensures that the right items are shipped to its stores in Portugal and Spain. After the deployment of this solution, the lead time has been significantly reduced. Before this, the average of this indicator was 4,97 days and after RFID deployment it reached an improvement to less than 24 hours (Azevedo & Ferreira, 2009a).

Also, increased visibility was attributed to the RFID deployment by logistics providers, specially the one associated to inventory (Figure

1). The reduction in lead times was identified in the literature but indirectly through the "Quicker collect of data". In this research, although only one logistics provider is analysed, this company was the one that identify more benefits associated to the RFID deployment.

### **Barriers and Disadvantages of the RFID Deployment in FSC**

Beyond the set of benefits associated to RFID technology, some disadvantages and barriers have also been pointed out (Table 5). The main disadvantage attributed to the RFID technology is its cost. The cost associated to the RFID deployment is one of the most critical concerns for managers and its estimation requires a detailed investigation on the individual cost components related with it. According to Lee and Lee (2010) there are five cost categories related to a RFID deployment: hardware (e.g., tags, readers, printers, and network infrastructure), software (e.g., middleware, labeling/automation equipment), development (e.g., testing, installation, and communication), training (initial training, certification), and services (initial consulting, implementation services). These cost categories are further divided into initial investment costs and recurring costs. The cost of individual RFID components varies, depending on the complexity of technological features. For example, the cost of tags is usually based on the volume, the amount of tag memory and the packaging of the tag. However it is important to note that the tags can be reusable which makes possible to spread their costs over the time and to minimize this initial barrier (Thiesse et al., 2009). In the Throttleman case, the investment in the entire project RFID was relatively low; however the big cost was associated to the tags, as their costs are four times more than the traditional bar codes (Azevedo & Ferreira, 2009b). The system cost as disadvantage is also signed up by the fashion manufacturer Gerry Weber, the distributor/logistics provider (Jöbstl Warehousing & Fashion) and

also by the retailer American Apparel. The tags' cost is recognized as an important disadvantage by the VF Corporation, the Jöbstl Warehousing & Fashion, the Gerry Weber, the Kaufhof, and also by the Throttleman.

Many companies are not deploying the RFID technology due to the associated disadvantages previously outlined. Furthermore, barriers exist which inhibit its widespread use. Among the barriers identified in the Table 5, the integration with current processes, that is its interoperability, it is the one recognized by four of the analysed companies. In almost of the cases, the introduction of this technology requires a processes reengineering in an attempt to maximize the potentialities of the

technology. Sometimes this is not well viewed by companies in general and by employees in particular.

**FUTURE RESEARCH DIRECTIONS**

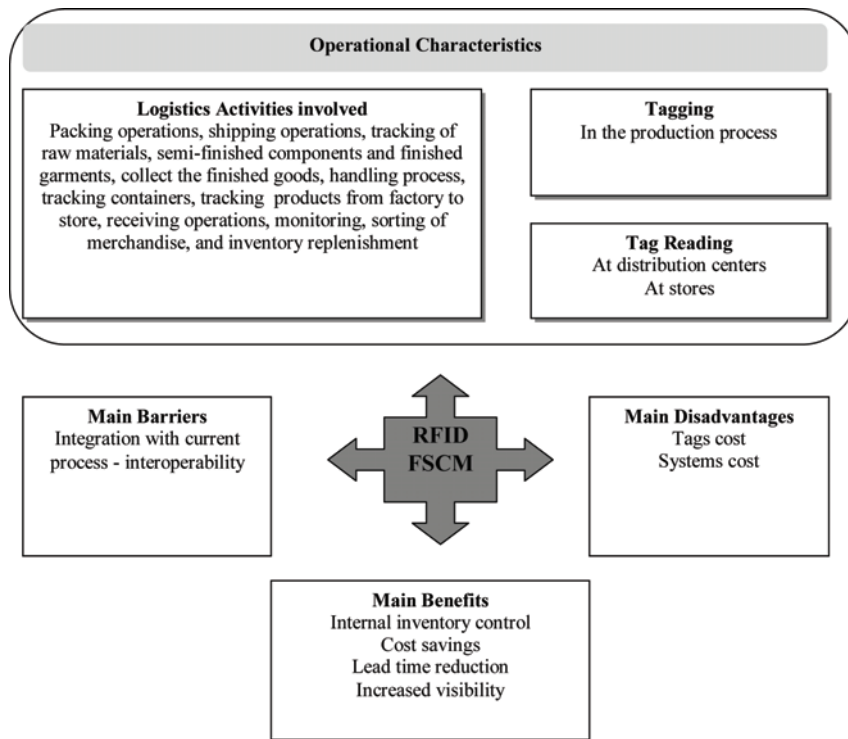
After the analysis of the eight companies' experience with the RFID technology, a framework is proposed in an attempt to illustrate some particularities of this technology deployment in fast moving FSCM (Figure 5).

The framework, designed from the case study exploratory analysis, outlines the following FSC logistics activities in which RFID is a reality: i)

*Table 5. Disadvantages and barriers of the RFID technology*

		Manufacturers/Suppliers			Distributors/ Logistics provider	Retailers			
		VF Corporation	Lawsgroup	Gerry Weber	Jöbstl Warehousing & Fashion	Charles Vögele Group	Kaufhof	Throttleman	American Apparel
<b>Disadvantages</b>	Insufficient read rates			X					
	System cost			X	X				X
	Tag cost	X		X	X		X	X	
	RFID system wasn't scaling cost-effectively								X
<b>Barriers</b>	Bar code system	X							
	Global standardization	X					X		
	Cultural issues	X							
	Integration with current process	X		X	X		X		X
	Technology	X							
	Customers privacy	X							
	Change management		X			X			
	ROI estimation		X						
	Alignment of its business processes						X		
Supply chain cost/benefit sharing			X	X					

Figure 5. Conceptual framework for RFID deployment in fast moving FSCM



packing and shipping operations; ii) tracking of raw materials, semi-finished components and finished garments; iii) collect the finished goods; iv) handling process; v) tracking containers and products from factory to store; vi) receiving operations; vii) merchandise monitoring and sorting; and viii) inventory replenishment.

The tagging operation in almost all of the cases is developed at the production process while the tag reading occurs at distribution centers or at stores.

The main barrier identified to the RFID deployment is the integration issues with current processes. The costs associated to this technology are the main disadvantage pointed out by the analyzed companies. Besides this disadvantage, it is interesting to note that focused companies recognize the cost saving opportunity as an important benefit. Beyond this, a better internal inventory control, a reduction of lead time and visibility increasing along the fast moving FSC are highlighted as important benefits.

After the development of this study, a future research is suggested to empirically test the validity of the proposed conceptual framework derived from the case studies. This will be conducted by using the Structural Equation Modelling (SEM). Moreover, future researchers should collect large samples of empirical data for a deeper analysis of the RFID deployment in FSC. Furthermore, it will be interesting to analyse the use of this technology in FSC but with different characteristics, such as the fast moving FSC and the Luxury FSC. In addition, quantitative analytical studies (theoretical modelling and simulations) similar to Szmerekovsky and Zhang (2008), Lin (2009), and Ustundag and Tanyas (2009) can be conducted to yield additional insights.

In fact, as in Szmerekovsky and Zhang (2008) work, it will be interesting and useful, to use mathematical optimization models in order to analyse the ability of the RFID to improve the efficiency of a set of logistics activities across FSC.

Beyond, and trying to replicate the methodology followed by Lin (2009) it will be also interesting, using the Fuzzy AHP method, to study issues and challenges that different member of FSC may face during the development and application of RFID technology. Finally a suggestion on the use of simulation model (Ustundag and Tanyas, 2009) will be interesting in an attempt to calculate the expected benefits of an integrated RFID system across the FSC. In this simulation model a set of performance measures previously identified as critical to FSC should be used.

## **CONCLUSION**

In the business context the RFID technology has reached a large interest because of the potentialities that it represents for companies considered individually or integrated in a supply chain. The drive toward RFID deployment is being further enhanced by mandates from large retailers such as Wal-Mart and Target, and the Department of Defence of many countries, who require all suppliers to implement this technology.

The RFID technology has received considerable attention also from academics and practitioners because of its potentialities and diverse fields of application in organisations such as manufacturing, transportation, distribution, information systems, store operations and sales. The increased use of the RFID has been pointed out by several kinds of companies particularly by fast moving fashion retailers because of its benefits. The fashion industry has unique requirements since retailers are locked in a battle to get key fashion trends from the design table to the shelves as quickly as possible. In this context, the RFID technology offers logistics benefits to respond to this challenge.

Both the theoretical analysis and the illustrative case studies show that the RFID deployment in fast moving FSCM poses potential advantages, but it must overcome the barrier of its interoperability

with existing systems. Additionally, the RFID system cost, namely the tag cost, must lower to a more acceptable level, so item level tagging can be widespread used. The RFID benefits result mainly from efficiency and efficacy improvements in logistics activities. All activities concerned with items movement and tracking (packing, shipping, handling process, receiving operations and inventory replenishment) are directly improved by the deployment of RFID technology in the FCSM.

There are several academic and managerial contributions of this study. It contributes with an empirical investigation on the deployment of the RFID in fast moving FSCM, examining different companies at different supply chain levels. Second, the RFID benefits and disadvantages across the FSC, the main barriers associated to its deployment, and the FSC' logistics activities in which RFID could be used are derived and examined. This represents an important contribution to companies in this industry to be more inside on the RFID deployment through the case studies presented.

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## **ADDITIONAL READING**

Beyond the references included in this chapter another ones could be consulted to a deeper analysis on the topic

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## **KEY TERMS AND DEFINITIONS**

**Case Study:** refers to the collection and presentation of detailed information about a particular participant or small group. It is a form of qualitative descriptive research, which looks deeply at an individual or small participant pool, drawing conclusions only about that participant or group and only in that specific context.

**Fast Moving Fashion:** A term used in reference to frequently purchased fashion goods.

**RFID (Radio Frequency Identification):** Is a technology that incorporates the use of radio waves to identify automatically an item (object, animal, or person). RFID is coming into increasing use in industry as an alternative to the bar code.

**Supply Chain Management:** A supply chain is the stream of processes of moving goods from the customer order through the raw materials stage, supply, production, and distribution of products to the customer. Managing the chain of events in these processes is what is known as supply chain management.

