

**The Reverse Logistics Process in the Supply Chain and Managing Its  
Implementation**

by

Joseph Raymond Huscroft, Jr.

A dissertation submitted to the Graduate Faculty of  
Auburn University  
in partial fulfillment of the  
requirements for the Degree of  
Doctor of Philosophy

Auburn, Alabama  
December 13, 2010

Keywords: reverse logistics, retrograde logistics, supply chain management, returns management, recycling, remanufacturing, green supply chain, reverse supply chain

Copyright 2010 by Joseph Raymond Huscroft, Jr.

Approved by

Dianne Hall, Co-Chair, Associate Professor of Management  
Joe Hanna, Co-Chair, Professor of Aviation and Supply Chain Management  
Wesley Randall, Assistant Professor of Aviation and Supply Chain Management

## Abstract

Increased competition caused by globalization and rapid technological advances has driven organizations to address and make efforts to improve efficiency in their supply chain. Increasing efficiency in reverse logistics processes such as the recovery of the returned products or disposal of end-of-life products is one way in which firms attempt to maintain and increase competitiveness and market share. The volume and monetary value of product flowing in the reverse direction within the supply chain has been and continues to be increasing, particularly as environmental, legal, and customer service requirements increase throughout the marketplace (Guide Jr, Souza et al. 2006). It has been reported that the value of product returns in the commercial sector have exceeded \$100 billion annually (Stock, Speh et al. 2002; Guide Jr, Souza et al. 2006). This process of returning products back through the supply chain is the reverse logistics process and it may encompass several different logistics activities.

This research effort is actually a compilation of three related research efforts. The first study focuses on the status of the reverse logistics field across multiple disciplines; logistics, operations management, information systems, environmental economics, and business management. The state of the field then provides the structure for a Delphi study on the key factors in a reverse logistics process. This Delphi ranking highlights possible shortcomings in the framework and provides insight into the priorities of practitioners.

The second paper analyzes the impact information systems, technologies, and innovation has on the reverse logistics process. It analyzes the information technology capabilities, compatibilities and technologies utilized in the organization and their relationship with reverse logistics performance in the areas of two measures, cost effectiveness and process effectiveness.

The final research paper addresses reverse logistics performance metrics within an organization. There is a lack of empirical research regarding reverse logistics metrics, especially in the area of determining if the metrics currently being utilized by practitioners are meeting the information needs of the organizations and the managers who make the resource allocation decisions. There is a need to assess the information reporting abilities of the key reverse logistics metrics in an organization and what aspect of information reporting are they providing.

When the three research projects are brought together, they represent one, unique research effort. This effort analyzes various key aspects of the reverse logistics process to include effectiveness of metrics, information systems impact on performance, and practitioners input on key factors impacting reverse logistics processes and how well they compare with the established reverse logistics framework.

## Acknowledgements

I would like to express my sincerest love and gratitude to my beautiful, loving wife and our amazing and sweet child. You both continue to warm my heart with your faithful love and commitment. You have kept me focused, driven, and allowed me to get the job done. I truly thank God daily for blessing me with such an incredibly fun and loving family.

I also want to express my sincere appreciation and gratitude to Dr. Dianne Hall and Dr. Joe Hanna for their dedication, guidance and mentorship throughout the Doctoral program. I am truly blessed to have two mentors and committee co-chairs with such strong belief in me and my abilities. Thank you for your perseverance with me throughout this process and successfully guiding me throughout this program. I am truly blessed.

This dissertation represents the culmination of countless influences and continued encouragement from family, friends, colleagues, and professors. I also want to thank the other member of my dissertation committee, Dr. Wesley Randall for his helpful suggestions and guidance. Finally, I want to thank the United States Air Force for providing me the incredible opportunity to pursue a lifelong dream.