## Chapter 18

# Fashioning a Socially Responsible Garment Supply Chain:

## A Qualitative Exploration of Corporate Social Responsibility in Sri Lankan Export Garment Manufacturers

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### **ABSTRACT**

*The high street fashion industry is a dynamic, challenging global industry and one of few sectors under simultaneous pressure for short lead times and low costs. However, the increasing use of complex global supply chains in order to meet the challenges of the new competitive environment has also increased focus on issues of worker exploitation in globally dispersed production networks. Although there is evidence of a rising consumer demand for low cost, fashionable clothing sourced through ethical supply chains, the nature of the high street fashion industry is not conducive to the implementation of corporate social responsibility (CSR). Qualitative research was undertaken to understand the interplay of obstacles and drivers of CSR implementation in Sri Lankan export garment manufacturers.*

### **INTRODUCTION**

This chapter explores how issues and drivers in global garment supply chains impact on the implementation of corporate social responsibility in garment manufacturers supplying Western

retailers and brands. As one of few sectors under simultaneous pressure for short lead times and low costs (Masson *et al.*, 2007), overseas labour rates are a strong influence on UK high street fashion retailers' sourcing decisions. With labour rates in developing countries a fraction of those in Western nations, the trend for global sourcing

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continues (Jones, 2006). However, the increasing use of complex global supply chains to meet the challenges of the new competitive environment has also increased focus on issues of human resource exploitation in the outer reaches of supply chains (New, 1997; Boyd *et al.*, 2007), and a further dimension in fashion supply chain management (SCM) therefore has been the focus on CSR (Emmelhainz and Adams, 1999).

It is recognised that the characteristics of garment supply chains, with their focus on effectiveness (speed-to-market) and efficiency (lowest cost per garment), are not conducive to CSR implementation. However, SCM initiatives, with the focus on cooperation between chain partners for the mutual benefit of all, present strategic and operational solutions to the challenges in the high street garment sector as well as supporting the implementation of CSR.

The objective of the chapter is to explore from a managerial perspective the impact of negative and positive forces within the garment supply chain on CSR implementation, with a view to understanding how CSR implementation can be reconciled with competitive challenges of the fashion industry.

## **BACKGROUND: THE NATURE OF THE HIGH STREET FASHION INDUSTRY**

The high street fashion sector, which dominates the fashion retail industry in the UK (Mintel, 2010), refers to the mid-market and value segments served by multiple fashion retailers such as TopShop, Zara, H&M, New Look, Primark, Tally Weijl and Forever 21, which are typically found on a high street or in a shopping mall in developed economies. The sector is characterised by short product life cycles, high product variety, high volatility, low predictability, relatively low margins and high levels of impulse purchasing (Masson *et al.*, 2007; Bruce *et al.*, 2004; Fernie

and Sparks, 1998; Christopher and Peck, 1997). Globalisation, changing consumer expectations, advances in technology and the availability of information have reshaped the competitive landscape (Sridharan *et al.*, 2005; Griffiths *et al.*, 2001). Socio-cultural changes such as the orientation towards constant progress and change filter through to the fashion apparel market where consumer needs and wants change at a faster pace (Barnes and Lea-Greenwood, 2006). ‘Fast fashion’, the strategy of rapidly changing collections of high-fashion garments, accounts for an increasing share of the UK apparel market. The aim is “to reduce the processes involved in the buying cycle and lead times for getting new fashion product into stores, in order to satisfy consumer demand at its peak” (Barnes and Lea-Greenwood, 2006, p.259). Some retailers in the ‘fast fashion’ sector may count as many as twenty planned seasons per year (Christopher *et al.*, 2004). A pioneer of ‘fast fashion’, Spanish retailer Zara harnesses its vertically integrated supply chain to maximise speed, synchronicity and responsiveness which enables it to deliver budget interpretations of catwalk looks into stores within two weeks (Tokatli, 2008). With product life-cycles averaging six weeks but some as short as three weeks, Masson *et al.* (2007, p.239) described the European mass fashion industry as “fickle, volatile and unpredictable”. With the added challenge of long-term falling prices in the sector, brands and retailers have had to re-examine their sourcing and supply chain practices (Hines and McGowan, 2005).

## **SUPPLY CHAIN MANAGEMENT IN FASHION**

SCM has gained much prominence in recent years due to recognition of its potential as a major new area of profit and growth, rapidly becoming a strategic priority in many firms (Jüttner *et al.*, 2007), and especially during the recent global recession. The term denotes a management dis-

cipline which concerns “the set of practices aimed at managing and co-ordinating the supply chain from raw material suppliers to the ultimate customer” (Heikkila, 2002, p.749), moving away from adversarial trading relationships towards an emphasis on shared goals and mutual benefit for all members in the chain. This approach has become even more important in recent years as the effects of the Western recession filter impact upon business operations. Whereas in the past suppliers would traditionally negotiate an annual price increase for long-running items (Lamming, 2000), the economic crisis forced companies to look at ways to better control costs and renew their capabilities across global supply chains. As “a way of thinking that is devoted to discovering tools and techniques that provide for increased operational effectiveness and efficiency” (Cox, 1999, p.167), SCM requires closer collaboration between buyers and suppliers to reduce process costs and improve product value in light of reduced order volumes and pressures to reduce cost-per-item. A survey of over 500 corporate risk management executives conducted with the Economist Intelligence Unit in 2009 found that the most common response (58% of companies) to the economic downturn was to negotiate lower prices from suppliers (Malhi, 2010). Furthermore, supplier rationalisation initiatives and the placement of larger orders with fewer suppliers were seen to improve economies of scale, also contributing to increased efficiency.

Macro factors such as the trend towards vertical disintegration and a renewed focus on core activities have led to a greater interest in supply chains as networks of interlinked firms (Chen and Paulraj, 2004). While vertical integration is commonly found in the luxury segment of the apparel industry, in couture houses such as Gucci and Louis Vuitton, it is far less common at the mid-market level. The ownership of successive processes in the supply chain is generally ill-advised in most well-established industries, since it ties up capital resources and offers less flexibil-

ity, carries greater risk of plant obsolescence and restrains natural competitive forces when present on a large scale in a mature industry (Langlois, 2003). The same economies achievable by vertical integration can often be obtained more efficiently via partnership agreements such as strategic alliances (Reve, 1990). Competition therefore occurs between flexible supply chain networks rather than between individual companies (Lambert *et al.*, 1998). However, there are a few examples of successful mid-market apparel firms structured on a vertically integrated business model, including the European fast fashion retailer Zara, the Chinese shirt manufacturer and retailer Esquel, and the US basic casualwear retailer American Apparel, which markets itself with a strapline of ‘Made in Downtown LA: Vertically Integrated Manufacturing’.

The underpinning philosophy of SCM is the pursuit of mutual benefit for all network members rather than individual success at the expense of others. This is shown in Hong and Jeong’s (2006, p.292) definition of SCM as “a set of approaches utilised to effectively integrate suppliers, manufacturers, logistics and customers for improving the long-term performance of the individual companies and the supply chain as a whole”. Although the high street fashion garment industry has been characterised by adversarial trading relationships (Jones, 2006) as well as complex, inflexible and uncooperative supply chains (Barnes and Lea-Greenwood, 2006), buyer-supplier relationships have since moved towards long-term, mutually beneficial, ‘win-win’ partnerships (Fernie, 1998). Partnership is based upon commitment, trust and continuous improvement for the mutual benefit of both parties (Bixenden and Abratt, 2007; Valsamakis and Groves, 1998). For fashion products in particular, closer trading relationships are necessary to maximise supply chain effectiveness and efficiency in terms of reducing lead time and maximising stock availability. Close co-operation and high levels of trust between supply chain partners are crucial in facilitating information

sharing and achieving true agility and competitive advantage in volatile markets. Rationalisation of the global supply base enables retailers to reduce costs and develop closer partnership relationships with a fewer number of suppliers (Welford and Frost, 2006).

However, the success of SCM and partnership buyer-supplier relationships may be questionable in the fashion apparel industry – does the nature of the fashion apparel industry in fact preclude the implementation of a ‘win-win’ philosophy? Characterised by an inequality of power where large retailers dominate smaller suppliers (Hines and McGowan, 2005; Hughes, 2001), intensification of globalisation and a relentless quest for increased profitability through lower costs (Bruce *et al.*, 2004), it follows that supply chain relationships are more likely to be short-term than partnership-based. Hearson (2006) asserted that British low-cost fast fashion retailer Primark was able to achieve its preferred terms by constantly jumping between suppliers, pitting them in competition with each other and moving onto another supplier once a cheaper or faster one was found. A Primark shareholder reported in 2005:

*Key to Primark's business model is the sourcing of products from the cheapest possible supplier. Primark has used hundreds of suppliers located across the world. Relationships with suppliers can be short and variable, sometimes even changing mid-season (Newton Responsible Investment, 2005, p.21)*

Many fashion collaboration projects also tend to be short-term over a season rather than over several years, as the very nature of fashion demands it is short-lived. US low-cost retailer Target has collaborated with a number of designer names including Jean-Paul Gaultier, Anna Sui, Zac Posen, Mulberry and Alexander McQueen, but each collection is available for a limited time only. In Europe, fast fashion retailer H&M has collaborated with designers and celebrities such as

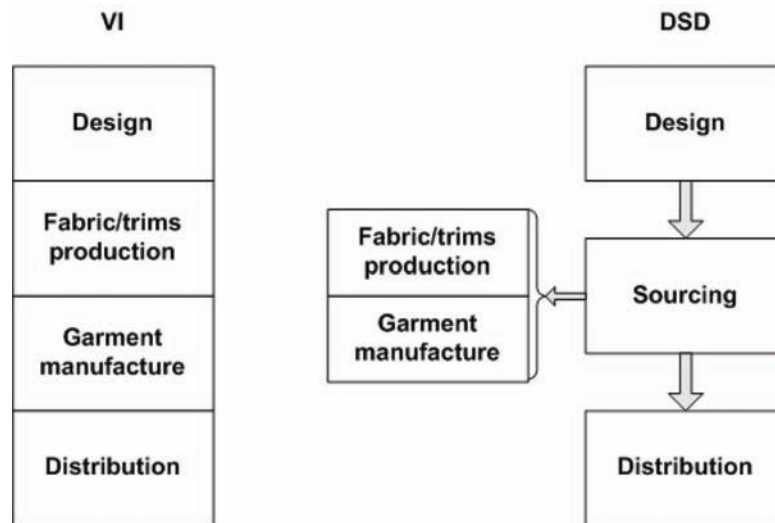
Karl Lagerfeld, Madonna, Jimmy Choo, Roberto Cavalli and Stella McCartney, but similarly each collection is available for a limited time only and there are no repeat orders, regardless of the fact that the collections often sold out in a matter of hours or days.

## **GLOBAL SHIFT OF GARMENT PRODUCTION**

In contrast to Zara's vertically integrated (VI) business model, many UK high street brands and retail groups such as Arcadia, Aurora, Next, H&M, New Look and Marks & Spencer are structured according to a design, source and distribute (DSD) business model rather than being vertically integrated brand owner-manufacturers. By not owning production facilities, they can take advantage of the flexibility offered by subcontracting garment manufacture to lower labour cost countries and operate on the basis of supply chain networks. Figure 1 compares the operational structure of the VI and DSD business models.