**The views expressed in this dissertation are those of the author and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the United States Government.**

## Table of Contents

Abstract .....	ii
Acknowledgements .....	iv
List of Tables.....	viii
List of Figures .....	x
Chapter 1. Introduction .....	1
Chapter 2. State of the Reverse Logistics Field: Key Factors Driving its Performance and Implmentation.....	6
Abstract .....	6
Introduction .....	7
Motivation for Research.....	9
Research Design.....	12
Journal selection.....	12
Criteria for article selection.....	14
Categorization of articles .....	16
Methodology .....	25
Analysis and Results .....	28
Measuring Consensus.....	33
Public sector vs. private sector.....	33
Limitations .....	35
Discussion and Implications.....	36

Contribution of this study.....	51
Chapter 3. Information Systems Support as a Coordination Tool of the Reverse Logistics Systems Process.....	54
Abstract .....	54
Introduction.....	55
Motivation for Research.....	57
Theoretical Foundation of the Research.....	59
Information technology.....	59
Information system support capability.....	62
Information system support compatibility .....	63
Information system technologies .....	64
Information systems technology implementation .....	65
Reverse logistics process innovation.....	66
Methodology .....	69
Participants.....	70
Measures.....	72
Model estimation.....	79
Discussion .....	82
Contribution of the Study and Future Research .....	85
Limitations .....	87
Chapter 4. Performance Metrics and the Reverse Logistics Process .....	89
Abstract .....	89
Introduction.....	90

Methodology .....	97
Participants .....	98
Results and Discussion.....	100
Reverse Logistics Objectives and Goals .....	101
Reverse Logistics Metrics Utilized .....	105
Reverse Logistics Challenges.....	106
Contribution of this Proposed Study .....	108
Limitations and future research.....	109
Chapter 5. Conclusions .....	111
References .....	118
Appendix A: Reverse Logistics Information Systems and Performance Survey .....	134
Appendix B: Example of Survey instrument for assessing reverse logistics performance measures .....	138

## List of Tables

Table 2.1 Journals reviewed.....	14
Table 2.2 Article Publication Trends .....	16
Table 2.3 Data Collection Approach.....	19
Table 2.4 Framework Constructs .....	22
Table 2.5 Background of Panel Members for all three Delphi rounds .....	29
Table 2.6 Challenges of Logistics Managers Regarding Reverse Logistics .....	30
Table 2.7 Weighted Average Ranking of the Factors Following Round 2 .....	31
Table 2.8 Ranking of the Factors Following Round 3 .....	32
Table 3.1 Summary of Hypotheses .....	68
Table 3.2 Respondent Knowledge .....	71
Table 3.3 Respondent Experience.....	71
Table 3.4 Respondent Position.....	71
Table 3.5 Respondent Industry.....	72
Table 3.6 Respondent Type of RL Function .....	72
Table 3.7 Respondent Type of RL Function .....	72
Table 3.8 Utilized Constructs.....	75
Table 3.9 Factor Analysis of Construct Items.....	76
Table 3.10 Common Method Bias .....	78
Table 3.11 Hypothesis Results for Model 1 .....	80



Table 3.12 Hypothesis Results for Model 2.....	82
Table 4.1 Reverse Logistics Metrics.....	93
Table 4.2 Respondent Knowledge.....	99
Table 4.3 Respondent Experience.....	99
Table 4.4 Respondent Position.....	99
Table 4.5 Respondent Industry.....	100
Table 4.6 Respondent Type of RL Function.....	100
Table 4.7 Reverse Logistics Metrics Reported by Respondents.....	105
Table 5.1 Reported Metrics Utilized by Practitioners.....	116

## List of Figures

Figure 2.1 Primary purpose of the published research.....	19
Figure 2.2 Data Collection Method Utilized.....	21
Figure 2.3 Reverse Logistics Construct and Framework.....	23
Figure 2.4 Framework constructs & utilization in reverse logistics literature.....	24
Figure 3.1 Reverse Logistics Performance and Information Technology Model.....	70
Figure 4.1 Reverse Logistics Metrics Concepts.....	101

## Chapter 1

### Introduction

The ability of a firm or organization to handle the processing of product and material returns has quickly become key and critical logistics process. The volume and monetary value of product flowing in the reverse direction within the supply chain has been and continues to be increasing, particularly as environmental, legal, and customer service requirements increase throughout the marketplace (Guide Jr, Souza et al. 2006). It has been reported that the value of product returns in the commercial sector have exceeded \$100 billion annually (Stock, Speh et al. 2002; Guide Jr, Souza et al. 2006). This process of returning products back through the supply chain is the reverse logistics process and it may encompass several different logistics activities. These activities can include disposition determination, recycling, remanufacturing, disposal, re-sale, warehousing, or transportation; depending on the type of product or material being returned. Some of the reverse logistics activities have a counterpart in the forward distribution channel, but the difference primarily lies in the disposition activities and final action regarding the product.

A firm that can develop and properly monitor reverse logistics processes in product returns and reverse logistics can be a mutually beneficial situation for both the firm and the customers (Stock and Mulki 2009). Increasing the understanding of the factors related to reverse logistics and product returns can assist in identifying areas in

supply chain management and manufacturing where changes in the reverse logistics process might be needed.

Therefore, maintaining an effective and efficient reverse logistics process has moved to the forefront as a key capability for logistics and manufacturing firms. An effective and standardized reverse logistics process can give a firm the necessary competitive advantage to move above peers and competitors, and possibly capture larger market share within their industry because of their superior process and being able to meet the demands of the customers. Today's customer expects and demands to be able to return a defective or unwanted product smoothly and quickly, and receive a refund or correct order as fast and inexpensively as possible. A firm that is able to meet these increasing customer requirements is going to gain customer loyalty and retain, and perhaps increase, their overall market share.

This is a key factor as to why management within a firm needs to focus necessary resources on the reverse logistics process and properly monitor and measure their reverse logistics processes. The possible penalties for not adequately addressing the reverse logistics needs of the firm could be increased transportation costs, increased inventory and warehousing costs, increased repair costs of returned products, and lost secondary value of defective products or materials due to processing delays in the reverse logistics process.

This is a main reason that reverse logistics processes and their management have increased in importance within the business community and academia (Carter and Ellram 1998; Blumberg 1999; Dowlatshahi 2000; Rogers and Tibben-Lembke 2001; Mason 2002). Because the area of reverse logistics can have a number of different viewpoints or

driving factors, it is essential to establish a baseline definition for the purposes of this research effort. The work of Rogers and Tibben-Lembke established a reverse logistics process definition that is fairly all-encompassing and has been adopted by a majority of the field:

The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing or creating value or proper disposal (2001).

This definition establishes the foundation and framework from which this research will build upon.

This research effort is a compilation of three related research efforts. The first study focuses on the status of the reverse logistics field across multiple disciplines; logistics, operations management, information systems, environmental economics, and business management. The state of the field then provides the structure for a Delphi study on the key factors in a reverse logistics process. Key industry logistics practitioners took part as a panel to determine and prioritize the key factors in a reverse logistics process. Their factors and rankings are compared to the framework established by Carter and Ellram (Carter and Ellram 1998). This comparison highlights possible shortcomings in the framework and provides insight into the priorities of practitioners compared to those outlined in the model.

The second paper in this dissertation analyzes the impact information systems and technologies have on the reverse logistics process and its performance. It analyzes the information technology capabilities, compatibilities and technologies utilized in the

organization and their relationship with reverse logistics performance in the areas of two measures, cost effectiveness and process effectiveness.

The final research paper addresses reverse logistics performance metrics within an organization. There is a lack of empirical research regarding reverse logistics metrics, especially in the area of determining if the metrics currently being utilized by practitioners are meeting the information needs of the organizations and the managers who make the resource allocation decisions. There is a need to assess the information reporting abilities of the key reverse logistics metrics in an organization and what aspect of information reporting are they providing. When the three research projects are brought together, they represent one, unique research effort. This effort analyzes various key aspects of the reverse logistics process to include effectiveness of metrics, information systems impact on performance, and practitioners input on key factors impacting reverse logistics processes and how well they compare with the established reverse logistics framework.

The goal of this dissertation is to develop a stronger understanding of the role and key factors that influence the reverse logistics process in an organization in the context of the supply chain. The dissertation has five chapters and these chapters will deviate from the traditional dissertation format. Chapter 1 outlined the introduction to the reverse logistics process and the importance it can have on firm efficiency, performance and customer support and satisfaction. Chapters 2, 3, and 4 are comprised of three separate research efforts focused on the reverse logistics process. Even though they are distinct from each other, they are all related and provide support for each other and assist in developing final conclusions and areas for future research. Chapter 5 concludes this

dissertation. It ties the three research papers together, summarizes the results regarding reverse logistics, outlines its contribution to the field of study, and highlights possible areas of future research in the reverse logistics area.

## Chapter 2

### State of the Reverse Logistics Field:

#### Key Factors Driving its Performance and Implementation

##### Abstract

Increased competition caused by globalization and rapid technological advances has driven organizations to address and make efforts to improve efficiency in their supply chain. Increasing efficiency in reverse logistics processes such as the recovery of the returned products or disposal of end-of-life products is one way in which firms attempt to maintain and increase competitiveness and market share. This study describes and analyzes the key characteristics of research on reverse logistics. However, the varied disciplines and perspectives from which reverse logistics research arises complicate the efforts of those seeking to develop a comprehensive understanding of the subject.