The apparel manufacturing process is labour-intensive and not disposed to automation (Jones, 2006; Abernathy *et al.*, 2006). Because the process of sewing makes up around 30% of the total garment cost (Jones, 2006), the impact of the labour cost differential between developed and developing countries is significant. With the relatively small amounts of skill and capital investment required and the enduring labour-intensive nature of the manufacturing process, competitive advantage has shifted from economically advanced nations to developing countries with large pools of labour resources. Intensifying competition in the fashion market has led to extra pressure on profit margins in recent times, resulting in the increased use of offshore manufacturing facilities for UK retailers (Adams, 2002). Mass outsourcing became a commercial reality due to geopolitical reasons (end of quotas), market needs (increased competition) and technological advancements (IT

*Figure 1. Vertical Integration vs. Design, Source, Distribute business models*

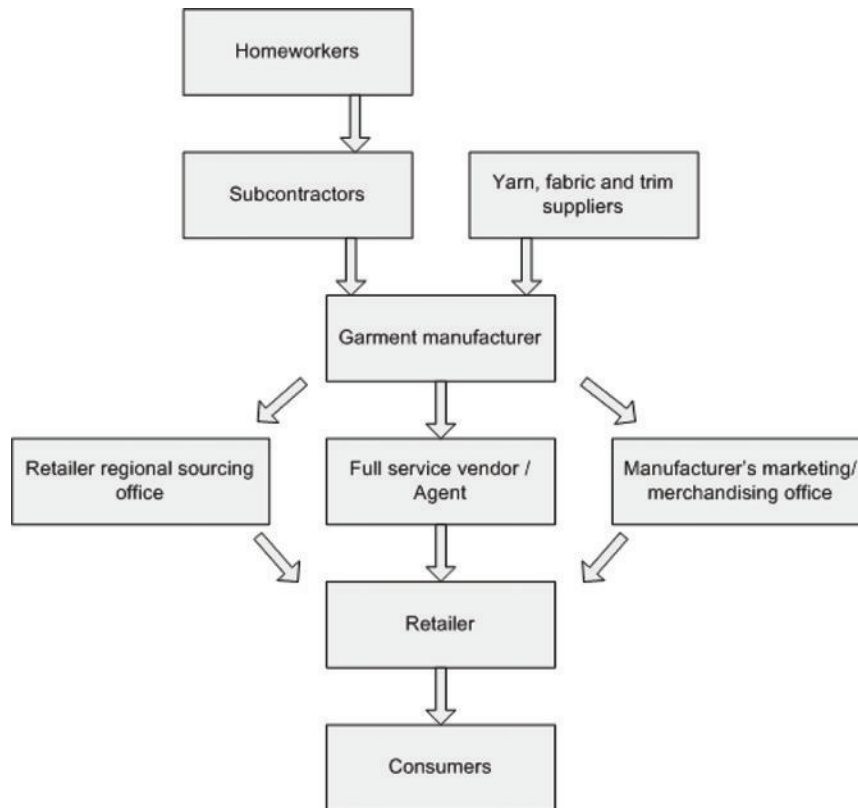


and transport advancements) (Ferne and Azuma, 2004). As overhead costs in Western locations escalated, the advances in IT and transportation meant that the lack of geographical proximity became less of an obstacle and was far outweighed by the cost savings achievable through global sourcing. Figure 2 depicts a typical global garment supply chain spread over more than one country.

Since it is more difficult to sustain competitive advantage on the basis of cheap labour than on the basis of performance of more sophisticated factors such as technology and skill, competitive advantage moves successively to the next newly industrialising country where labour costs are even cheaper (Singleton, 1997). Commoditisation of the core low-tech activities of garment manufacture means that labour-intensive CMT (cut, make and trim) operations can be located anywhere in the world where there is a readily available labour source, and can be moved from one low cost country to another in a seamless manner according to business requirements (Sethi, 2003). For example, Hong Kong, South Korea and Taiwan were popular sources of low-cost manufacturing labour but by the beginning of the 1990s rising domestic labour costs meant they were no

longer competitive on a cost basis. The influx of business from Western countries seeking lower labour costs enabled their economies to develop and their workers to become better trained. However, as a country's garment manufacturing industry matures, firms tend to move into niche markets, invest in more advanced technology or engage in subcontracting arrangements to lower labour cost countries themselves (Singleton, 1997). Hong Kong, South Korea and Taiwan have now moved away from labour intensive garment manufacture into capital intensive textile industries or production of higher value-added items which require skilled operators at a subsequently higher labour rate. Hong Kong has also become a sourcing hub connecting Western retailers such as Marks & Spencer to suppliers and factories in China (Jackson and Sparks, 2005; Fernie *et al.*, 2009; Skov, 2006). Basic garment production has therefore migrated to lower-cost labour countries such as Vietnam, China and Indonesia (Sethi, 2003; Maitland, 1997; Elbehri, 2004). In Turkey, the EU's largest supplier of garments which accounted for 75.5% of total exports in 2007, garment manufacturers have begun outsourcing production to neighbouring Egypt and Syria. As production

Figure 2. The global garment supply chain



costs rise in their home country, quality and skill levels are improving in Egypt, with the benefit of lower wage and energy costs (Just-style.com, 2008). However, this process of industrial upgrading and the global shift to new centres of low-cost labour leads to a ‘race to the bottom’, resulting in fashion retailers being accused of “chasing cheap labour around the globe” (Maitland, 1997, p.593).

Apparel supply chains are increasingly driven by powerful retail buyers who organise globally dispersed production networks (Gereffi *et al.*, 2005; Hughes, 2001), enabling them to respond effectively and efficiently to a changing competitive environment. UK apparel retailing is highly concentrated within a small group of large retailers and there is a significant disparity between the size of UK retailers and UK-based manufacturers (Hines and McGowan, 2005). While the degree

of buyer concentration is exceptionally high, the very low degree of seller concentration and the industry’s historical tendency towards adversarial trading relationships means that garment manufacturers possess a very low degree of market power compared to retailers (Jones, 2006). The bargaining power of fashion garment suppliers is thus limited, due to the global abundance of garment manufacturing capacity (Hergeth, 2007).

The combination of a number of factors outlined above – namely, global fragmentation of production, a highly competitive marketplace with pressure on both lead time and cost, and the sector power imbalance weighted in favour of retailers – results in a challenging, dynamic industry sector.

*Table 1. Definitions of Corporate Social Responsibility*

<b>Author</b>	<b>Definition of CSR</b>
McWilliams and Siegel (2001) p.117	“actions that appear to further some social good, beyond the interests of the firm and that which is required by law”
Barnett (2007) p.795	“any discretionary corporate activity intended to further social welfare”
Basu and Palazzo (2008) p.124	“the process by which managers within an organisation think about and discuss relationships with stakeholders as well as their roles in relation to the common good, along with their behavioral disposition with respect to the fulfillment and achievement of these roles and relationships”
Berger <i>et al.</i> (2007) p.133, citing Industry Canada’s (2006) definition	“the way firms integrate social, environmental, and economic concerns into their values, culture, decision making, strategy, and operations in a transparent and accountable manner and thereby establish better practices within the firm, create wealth, and improve society”
European Commission (2006) p.2	“a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis”
Doane (2005) p.215	“a voluntary form of self-regulation that aims to tackle everything from human rights and labour standards to limiting carbon dioxide emissions that lead to climate change”

**CORPORATE SOCIAL RESPONSIBILITY IN GARMENT SUPPLY CHAINS**

CSR in garment supply chains concerns the ethical sourcing of garments from lesser-developed countries for sale in Western markets. The World Business Council for Sustainable Development (WBCSD, 1999, p.3) summarises CSR as:

*the continuing commitment by business to behave ethically and contribute to economic development while improving the quality of life of the workforce and their families as well as of the local community and society at large.*

Table 1 presents some academic definitions of CSR and demonstrates the wide-ranging scope and nature of the subject area.

Whichever definition is applied, CSR essentially conveys the idea that business should assume social responsibilities beyond the economic, technical and legal responsibilities which constitute its existence (Davis, 1973; European Commission, 2006).

CSR centres on the accountability of firms to society for the negative consequences of their wealth-creating activities (Sethi, 2003). Although the shift in organisational structure from vertically integration to supply chain networks enables firms to maintain economic control over their global supply chains without being legally liable for the social impact thereof (Sobczak, 2006), firms must therefore balance a multitude of commercial, legal and moral standards amongst the various countries in which they have operations (Laudal, 2010). Notwithstanding the fact that retailers and brands do not own production facilities, they are still held to account by consumers over ethical transgressions. For example, during the 1990s, news of industrial action due to poor working conditions at Nike’s subcontractor facilities in South-East Asia led to considerable negative publicity from public protests and boycotts in Nike’s Western markets and ultimately contributed to an 8% fall in sales by 2000 (Wazir, 2005). This was despite the fact Nike considers itself to be a designer, marketer and distributor of sportswear, not a manufacturer and therefore does not own any production facilities (Maitland, 1997). This indicates that the boundary

of the firm's responsibility becomes increasingly blurred for consumers and markets, especially when the supply chain is complex and global, and firms may find themselves held to account for activities in the outer reaches of their supply chains. More recently, in 2010, Nike agreed to pay \$1.5 million into a fund for displaced workers in Honduras following pressure from trade unions and universities over the closure of two independent subcontractor factories which employed 1800 garment workers (Parry, 2010). Although it was allegedly the subcontractor's decision not to pay laid-off workers the severance pay they were entitled to under Honduran law (Foley, 2010), external parties nevertheless called on Nike to take responsibility for correcting the violations of its subcontractors by supporting the former employees concerned (just-style.com, 2010). It could therefore be said that the boundary of the firm in this case extended to Nike as a customer of the two contractors, regardless of the fact that the supplier factories operated completely independently of Nike.

CSR issues have arisen as a direct consequence of the large-scale move to global sourcing in the fashion apparel industry (Jones, 2006; Dicken, 2003; Hughes, 2001). Indeed, Smestad (2009) asserted that "the fashion industry is notorious for its connection to sweatshops ... because it combines the intensely intricate handiwork of fashion construction with the modern assembly line". The flexible nature of fabric means that garment production will remain a labour-intensive activity, while the commercially challenging nature of the industry drives companies in seeking out cost saving measures in production.

Notwithstanding the shift in organisational structure from vertical integration to flexible independent supply chain networks, firms are increasingly being held accountable for the policies and practices of their whole supply chain (Wong and Taylor, 2000; Parry, 2010). Maitland (1997, p.593) cited some of the accusations levied against firms as "failing to pay their workers a living wage,

using child labour, turning a blind eye to abuses of human rights, being complicit with repressive regimes in denying workers the right to join unions and failing to enforce minimum labour standards in the workplace".

In recent years however, there has been a widespread backlash against globalisation and large corporations in general, as global insecurity grows and the gulf between developed and less-developed nations becomes more evident (Smith, 2003). It is becoming less acceptable by society that the relentless drive for wealth creation in capitalist economies results in unfair distribution of prosperity amongst global workers (Sethi, 2003; Lobel, 2006), leading to increased pressure on business to deliver societal goals as well as shareholder profits (Smith, 2003; Kapstein, 2001; Cotrill, 1996). Fukuyama (1995) noted the growing perception that networks will outperform hierarchical corporations as well as market relationships, but believed the efficiency of networks "will come about only on the basis of a high level of trust and the existence of shared norms of ethical behaviour between network members" (p.195).

CSR consists of three theoretical components:

- the moral philosophical argument, also known as the normative case
- the business case for competitive advantage
- the concept of sustainable development.

The philosophical component of CSR stems from the moral argument for inviolable human rights. This perspective focuses on the process, rather than the outcome, and follows Kant's categorical imperative that humanity should not be treated as a means to an end. German philosopher Emmanuel Kant was a major contributor to the deontological ethical perspective. With his belief in inviolable human rights and justice, he set out to construct an absolute and unconditional principle, known as the categorical imperative, which should be adhered to for its own sake due to its universal and rational nature. Focusing on means over ends,

the purity of motive should transcend enlightened self-interest or any regard for the consequences of the act (Reynolds and Bowie, 2004). The humanitarian aspect of deontological theories thus considers that all people possess intrinsic rather than merely instrumental value, and are equally worthy of protection (Perry and Towers, 2009).

Although actions must go beyond the immediate interest of the firm and beyond merely obeying the law or other regulations (McWilliams and Siegel, 2001; Davis, 1973), current understanding has progressed beyond the idea of CSR as economic philanthropy (Donaldson, 1989) towards an integrative model where CSR undertakings may have strategic motivations. Porter and Kramer (2006, p.80) contended that CSR could be “a source of opportunity, innovation, and competitive advantage” and activities should be therefore be guided by their ability to create shared value to society and to the firm. This contrasts sharply with Donaldson’s (1989) idea of economic philanthropy, where the donating firm expects no dividends in return for its efforts.

Increased profitability is often a driver for implementing CSR practices research has suggested that CSR does result in financial benefit to the firm (Griffin and Mahon, 1997; Margolis and Walsh, 2001; Orlitzky *et al.*, 2003; Markley and Davis, 2007). However, the direction of the causality between good CSR practices and increased profitability is unclear (Vogel, 2005; Marom, 2006), and a causal link between CSR and improved financial performance has not yet been proven (Jenkins, 2006). Previous positive financial performance may encourage a firm to invest in CSR initiatives (Ullman, 1985), whereas a lack of excess resources may inhibit a firm’s ability to absorb the initial set-up costs of CSR initiatives (McGuire *et al.*, 1988). While firms which are more profitable may therefore pledge greater resources to CSR, it is equally likely that firms which adopted better CSR strategies have thus become more profitable. Sprinkle and Maines (2010) proposed that the relationship between cost

of CSR implementation and CSR benefit to the firm is concave, that is, returns diminish as the level of CSR increases.

A range of intangible strategic benefits also support the business case for CSR, such as the avoidance of damaging negative publicity as well as the positive enhancement of the firm’s reputation which may lead to an increase in customers (Sprinkle and Maines, 2010; Welford and Frost, 2006; Melrose-Woodman and Kverndal, 1976; Davis, 1973). Ethical transgressions in the outer reaches of garment supply chains can result in consumer boycotts protests in a firm’s home market, leading to a loss of brand value for Western retailers and brands (Sethi, 2003; Werther and Chandler, 2005). Industrial action in supplier countries and supplier relationship problems also contribute to increased supply chain risk by disrupting the smooth flow of product from raw material supplier to final consumer (Waters, 2007). Good CSR, in contrast, can help establish good industrial relations which leads to higher productivity levels and higher employee morale (Melrose-Woodman and Kverndal, 1976; Sprinkle and Maines, 2010; Jenkins, 2006), which in turn leads to less absenteeism and turnover as well as attracting better quality labour and lowering recruitment costs (Davis, 1973; Jenkins, 2006; Sprinkle and Maines, 2010). A resentful or fearful employee is less efficient and loyal than one who feels recognised and fairly treated in a firm (Solomon, 1992). In addition to pursuing supply chain efficiency or effectiveness, therefore, retailers and brands also have a duty to respect the dignity of the workers in their supply chain networks (Arnold and Bowie, 2003).

CSR also supports the wider societal goal of sustainable development, concerning a particular subset of issues relating to employment and personnel issues and the overall impact of a firm’s operations on the economy and development of host countries.

As a means of addressing the negative consequences of global business operations, CSR



is based on the stakeholder theory of the firm (McWilliams and Siegel, 2001). In contrast to the shareholder model, which views the firm as a profit-maximising and value-free economic mechanism (Friedman, 1970), the stakeholder model illustrates the bigger picture in terms of other purposes which business is designed to serve over and above its legal, technical and economic duties. This leads to the definition of a firm as “a culture with shared values and larger social concerns” (Solomon, 1992, p.133). CSR requires a responsible firm to take into full consideration its impact on all stakeholders prior to making any business decisions which may affect them, rather than merely focusing on its fiduciary responsibilities. It conveys the idea that business should assume social responsibilities beyond the economic, technical and legal responsibilities which constitute its existence (Davis, 1973; European Commission, 2006). Actions must go beyond the immediate interest of the firm and beyond merely obeying the law or other regulations (McWilliams and Siegel, 2001; Davis, 1973).

In response to issues of child labour and worker exploitation in developing countries (Shaw *et al.*, 2006; Iwanow *et al.*, 2005; Adams, 2002; Kolk and van Tulder, 2002), there is evidence of rising consumer demand for low cost fashionable clothing sourced through ethical supply chains (Gilbert, 2006; Adams, 2002; Frenkel and Scott, 2002). Consumer ethical attitudes and awareness of ethical production and trading issues are currently at their highest levels and sales of ethical clothing have more than quadrupled over the last five years, helped by styles becoming more fashionable and more retailers entering the market (Mintel, 2009). Ethical trading is a strong emotive issue in the UK apparel market with growing concern from consumers in the womenswear market in particular (Mintel 2008a; 2008b).

The increase in attention to CSR within British society may be attributed to a general increase in concern about ethics, increased awareness of risk and risk management and the growth in

media exposure of CSR issues (Solomon *et al.*, 2004). Advances in communications technology, such as the World Wide Web, facilitate the rapid global dissemination of issues that occur in distant reaches of the supply chain. The counterculture activist movement of the 1990s (Klein, 2000) has now given way to mainstream public awareness and concern of the social implications of global corporate activity (Martin, 2002). As a business-to-consumer industry, with a higher public profile than industrial markets (Jones, 1999), the high street fashion industry is particularly susceptible to media and NGO (non-governmental organisation) scrutiny regarding issues such as child and forced labour and human rights violations in supply chains (Hughes, 2001).

## **THE IMPACT OF BUYING PRACTICES ON CSR IN GARMENT SUPPLY CHAINS**

Although it has been accepted for some time that CSR can bring about long-term business benefits for Western brands and retailers (Porter and Kramer, 2006; Welford and Frost, 2006; Zadek, 2004), the nature of fashion apparel, with its high level of product variety, uncertain demand profile and short product life-cycle, influences the design of the supply chain and in fact compromises the implementation of CSR (Perry and Towers, 2009). New (1997) noted the influence of supply chain design and operation on the socio-economic experience of those with the least power in the global economy. CSR in garment supply chains centres on balancing the acceptance that developing nations need low-tech industries which employ large numbers of workers and that low wages are necessary to create more jobs and fuel income growth with the promotion of human dignity, individual choice and democracy (Sethi, 2003). However, does the nature of garment supply chain in fact preclude implementation of CSR? Laudal (2010)

## ***Fashioning a Socially Responsible Garment Supply Chain***

identified six features of the garment supply chain that compromise the implementation of CSR:

- Labour-intensity of production
- Large cost differentials between home and host markets
- Power balance towards retail buyers
- Short lead-times and unpredictable order procedures
- Low visibility
- Communication barriers

Furthermore, retailer buying practices affect labour conditions in globally dispersed supply chains (Laudal, 2010). Despite a lack of academic research on the impact of retailer buying practices on CSR in garment supply chains, much anecdotal evidence exists from research conducted by NGOs, consultancies and advocacy groups. In a study of the ready-made garment industry in Bangladesh, FIDH (2008) concluded that social auditing efforts were largely undermined by downward price pressure and demand for shorter lead times, and that buyers were contradictory in their requests for compliance with social responsibility standards alongside demands for lower cost per garment. Similarly, Hearson (2009) argued that big box garment retailers such as Tesco, Wal-Mart, Carrefour, Lidl and Aldi could not balance the competing demands of the fashion industry business model – low prices, quick turnarounds and greater uncertainty – with those of good labour standards in the supply chain. He concluded that certain aspects of retailer buying terms were incompatible with upholding the required ethical standards in the supply chain. With fast fashion in particular, the pressure to reduce lead time and garment cost may lead to buying practices which undermine efforts to implement CSR in supply chains. Late sample approval, late order placement or last-minute order changes due to poor forecasting can compromise social compliance at factory level. Pan and Holland (2006) found that export garment manufacturers in Hong Kong, Taiwan

and South Eastern China were pressured to reduce production time (including partial distribution i.e. shipping to retailers' warehouse or distributing centre) from 20-22 weeks to 16-18 weeks. Since shipping time was fixed and took three to three and a half weeks of the total production time, this translated into pressure to reduce manufacturing time. In a report on responsible sourcing practices, international risk consultancy Acona (2004, p.35) concluded that:

*There are profound and complex connections between the normal commercial buying practice of a company and its suppliers' ability to meet required ethical standards.*

In particular, they found that three areas of SCM appeared to have a negative effect on the ability of the supplier to uphold ethical requirements: lead time, flexibility and cost. As buyers seek to reduce their risk of under- or over-buying by placing orders as close to the season as possible, short lead times and unrealistic delivery schedules increase the likelihood that suppliers would have to work overtime to complete orders on time. Lack of advance commitment to orders and requirement for supplier flexibility affects the supplier's ability to plan the business and recruit permanent employees, while encouraging the use of temporary workers who may also belong to vulnerable social groups such as economic migrants. Pressure to reduce garment cost could force the supplier to lower wages, not pay overtime and use vulnerable workers such as economic migrants. In 2006, the Responsible Purchasing Initiative cited these retail buying practices as having a contributing effect to poor labour standards in the supply chain:

- Demand for shorter lead times
- Demand for flexibility in meeting customer demand (peak seasonal orders as well as changing, increasing, decreasing or cancelling orders at short notice)

- Continual search for lower prices and better terms of business.