This study provides a multidisciplinary review of the existing literature and assesses the progress of reverse logistics research as it pertains to these five fields of research: operations management, logistics, information systems, environmental economics, and business management. This phase allowed for the identification of research gaps and areas needing inspection. In the next phase, the study utilized a Delphi technique to determine what key logistics practitioners thought were driving factors in the reverse logistics process development and implementation. These key factors are then



compared to the reverse logistics construct framework as developed by Carter and Ellram (1998).

The Delphi technique produced 7 ranked, key reverse logistics factors, determined by logistics practitioners. They would be: Customer support, top management support, communications, costs, having a formalized program, timing of operations, and environmental issues. When these 7 key factors are compared to Carter and Ellram's (1998) framework, 5 of the 7 factors directly relate to one of the 9 constructs. The two factors not represented are cost and having a formalized program.

### Introduction

In today's globalized and fast paced economy, competition is driving companies to address the importance and impact of the reverse logistics processes on firm performance. Customers expect more from manufacturers, retailers, and service providers in regard to return policies, and companies are seeking to attain as much value out of any returned product (Daugherty, Autry et al. 2001). Customers can return products for any number of reasons and the firm must be prepared to handle and process the return in a timely manner to ensure they are maintaining adequate customer satisfaction levels and increase the likelihood of future transactions. The reasons for return can range from shipping the wrong product or quantity, goods damaged in shipping, receiving and repairing products for re-sale, or environmental issues (Richey, Chen et al. 2005). A key factor firms need to focus resources on the reverse logistics process is that it can have a dramatic monetary impact on the bottom line of the organization. It is estimated that approximately 4.5% of all logistics costs within the United States stem from reverse logistics activities (Richey, Chen et al. 2005).

As with any organization, processes that take away from potential profit or put a drain on limited resources will gain the watchful eye of management in an attempt to rein in costs and streamline the process. It is this reason that field of reverse logistics has increased in importance within the business community and academia (Carter and Ellram 1998; Blumberg 1999; Dowlatshahi 2000; Rogers and Tibben-Lembke 2001; Mason 2002). Now that a foundation for the importance of the reverse logistics process has been established, it is necessary to discuss the roles that reverse logistics plays in an organization and how important a process it is.

The reverse logistics process in an organization consists of primarily two aspects; returning a product and returning packaging to the point of origin or manufacture (Rogers and Tibben-Lembke 2001). Studies have shown that products are either returned to the point of distribution or manufacturing to deal with the end of life of the product for refurbishment, recycling, or disposal (Andel 1997; Carter and Ellram 1998; Blumberg 1999; Rogers and Tibben-Lembke 2001; De Brito and Dekker 2003). Another factor of the reverse logistics process is that it is nearly always part of a closed-loop system. In this type of system, product or packaging flows outbound to a customer and the same assets flow in the reverse channel, usually in an altered state or condition (Jayaraman and Guide Jr 1999; De Brito and Dekker 2003).

Firms realize that the reverse channel is a target for gains in efficiency and reduction of costs. Businesses have started to focus on the reverse channel and started operating it as a value added center and using their reverse process as a differentiator (Stock 2001). This differentiation should allow them to gain/maintain market share, add revenue, and possibly reduce transportation and inventory costs through the continual monitoring and gained efficiencies of their reverse logistics process (Daugherty, Myers et

al. 2002). This increased focus on the reverse logistics process has started moving organizations beyond just customer service with the timely delivery of a product, but to total customer satisfaction; moving beyond the initial transaction to ensuring the customer's needs are cared for if the product needs returned or exchanged (Mason 2002).

### Motivation for Research

Because of this increase of focus by firms and logistics managers, it is a field that has been and continues to receive increased interest in the last few years. Product returns have been shown to constitute anywhere from 15% of manufacturers and merchandisers all the way to 35% for e-commerce industries (Gentry 1999). The reverse flow of product, materials, and packaging returns are part of the field of reverse logistics and include, but not limited to, the activities of recycling, refurbishing, remanufacturing, reselling, disposing, and repair (Stock 2001).