As well as jeopardising labour standards in the supply chain, such buying practices potentially jeopardise the supplier's whole business. However, Ancona (2004) acknowledged that the competence and quality of local management could counteract the negative effect of retail buying practices. Pan and Holland (2006) found export garment manufacturers took a different approach to meet the challenge of retail buyers' demand for shorter lead times: by moving the design development services down the supply chain and taking the function in-house, thus feeding directly into order specifications and production, they were able to compress and control the time factor.

Responsible purchasing practices on the other hand support the sustainability of globally dispersed garment supply chains as a whole, as well as upholding ethical standards within individual supplier businesses. Examples of responsible buying practices that support CSR include:

- Sustainable pricing and timely payment to suppliers
- Realistic delivery schedules
- Building long-term relationships in the supply chain (CIPS, 2008; Acona, 2004; Responsible Purchasing Initiative, 2006; Hearson, 2009)

It is the function of CSR to safeguard the notion of ethics in the competitive fashion apparel industry's supply chain, co-existing alongside cost efficiency and effectiveness. Tate *et al.*'s (2010) study of a range of companies' CSR reports found a clear link between CSR issues and supply chain themes such as risk management, sourcing policies and supplier management. The quandary remains, therefore, of how to maximise gains from effective and efficient SCM whilst also respecting the dignity of workers in the outer reaches of complex, globally dispersed supply chains where visibility

past first tier suppliers may be poor. In addition to the societal pressure for ethical sourcing and consumer desire for guilt-free garments, there are several SCM factors which support the implementation of CSR in garment supply chains and counteract the negative forces of downward price pressure, fashion product nature, labour intensity of manufacture, retailer buying practices, power inequality and supply chain complexity. Figure 2 below shows a framework for understanding CSR in garment supply chains, based on the above literature review.

### **CSR in Sri Lankan Export Garment Manufacturers: Research Findings**

Qualitative research was undertaken to understand the issues and drivers surrounding CSR implementation in garment manufacturing companies in lesser-developed countries, from a managerial perspective. Research was conducted in Sri Lanka, a key garment manufacturing centre supplying many global retailers and brands such as Marks and Spencer, Next, Nike, Victoria's Secret and Gap, and home to the world's first platinum LEED rated 'green' garment manufacturing facility. Sri Lanka is one of Asia's 'Big Six', a group of six Asian countries that account for 80% of Asia's apparel exports (Flanagan, 2009). In 2007, textile and apparel manufacturing accounted for 43% of Sri Lanka's total exports, 56% of its industrial exports and 75% of all manufacturing employment (Tait, 2008). The garment industry expanded rapidly following Sri Lanka's economic liberalisation in 1977 and by 1992 overtook the tea industry to become the country's largest foreign exchange earner (Kelagama, 2005). The key market is the US, which accounts for 51% of Sri Lanka's apparel exports but this is closely followed by the EU, which accounts for 44% of which 22% is destined for the UK (Barrie, 2008; JAAF, 2009).

Sri Lanka's garment industry has a reputation for high quality, on-time deliveries and good customer service (Tait, 2008). Typically producing

leisurewear, casualwear and sportswear but not tailored items such as formal structured suits (Tait, 2001), Sri Lanka focuses on core basic garments rather than fast fashion. However, its product range now includes babywear, childrenswear, shirts, blouses and lingerie. For Western retail buyers, Sri Lanka's competitive advantage is based on low-cost labour, a literate labour force, high labour standards, investment-friendly government policies and strategic shipping lanes (Kelagama, 2005). However, its key competitive strength is its reputation for high levels of social responsibility and compliance with norms of ethical sourcing (Saheed, 2007; Fibre2fashion, 2009). It is home to the world's first eco-manufacturing apparel plant and the only Asian outsourced apparel manufacturing country that has signed up to thirty of the International Labour Organisation (ILO) Conventions prohibiting child and forced labour (Apparel Exporters Association, 2009). Additionally, strict labour laws have been in place for a long time (Tait, 2001). For example, females are not allowed to be employed past 10pm without the express written permission of the employee and the Labour Commissioner. Therefore, although labour costs are significantly higher than in other developing Asian countries such as Bangladesh, China, Cambodia or Vietnam, Sri Lanka is able to compete as a niche player by capitalising on its reputation as a low-risk sourcing destination (Hindle, 2007). A spokesman from JAAF acknowledged:

*It's almost impossible for Sri Lanka to compete with low cost but we can offer competitive cost with environmental and social sustainability (Barrie, 2008).*

Empirical data were collected through key informant interviews conducted with Senior Managers of Sri Lankan export garment manufacturing firms and personal on-site observations. Companies were selected using purposive sampling, on the basis that they were rich in information and would provide insight and an opportunity to learn

(Stake, 1998), thus facilitating theory development, rather than because they were statistically representative. Cases were selected according to the following criteria:

- The company would be willing to participate in the research and allow open access as far as possible to the researcher
- The company had been trading for at least ten years to ensure continuity
- The company was part of a UK, US or Australian fashion apparel retailer's global supply chain.

A range of different types of garment manufacturers were studied: a cross-section of organisational sizes as well as different business models. Companies A, C and E were vertically integrated. Table 2 provides a brief description of the companies in terms of size, business model (FPS – full package supplier, CM – contract manufacturer), age and typical customers.

In addition to the above companies, key informant interviews were conducted with a Senior Investment Appraisal Manager in charge of the garment industry at the BOI (Board of Investment – a government agency), and with the Head of Sustainable Business at Marks & Spencer, the largest British retail buyer of Sri Lankan garments and a common customer to many of the case study companies.

The following sections provide a discussion of the findings based on the themes which emerged from the literature review, shown in the model in Figure 3. Four emerging themes are then discussed, followed by a summary of the key findings and conclusion.

- **CSR Inhibitors: negative forces that compromise CSR**

**Downward price pressure.** For full package suppliers that had long-term, collaborative and integrated trading relationships with their cus-

Table 2. Case study companies

Co.	Employees in Sri Lanka	Factories in Sri Lanka	Business model	Date set up	Customers
A	25,000	24	FPS	1969	Gap, Old Navy, Marks & Spencer, Next, Lands' End, Abercrombie and Fitch
B	10,000	12	CM	1979	George (Asda), Marks & Spencer, Gap, Intimissimi, Tesco, Warner Bros.
C	15,000	21	FPS	1946	Eddie Bauer, Liz Claiborne, Levis, Tesco, Marks & Spencer, BHS, Asda
D	5,200	7	FPS	1991	Gerry Weber, Esprit, Chaps Ralph Lauren, Betty Barclay
E	5,000	4	FPS	1978	Tommy Hilfiger, Nike, Polo Ralph Lauren, Liz Claiborne
F	300	1	CM	2000	Noni B
G	300	1	CM	1995	Reborn, Macy's

Figure 3. Framework for understanding CSR in garment supply chains



tomers, downward price pressure had less of a negative effect as both parties were able to work together to achieve a mutually acceptable solution. Although buyers requested cost reductions, they would help their supplier achieve the target by suggesting design modifications or alternate sources of supply to enable the final cost to be brought down. For example, an alternative seam construction which was quicker would lower the SAM value of the garment, a seam construction which required less seam allowance would reduce the total fabric cost of the garment, or an alternative quality of button would lower the

cost of garment trimmings. However, contract manufacturers suffered noticeably greater effects of downward price pressure, cancelled orders and reduced volumes. No added-value services such as design, product development or sourcing were offered; hence margins were tight and there was little reason for a collaborative integrated trading relationship with customers.

**Product nature.** This did not appear to compromise CSR in the Sri Lankan context since garments tended to be core basic rather than fast fashion. Hence, product life cycles were longer and garment construction was relatively

straightforward. This enabled machine operators to learn a style and reach a relatively high level of efficiency over a longer period of time than would be possible with the greater level of style changes characteristic of fast fashion garments. The long-running nature of certain styles, for example men's casual woven bottoms, enabled management to plan ahead and workers to achieve a higher rate of efficiency and earn production bonuses. Furthermore, there was less likelihood of last minute order changes or cancellations due to inaccurate forecasting than would be envisaged for fast fashion garments.

**Labour intensity of manufacture.** There was little evidence of investment in automation in the sewing process. The low labour cost and high availability of labour in the industry meant that there would often be a sound case for employing more workers rather than investing in technology. However, the enduring labour-intensive nature of garment manufacturing seemed to lead the investment in human resources that supported the wider goals of CSR. There was an awareness of the workers' contribution to corporate success, given the labour-intensive nature of the industry, and the consequent need for good standards of worker welfare. HR and CSR policies and practices addressed protection from harm as well as nurturing and empowerment of employees. The Chairman of Company B recognised the role of the factory workers in the success of the business:

*“As a Chairman, I know the most important thing is the human resource ... without the people there is no factory”.*

This was echoed by the Deputy Chairman, who said:

*“Our biggest asset is our workforce ... we have to give priority number one for the workforce”.*

In Company D, the General Manager expressed a strong personal belief in the importance of CSR in the business:

*“We have a responsibility for their lives and not only for achieving the quality or the cost factor profitability but something better, to improve their lives”.*

Meanwhile, in Companies A and C, people were the focus of each company's corporate strapline (“Inspired people” and “The difference is our people” respectively). This suggested that in the Sri Lankan context, the labour intensity of the process in fact was a driver of CSR rather than an inhibitor.

**Retailer buying practices.** Interviewees did not admit to experiencing problems as a result of retailer buying practices. Although there was a general lack of written contracts of advance commitment that would enable manufacturers to plan their business, the closeness of the trading relationship and the added value services provided by some firms seemed to counterbalance the risk of losing a particular customer's business. The long-term nature of the relationship provided manufacturers with some faith in the continuation of business. As supply chain operations became more integrated, the balance of power shifted towards the manufacturer. For example, a VMI agreement for men's casual woven bottoms enabled Company A to feel secure in the continuation of the trading relationship with their key buyer, as it would be costly and time-consuming for the buyer to find another supplier that was able to provide the same volume and service levels. While lead time was three months for normal orders, from the point of fabric procurement through manufacturing and shipping to arrival in the customer's country, the VMI arrangement enabled Company A to reduce this lead time to six weeks.

Due to the core basic nature of the garments, there was less pressure to reduce lead times, and urgent orders were referred to as requests

for 'favours' rather than demands from buyers. Open-book accounting was practised in Company A, and linked to the VMI agreement with its key buyer. However, this level of openness and sharing of confidential information was seen in positive terms by the Senior Operations Manager, who described it as a 'win-win' situation whereby both parties could work together to mutual advantage. As a full-package supplier with integrated supply chain operations, this practice cemented the collaborative nature of the trading relationship by providing the buyer with the necessary information to advise on cost savings. The most harmful retailer buying practice appeared to be the length of payment terms, which varied from 30 to 90 days. One of the effects on the Western recession was the increase in invoice settling time: for example, Company A's key buyer had recently moved from 30 to 45 days. For full package suppliers that sourced fabrics, trims and accessories outside the boundaries of the firm, this could be problematic in terms of managing cash flow. Fabric was paid for in advance or upon delivery and employee wages were paid on a monthly basis; hence, a significant amount of capital support was required to keep the business going if buyers insisted on lengthy payment terms. The MD of Company D spoke of his decision to cease or scale down business with the two buyers that insisted on 90 day payment terms. As a smaller, non-vertically integrated organisation, Company D experienced difficulties managing the business on such credit terms. Company G was a SME subcontractor and required prompt payment of invoices in order to maintain a steady cash flow. The MD had therefore made a conscious decision to supply the domestic market only. While export customers specified payment terms ranging from 30 to 90 days, domestic customers' invoices were settled within 14 to 25 days.

**Supply chain complexity.** Vertical integration facilitated management control of CSR within the supply chain. Although there was strong evidence of CSR implementation within many of the case

study companies, the philosophy did not always extend further upstream in the supply chain to the sourcing of fabrics and trims in those companies that were not vertically integrated. For example, the Chairman of Company B professed that his prime motivation for running the business was to help society rather than maximise profits and had drawn up its own comprehensive code of conduct. However, although Company B did not subcontract production due to quality issues, it had no ethical requirements of its fabric and trim suppliers. The Chairman admitted:

*We don't check any of those things, we just buy. Only we are ethical for our (own) manufacturing plants.*

Likewise, in Company D, the Director admitted that where customers did not nominate sources of supply for fabric and trims, Company D would use its own network of suppliers, which were not ethically audited. This was despite the fact that Company D provided a range of social benefits to its employees and was in the process of drawing up its own code of conduct, in addition to following its buyers' codes of conducts. The Director acknowledged that this situation would no doubt change in the future:

*We have not gone into that too much into checking about their compliance. Of course I think we might have to also do it because things are becoming more and more important.*

Firm size influenced the approach to ethical auditing outside the boundary of the firm. Large industry leaders had closely integrated relationships with their key customers and this seemed to be a significant driver maintaining the same standards of CSR further upstream in the supply chain, as the buyers would nominate their own (ethically audited) suppliers or require ethical audits to be carried out prior to approving a subcontractor or supplier.

**Supply chain power distribution.** The power distribution between buyers and suppliers appeared to be influenced by the closeness and the level of supply chain integration in the trading relationship. The power balance shifted towards the supplier as the relationship became closer and more integrated and as the supplier performed more value-added services. For example, Company B excelled in manufacturing garments in difficult-to-handle micro-fibre fabrics for its Italian buyer; hence the buyer was prepared to help the supplier's cash-flow management by sending payment earlier than required under the contract, in order to ensure Company B could adhere to its CSR requirements and pay its workers on time. Companies A and C were both large global suppliers with offices in key customer countries and production facilities throughout and well as outside of Sri Lanka, while Company E was the Sri Lankan subsidiary of a large Chinese shirt manufacturer. The traditional model of the powerful, dominant retail buyer and the powerless, compliant manufacturer was thus less evident in the Sri Lankan context. The greater equality of the relationship between buyers and suppliers also supported the longevity of the trading relationship. The Head of Sustainable Business at Marks & Spencer confirmed that the quality of management and the far-sighted perspectives of the Sri Lankan factory owners supported the presence of good ethics within the supply chain, as well as facilitating long-term buyer-supplier partnerships.

- **Components of CSR**

Evidence of CSR was found within all case study companies. At a basic level, all companies apart from domestic subcontractor Company G were BOI enterprises and as such had to adhere to BOI regulations on CSR issues such as employment law and labour relations. In addition, all companies produced for large international retailers and brand names and therefore had to adhere to

their customers' codes of conduct. All interviewees were aware of the concept of CSR and the benefits to the business, although the Director of Company D acknowledged the potential conflict between CSR and commercial demands, such as the inability to do excessive overtime for short-notice orders. According to BOI requirements, overtime hours were limited and factories had to provide canteens as well as medical facilities for employees. However, there was much evidence of greater CSR activity over and above these requirements in all the case study companies, including social reporting, monitoring of employee satisfaction, charitable activity, measures to address diversity and improve working conditions, and human capital development. In terms of improving the quality of life of the local community, all factories contributed to some degree towards local schools, temples and orphanages. Many were involved in sending excess garment stock to internally displaced people in refugee camps in the north of the country, following the recent end of the civil war. The larger companies contributed to economic development by investing in national projects, sometimes with the involvement of their key buyers. Examples were: improving access to clean water for rural communities, rebuilding homes following the 2004 tsunami, and building factories in northern territories following the end of the civil war, in order to provide employment for those communities as well as rehabilitating ex-LTTE soldiers. The Senior Investment Appraisal Manager from the BOI confirmed that the apparel industry in Sri Lanka generally did a lot of CSR activities over and above what was required by law or BOI regulations:

*Factories do a lot of CSR. They have their own training centres, medical centres for the villagers, sometimes they provide cut fabric to the villages to do their small businesses, they are constructing schools, temples, churches, all sorts of things are done by themselves without force or anything ... Some areas are developed because of the garment*



*factories. When the factories set up there, lot of facilities are created and indirectly that is CSR.*

**Moral philosophy.** The moral argument for CSR in the industry was a Kantian imperative not to use the human resource as a means to an end, but to grant workers dignity and respect as they contributed towards organisational goals. This imperative was greatly supported by Sri Lanka's main religion of Buddhism, which holds that it is wrong to exploit people beneath oneself. Company A's aim, for example, was:

*To lead in being responsible corporate citizens. Not because we are convinced it is a good way of doing business but because we believe it is the right way of doing business (Mission Statement, Company CSR magazine, Issue 1 2009).*

Since the industry was female-dominated, and females were traditionally perceived as the guardians of Sri Lankan culture (Lynch, 2007), this may have strengthened the moral underpinning of CSR.

**Competitive advantage.** However, in addition, CSR was seen as an effective way of competing against other garment producing nations. The CEO of Company A's College of Clothing Technology believed that good standards of CSR could be used as a competitive weapon to help Sri Lanka compete against its lower labour cost neighbours such as Bangladesh, Pakistan and Cambodia.

*We are using (CSR) as a weapon. We have clean factories; we have superb manufacturing management compared to other neighbours in this part of the world.*

Additional benefits included employee motivation and retention, increased productivity and the ability to win more business from Western retailers. Company C's Compliance Manager spoke

of reduced accidents and downtime that resulted from improved health and safety procedures in the factory. Investment in human capital in the form of training and development increased the skills and efficiency of the workforce so that they were better able to contribute towards organisational goals. Harmonious labour relations between workers and management contributed to improved productivity levels in the factory.

**Sustainable development.** The Senior Operations Manager in Company A spoke of how sustainable business development helped to drive the CSR agenda:

*Most of the businesses, especially in apparel, they are looking for a sustainable business. They do understand that unless you pay enough and look after your employees enough then ultimately you will not have people to work in your factories.*

Sustainable development was linked to the labour-intensive nature of the manufacturing process. Without adequate levels of worker welfare, the business would be unable to maximise the output of its human resource, in terms of productivity or loyalty that came from higher levels of motivation and retention. Lower productivity levels and higher labour turnover rates were not conducive to building a sustainable or successful business. Although females traditionally gave up work once they had married and therefore there was a constant drive to recruit new employees in the industry, Company E had recently found that many ex-employees had decided to return to work once they had got married and had children, encouraged by the prospect of training and development opportunities to enable them to progress their career perhaps to supervisory level. The HR Manager confirmed there were many long-term employees in Company E, despite the fact that the factory was situated in an industrial park with many other similar workplaces nearby:

*We have about 60% employees who have worked here more than five years; out of that 60% another 60% is more than ten years.*

- **CSR Drivers: positive influences that promote CSR**

**Buyers.** Consumers did not have a direct influence on CSR in Sri Lankan garment manufacturers due to the lack of direct connection in the supply chain. A greater influence on garment manufacturers was the buyers themselves, who were the main source of external pressure to drive the CSR agenda forward and improve standards. This was achieved by collaboration on CSR initiatives, such as Marks & Spencer's 'Plan A' (a 100-point plan for sustainable development), as well as through supplier development programmes by providing CSR training courses and seminars. Under Plan A, Company A converted one of their factories to an eco-plant, Company C had also built an eco-plant and found it to be so beneficial in terms of improved working conditions and reduced energy costs that it planned to roll the eco-plant concept out through the whole company. Additionally, Marks & Spencer held seminars with Sri Lankan suppliers to educate them about the 'Marks & Start' initiative, a programme designed to help vulnerable groups such as the long-term unemployed and disabled find work placements in industry which would then help them to enter the workplace. Company C embraced this initiative to the extent that it had recently set up its own corporate programme for providing opportunities to disabled people, based on the 'Marks & Start' initiative. The collaborative approach taken by certain buyers appeared to be successful in promoting engagement with CSR issues.

**Trust as an antecedent to commitment, co-operation, collaboration.** Trust developed from the lengthy durations of many of the case study companies' trading relationships with their buyers. It enabled them to bypass contractual stipulations in the case of problems and work together to reach

a mutual solution, thus supporting the supply chain management approach. It also formed the basis of the expectation that the trading relationship would continue, in the absence of any written guarantees. Therefore, suppliers were able to plan their business and avoid compromising CSR standards, hence overcoming the lack of written contracts characteristic of fashion retail buying practices. This demonstrated a clear shift away from traditional adversarial relationships towards long-term mutually beneficial partnerships characterised by commitment, trust and continuous improvement (Bixenden and Abratt, 2007). Furthermore, the Head of Sustainable Business at Marks & Spencer explained how the retailer's recent shift to semi-announced ethical audits was predicted to improve CSR performance in its supply chain, since a collaborative partnership approach would encourage innovation and creativity for mutual benefit in a way that a coercive compliance-based approach could not.

**SCM: long-term orientation, shared goals.** Most companies had supplied their key buyers for the past 10 to 20 years. Company B had been manufacturing for Marks & Spencer for 20 years, Company C had been supplying Liz Claiborne and Eddie Bauer for 20 years, and Company D had been supplying Gerry Weber for 12 years. Trust enabled both parties to feel secure in sharing confidential information without the threat of opportunistic behaviour by the other. Gerry Weber shared market information and retail demand with Company D ahead of the upcoming season, which enabled Company D to prepare for the season and better understand the buyer's business requirements. Built up over many years of trading, trust acted as an antecedent to collaborative working or integration of operations within the supply chain which in turn supported CSR implementation. The Head of Sustainable Business at Marks & Spencer spoke of how the company had decided to move from unannounced ethical compliance audits in supplier factories, which tended to breed a sense of distrust in trading relationships, to 75%

window auditing, where suppliers were given a 2-3 week window during which the audit would take place. Only 25% of site visits would then be unannounced. This change would facilitate the development of trust as well as the sense of partnership in the relationship, therefore promoting engagement with the CSR issue rather than merely compliance. This supports the arguments of Boyd *et al.* (2007) and Welford and Frost (2006), who proposed that greater levels of monitoring were in fact likely to result in lower levels of ethical compliance. As a coercive mechanism, monitoring is associated with low levels of trust in exchange relationships and tends to convey an adversarial rather than a collaborative stance.

The lack of formal contracts guaranteeing future work was overcome to a certain extent by the strength and longevity of the trading relationships. There appeared to be an unspoken commitment in several cases emanating from a combination of the duration of the relationship and past performance. Commitment supported business continuity and sustainable development: suppliers were able to invest in human capital development and process upgrading as they felt secure in the continuity of the trading relationship and wished to improve the level of customer service. Kelagama and Foley (1999) noted that Sri Lanka's most successful garment manufacturers were large businesses that had strong ties with the buying offices of large retailers such as UK retailer Marks & Spencer and US brand Liz Claiborne, thus emphasising the importance of strong relational ties to supply chain success.

The concept of seeking mutual value creation for all members of the chain, rather than pursuing self-interest at the expense of supply chain partners, was most clearly articulated by the Chairman of Company E's parent group:

*I'm not just trying to make a shirt ... I'm trying to see if we can make the shirt and bring everybody in the value chain with us.*

The larger case study companies worked together with their customers with the aim of ensuring sustainability of the trading relationship. Close relationships facilitated best practice to be cascaded through the supply chain: as well as CSR training and development, there was evidence of technical training and sharing of best practice in relation to the manufacturing process. Even domestic subcontractor Company G received CSR training provided by Gap and Macy's, which enabled the Managing Director to learn about new requirements and implement any necessary processes in time for the annual audit. A SCM mindset thus facilitated CSR.

**Supply chain rationalisation.** Rationalisation of the supply chain enabled buyers to build stronger trading relationships with fewer suppliers and by simplifying the supply chain in this way, visibility of CSR issues could be increased. For suppliers, being part of a buyer's rationalised supply chain enabled them to develop the relationship and improve their core competences. An important antecedent of CSR, the concept of supplier development concerns the improvement of various supplier capabilities that are necessary for the buying organisation to meet its increasing competitive challenges (Watt and Hahn, 2006). All of the case study companies had received training and/or attended supplier conferences organised by their key buyers, which enabled them to improve their competences and remain up to date with new developments and supply chain requirements in CSR.

**Supply chain integration.** A high level of integration between buyer and supplier encouraged CSR by facilitating visibility and control of the supply chain. The larger full package suppliers had sufficient resources to integrate the design and product development processes. Supply chain integration resulted in closer linkages between buyers and suppliers and strengthened trading relationships. In 2007, Company A built a state-of-the-art product development hub in Sri Lanka, where customers could come and work together

with Company A's employees during the product conceptualising, designing, constructing and sampling processes. This demonstrated Company A's commitment to collaborative working, as well as reducing lead time prior to the order going into production. Collaborative working and the development of trust that resulted from such supply chain integration also supported CSR implementation, by moving on from less effective coercive methods such as high levels of monitoring.

Four further themes emerged from the data that appeared to support CSR within the Sri Lankan context; namely, governmental support, national culture, the level of socio-economic development and the industry's shift from urban to rural areas.

- **Governmental support**

CSR in Sri Lanka's garment manufacturing industry was supported by strict labour laws which were monitored and enforced by the Labour Department, and by the BOI which regulated export businesses. It stipulated strict criteria on labour standards and employment relations which companies had to adhere to in their business operations. Non-adherence resulted in termination of the agreement with the BOI and loss of any incentive package, which included such perks as tax holidays, import duty exemptions and preferential access to credit. Additionally, the Joint Apparel Association Forum (JAAF), now known as Sri Lanka Apparel, was the first garment industry trade body to be positioned on an ethical platform. Sri Lanka Apparel represents garment manufacturers, accessory makers, fabric manufacturers and other ancillary garment-related businesses in Sri Lanka. In 2006 JAAF, as it was then known, launched its 'Garments Without Guilt' campaign to promote Sri Lanka's garment manufacturing industry as an ethical supply base for international buyers. This campaign aimed to capitalise on Sri Lanka's reputation as a low-risk sourcing destination with regard to ethical trading, by promoting Sri Lanka's ethical credentials as a

means of differentiation in a crowded and highly competitive global marketplace. However, the Director of Company D highlighted the potential conflict between ethical standards and commercial imperatives: labour laws restricted the freedom of business to maximise profits and serve its customers, for example when problems arose and extra overtime was required but prevented by Sri Lankan law. The General Manager at Company D similarly felt that overly strict labour laws could "contribute to the loss of efficiency" within the factory. The Senior Appraisal Manager at the BOI also acknowledged that although beneficial for workers, Sri Lanka's strict labour laws could sometimes be a hindrance to business and off-putting for potential foreign investors who would wish to maximise the return on their investment. However, interviewees felt that although the free market structure was advantageous for both business and society, it was appropriate that there existed some rein on the absolute freedom of business, to prevent exploitation. This corresponded with the Kantian imperative of not using human resources as a means to an end, the underpinning moral argument for CSR.

- **National culture**

The national culture of Sri Lanka provided a philosophical grounding of the moral argument for CSR. Approximately 70% of the population in Sri Lanka were Buddhists and this appeared to support the moral argument for CSR. For example, the Buddhist concept of *Śīla* refers to virtue, good conduct and moral discipline: the overall principles of ethical behaviour. Many of the initiatives undertaken by factories had been in place for many years prior to the advent of CSR. The founder of Company B, a large contract manufacturer with 25,000 employees across twelve sites in the country, had provided free breakfast and tea for workers for the past 30 years. This had since become standard practice within the entire industry. This confirmed find-

ings by International Alert, an NGO committed to peace building and conflict prevention in the developing world, who found that Sri Lanka had a long history of corporate philanthropy and that CSR was identified by many business leaders as a historical practice that had been modernised to suit local needs (International Alert, 2005). Visser (2008) similarly pointed out that CSR in developing countries commonly drew on deep-rooted indigenous cultural traditions of philanthropy, business ethics and community embeddedness.

The Senior Operations Manager in Company A felt that the Buddhist philosophy was supportive of social compliance in the garment industry:

*The mindset is that you can't exploit people who are under you ... the Buddhist culture is demanding fairness and social justice and equity between all.*

He felt the effect of the Buddhist culture on CSR implementation was so strong that ethical practices would be followed regardless of the existence of rules and regulations. Buddhism seemed to be widely practised and in Company C, the HR Manager alluded to the power of the religion in dictating business operations. As a result of employee feedback, it was rare for the factory to open on Sundays for overtime work, since workers preferred to attend religious classes. Therefore overtime was usually scheduled for Poya days, Sri Lankan monthly national holidays.

In Hofstede's (1980) framework of cultural dimensions, individualism and collectivism refer to the degree to which individuals are integrated into groups and provide an insight of how much members of the culture define themselves apart from their group memberships. Although Sri Lanka was not rated on Hofstede's scale, empirical data suggested that the country veers towards a more collectivist model of national culture, prioritising the family unit over the individual. In Company C, the effect of the strong familial ties became clear when the HR Manager pointed

out that as a result of employee feedback, the factory closed at 6.30pm as workers were keen to get back to their families and eat dinner together. If the factory stayed open later, workers became less motivated and this became counter-productive as efficiency levels decreased. Cultural tradition therefore acts as a driver of CSR in developing countries (Visser, 2008).

- **Level of socio-economic development**

Sri Lanka was classified by the UNDP as a medium developed country rather than a lesser developed country due to the higher level of education, greater average life expectancy and higher standard of living compared with other developing countries. Within the total group of medium developing countries, Sri Lanka had a higher than average overall Human Development Index value in 2007, a measure which indicated the level of socio-economic development. Its life expectancy (74 years) and adult literacy (91%) rates rival those of the UK (79 years and 100% respectively) (UNDP, 2009). With the nationwide system of free education for all, there was less necessity for children to work as schooling did not cost anything for parents. Books and uniforms were provided by the government for all children. Sri Lanka has a lower overall level of poverty than some of its garment-producing neighbours such as Bangladesh, India, Pakistan and Cambodia. With a higher quality of life in terms of life expectancy, adult literacy and education, Sri Lanka's socio-economic status supported the existence of CSR in the garment manufacturing industry.

This may be contrasted with Bangladesh, with a lower education index than Sri Lanka's in 2007. Its Minister of State for Labour and Employment confirmed in 2009 that the country's poor socio-economic status contributed to forcing children to work in hazardous jobs rather than attend school (Dhaka Mirror, 2009). The prevalence of child labour in Bangladesh is thus linked to the

socio-economic status of the country: its deep and widespread poverty, the poor state of the education system and the lack of day-care options for migrating workers (Nielsen, 2005).

CSR in developing countries is influenced by the socio-economic context and the resulting development priorities (Visser, 2008). In Sri Lanka this was made apparent with the basic priorities of poverty alleviation, infrastructure development and clean water provision addressed by the larger garment manufacturers in their CSR programmes. In developed countries, the provision of such social services would be considered the responsibility of government, not business (Visser, 2008). CSR initiatives tended to be philanthropic rather than strategic, suggesting that Sri Lanka is still at an early stage of maturity in CSR. However, there was also evidence that typical 'Western' CSR issues including climate change concerns and measures to address workplace diversity were integrated within the larger companies, via 'green factory' development and providing employment for disabled people where possible.

Although Sri Lanka's socio-economic status supported CSR implementation in the garment manufacturing industry, there is a counterargument that certain challenges may affect the country's socio-economic development in the future and compromise CSR progress. For example, GSP+ status, which gave Sri Lankan export garment manufacturers duty-free access to the EU from 2001 (Lezama *et al.*, 2004), was suspended from 2010 on the basis of human rights violations which occurred during the recent civil war. Although only one-third of Sri Lanka's total garment exports benefited from GSP+ status (Samaraweera, 2010), the extra duty was nevertheless predicted to increase the cost of garments to retail buyers. Therefore, if retail buyers pressure manufacturers to absorb the extra duty cost in reaction to the impact of the recession in Western markets, then it is entirely possible that CSR standards in the factories may be compromised. If, on the other hand, the civil

war had continued, the increased sourcing risk may have undermined retail buyers' confidence and order volumes could have decreased significantly. It is also possible that Sri Lanka's competitive edge in the ethical manufacture of quality garments is unsustainable in the long term as other Asian nations' garment manufacturing industries develop and become more sophisticated.

- **Industry shift from urban to rural areas**

In 1992, the Sri Lankan government established its 200 Garment Factories Programme (200 GFP), an ambitious rural industrialisation programme which offered private investors financial incentives to open 200 export-oriented garment factories in villages throughout the country. Locating new factories in rural areas reduced the need for female workers to move away from their villages and seek boarding accommodation in the urban areas surrounding Colombo, and contributed to the protection of the females' moral characters as well as the preservation of the family unit. In Sri Lankan tradition, women are considered to be the custodians of the national culture and similarly villages are the locus of tradition and considered impervious to moral degradation, which is usually associated with urban areas such as Colombo or the EPZs (export processing zones) scattered around the country (Lynch, 2007). Company B based its expansion strategy on the 'town to village' concept with assistance from the government's 200 GFP, and found that workers encountered fewer social problems as they were able to return to their homes each night and receive love and attention from their families, rather than being lonely and potentially vulnerable in an urban boarding room or dormitory. Since the garment manufacturing industry is heavily female-dominated, this helped to attract workers from traditional rural communities as their families were reassured their daughters were safe in the factories near their homes.

## **SUMMARY OF FINDINGS**

Since Sri Lanka's product strengths lay in core basic garments and lingerie, manufacturers were mostly sheltered from the trend towards fast fashion and the consequent unpredictability in orders and frequent style changes. Orders for core basic garments tended to be long-running and there were fewer style changes from season to season.

Sri Lanka had experienced the effects of global shift of production to lower labour cost countries such as Cambodia, India and Vietnam. However, using CSR as a differential advantage, it promoted itself as a low-risk sourcing destination on the basis of its ethical credentials. However, Company A and C had noted the unrelenting movement of the market and in order to combat losing business to lower labour cost countries, had recently set up operations in India to take advantage of the lower labour costs their customers sought.

The buying practices identified by previous authors as contributing to poor ethical standards in garment supply chains (Laudal, 2010; Hearson, 2009; FIDH, 2008; Responsible Purchasing Initiative, 2006; Pan and Holland, 2006; Ancona, 2004) were less apparent in the Sri Lankan context due to the presence of counterbalancing factors, as detailed below:

- Communication barriers were low, since English was widely spoken and in addition levels of literacy and education were high.
- A SCM philosophy was evident, with the long-term nature of the trading relationships and the level of trust, commitment and collaboration between manufacturers and retail customers.
- The prevalence of vertical integration in supplier companies ensured a good level of supply chain visibility. In addition, there was no culture of homeworking as is commonly found in parts of India and Bangladesh, where factories outsource production to workers in their homes, resulting in poor visibility of the supply chain and in particular a lack of control over the use of child labour. Outsourcing of production was not prevalent, notwithstanding the fact that one of the companies was a subcontractor for other Sri Lankan manufacturers. Interviewees gave the reason of lack of control over quality aspects for the reluctance to outsource production. However, this enabled retailers to rest assured that orders placed with their suppliers would likely be completed within the boundaries of that supplier firm. Vertical integration also helped manufacturers meet the challenge of their retail buyers' demands for shorter lead time: by offering a full service package including product design and development, as well as having the capabilities to produce fabric and trimmings in-house, the larger companies were able to compress and control the time factor (Pan and Holland, 2006).
- In line with findings by Ancona (2004), the competence and quality of local factory management as well as the far-sighted perspective of the Sri Lankan factory owners facilitated the development of trust and the long-term partnership approach to the trading relationship, and hence supported the existence of good standards of CSR. The competence and quality of management, in addition to the size of some of the case study companies, restored some of the power imbalance typical of the garment industry whereby large retailers dominate small suppliers (Bruce *et al.*, 2004).
- Labour intensity of manufacture in fact was a positive driver of CSR: factory management recognised that workers were the key organisational resource and as such required nurturing and protection from harm. Several companies found that as working conditions improved and working hours were reduced, production efficiency

increased while labour turnover and absenteeism decreased. Respecting the dignity of employees thus resulted in higher levels of commitment and loyalty to the firm. Company A referred to its employees as ‘associates’ rather than ‘workers’, and disabled people were referred to as ‘differently-abled’ in recognition that their contribution was valued as much as that of the able-bodied.

- Sri Lankan culture and the Buddhist philosophy appeared to provide a strong underpinning foundation for the concept of CSR. Some factories had been practising CSR long before codes of conduct were established. The Chairman of Company B for example, had provided his workers with free breakfast for the past 30 years since his business began, and this had since become common practice throughout the industry. The Senior Operations Manager in Company A felt the influence of Buddhist culture on CSR to be so strong that a large proportion of ethical practices would be followed even without CSR rules and regulations. Sri Lankan culture and the Buddhist philosophy was aligned with the Kantian moral imperative not to use human beings as a means to an end, but to grant them dignity and respect in their employment.

The larger companies had greater resources to invest in CSR initiatives; however, once the investment produced a return in terms of increased efficiency, commitment and loyalty from employees, as well as reduced energy costs, this initial success then drove further investment. This corresponds with the literature which concludes that the direction of causality between CSR and increased financial performance remains unclear (Jenkins, 2006; Vogel, 2005; Marom, 2006), but nevertheless there are many intangible benefits such as improvement and/or protection of corpo-

rate reputation as well as reduced labour turnover and increased employee motivation.

The most important supporting factor for CSR in the Sri Lankan context appeared to be the long-term partnership approach to buyer-supplier trading relationships, which corresponds with literature on the subject (CIPS, 2008; Acona, 2004; Responsible Purchasing Initiative, 2006; Hearson, 2009). Secondly, the high level of education and managerial ability enabled garment manufacturers to understand and implement CSR. The Head of Sustainable Business at Marks & Spencer alluded to the far-sighted, high quality management in Sri Lankan garment suppliers, while the Director of (Sri Lankan) Operations in Company E spoke of how education levels and social upbringing in Sri Lanka helped to support the implementation of CSR:

*“The upbringing and education levels of people in Sri Lanka are very good, even today the rural girls are very educated ... So I think it plays a major role. I would say the people understand what (CSR) is all about”.*

Thirdly, the CSR concept was closely aligned with the Buddhist philosophy and its tenets of moral discipline and ethical behaviour, and therefore was a familiar concept to both Sri Lankan managers and workers, thus facilitating its implementation.

## **FUTURE RESEARCH DIRECTIONS**

CSR is gaining momentum and there is a movement towards institutionalisation of the concept. A number of internationally recognised CSR accreditations now exist which provide a way for garment manufacturers to certify their businesses as ethically sound. These include WRAP, SA8000 and CSC900T. In addition, the forthcoming ISO26000, designed to promote a common understanding of CSR, represents further institutionalisation.



Future issues for apparel companies identified by Ansett (2007) include the need to provide deeper assurance into supply chains, the potential of full supply chain disclosure requirements and the adoption of a common code of conduct. Brands and retailers will continue to face increasing stakeholder expectations as the competitive environment evolves and stakeholders gain greater awareness of the issues facing the garment industry. This suggests that further CSR research is needed within other national contexts in global garment supply chains. In addition, conducting quantitative analysis may yield additional insights on socially responsible supply chain management (see e.g. Cruz and Wakolbinger, 2008; Bonney and Jaber, 2010), for example by modelling the effect of CSR on transaction costs and supply chain risk.

## CONCLUSION

As a challenge to globalisation, CSR centres on balancing the acceptance that developing nations need low-tech industries which employ large numbers of workers and that low wages are necessary to create more jobs and fuel income growth with the promotion of human dignity, individual choice and democracy (Sethi, 2003). The maxim for globalisation must be heedful of the poor as well as the powerful and must reflect a basic sense of decency and social justice (Stiglitz, 2002).

In terms of garment supply chain management, Wright *et al.*'s (2008, p.64) assertion that "outsourcing, sourcing location and supplier selection adversely impact value creation and perceptions of the organisation" demonstrates the importance of CSR to long-term business sustainability. The research in Sri Lanka provides an insight into how certain characteristics of the buying function in garment supply chains impede CSR implementation. However, understanding CSR in terms of the moral argument, the business case and its contribution to sustainable

development increases the likelihood that CSR is embedded within the management philosophy and organisational culture. When CSR is embedded within the entire organisation, rather than being just another corporate function or staff activity, there is greater likelihood that CSR practices will cascade throughout the supply chain (Andersen and Skjoett-Larsen, 2009).

Furthermore, the principles and practices of SCM counterbalance obstacles to CSR in the garment supply chain. The development of long-term partnerships characterised by trust and commitment helps to reduce the likelihood of ethical transgressions and hence results in a reduction in sourcing risk, compared to short-term price-based sourcing arrangements which are focused on lowest labour cost. Sourcing from full package suppliers that demonstrate a commitment to collaborative ways of working may help to compress lead times without compromising factory working conditions. High quality management and low communication barriers in the supplier country increase the likelihood that the concept of CSR will be understood and embedded within the supplier's business in a holistic manner, rather than a superficial compliance-based implementation. Additionally, a partnership approach that encourages collaboration on CSR initiatives is more likely to promote supplier engagement with CSR issues than coercive compliance-based mechanisms.

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## KEY TERMS AND DEFINITIONS

**Board of Investment (BOI):** A Sri Lankan government agency which promotes industrial investment and is responsible for promoting, approving and assisting industrial foreign investment in the country for export-oriented projects.

**CSC900T:** Chinese national CSR standard for the textile and apparel sector.

**Export Processing Zone (EPZ):** A geographical area offering incentives and a barrier-free environment for export-oriented production.

**ISO26000:** A global standard offering guidance on socially responsible behaviour although since it does not contain requirements, it is not certifiable.

**Leadership in Energy and Environmental Design (LEED):** An internationally recognised green building certification system developed by the US Green Building Council.

**LTTE:** Liberation Tigers of Tamil Eelam (Tamil Tigers).

**Open-Book Accounting:** A practice whereby suppliers make their confidential cost sheets,

including profit margins, available to buyers to enable the latter to advise on where costs can be reduced in order to achieve targets.

**Standard Allocated Minutes (SAM):** The time required for all the component actions involved in sewing a garment.

**SA8000:** A global and verifiable social accountability standard to make workplaces more humane, developed and overseen by Social Accountability International. Combines key elements of ILO (International Labour Organisation) conventions with the management systems of ISO (International Organisation for Standardisation).

**Small or Medium-Sized Business (SME):** Typically characterised by an employee count of fewer than 500 persons, limited resources and a lack of separation between ownership and management.

**Sustainable Development:** “Development which meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987).

**Vendor Managed Inventory (VMI):** Supplier monitors inventory levels at its customer’s warehouses and takes on responsibility for inventory replenishment according to specified targets, via the use of automated electronic messaging systems.

**Worldwide Responsible Apparel Production (WRAP):** A global and verifiable certification of lawful, humane and ethical manufacturing.

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