Because the reverse logistics field is just in its infancy, there has not been a lot of academic research on the topic. Practitioner related articles and process improvement guides have been at the forefront of informing firms how to be environmentally conscious, meet customer returns needs, and develop effective remanufacturing processes. This falls in-line with the findings of Carter and Ellram (1998). Their analysis found the majority of research on reverse logistics was practitioner related and very little research was available on the academic aspect regarding developing frameworks and constructs. It appears that Carter and Ellram's framework development and call for increased academic rigor regarding reverse logistics was heard. It is within the last number of years that empirically based reverse logistics research has been performed and published (Daugherty, Autry et al. 2001; Daugherty, Myers et al. 2002;

Daugherty, Richey et al. 2005; Dhanda and Hill 2005; Richey, Genchev et al. 2005; Mollenkopf, Russo et al. 2007). This increase in research reinforces the growth of reverse logistics as a key strategic capability for any organization that deals with customers and products. One thing missing from the recent literature is a comparison or test between the constructs in Carter and Ellram's framework and the priorities and important factors, as deemed by practicing logisticians in today's marketplace. There is a need for academics to gain a stronger and clearer understanding of the reverse logistics constructs, performance measures, and necessary levels of resource commitment required of logistics managers and top management within an organization.

This need to examine key constructs, measures, and levels of resource commitment validates the necessity for a multi-disciplinary review of the academic literature. Being aware of what the top journals have published, what constructs have been analyzed, what methods have been used and what analysis tools have been implemented helps to develop a foundation for advancing knowledge, guiding future research, and facilitates future theory development (Webster and Watson 2002).

Furthermore, there is a need to assess and analyze the reverse logistics process through the inputs of logistics practitioners which allows for a more comprehensive view of the reverse logistics process. Utilizing the Delphi technique allows for broader practitioner input and consensus building and will therefore contribute a more comprehensive view of the reverse logistics process and its key factors. Using the results of the Delphi technique and comparing them with the framework of Carter and Ellram the researcher will identify agreements and shortcomings in the model as compared to the needs of logistics managers.

Based on this increased interest in the reverse logistics process, the researcher has collected and analyzed the main attributes of these academic, reverse logistics studies to determine what constructs have been researched and to identify gaps within the literature to guide future research. Reverse logistics entails such activities as routing, scheduling, and information sharing; it also has close relationships with operations management, information systems, environmental economics, and business management fields of research. Because of this diversity of research fields for the topic of reverse logistics, a multi-disciplinary analysis of reverse logistics research was performed to assist in identifying research gaps and highlighting research opportunities. Part 2 of this research steps off from the multi-disciplinary research review to question logistics practitioners on what they determine are key factors in the reverse logistics process. The need to determine logistics practitioners key reverse logistics concerns serve as the motivation for this study.

Because the breadth of this research encompasses five different disciplines, it had to be scaled to ensure appropriate levels of thoroughness for the literature review and to be useful to both academic researchers and practitioners. The literature analysis on reverse logistics research was limited to articles published in the leading journals in the above mentioned fields. This decision makes the review manageable and reflects top published researchers and their articles in each field. The literature review seeks to collect, classify, and analyze the journal articles to provide a more integrated perspective on the direction academic reverse logistics research is headed and identify areas for future research.

This analysis provides an expansion of knowledge on the field of reverse logistics and also determines where gaps remain in the literature. After reviewing the literature and determining the current state of research and identifying possible gaps, the researcher used the Delphi technique to determine the ranked key factors to the reverse logistics process, as determined by practitioners. These key factors are contrasted to the reverse logistics framework of Carter and Ellram (1998). The comparison allowed for an assessment of the validity of the framework in today's logistics environment, 11 years later, and highlights any areas that may need added to the framework, based on practitioners' judgments. From the comparison of the practitioners key factors to the framework proposed by Carter and Ellram (1998) propositions were developed to explain key characteristics between the two and provide a basis for future hypothesis testing.

#### Research Design

An in-depth review of the reverse logistics literature was completed to analyze the progress of research, identify potential gaps in the literature, and lay groundwork for future reverse logistics research. In an effort to be as thorough as possible, the researcher analyzed the top journals in logistics, operations management, information systems, environmental economics, and management.

*Journal selection.* Due to its diversity of operations and activities, the reverse logistics process spans across a number of different research fields. The process operates within the supply chain domain, but it has facets of production planning, scheduling, transportation networks, information collection and transmittal, recycling, hazardous materials disposal and handling, management support for resource allocation, training and education of personnel, and customer service. To ensure comprehensiveness top

academic journals in the fields of logistics, operations management, information systems, environmental economics, and business management were examined. Published articles within each field were used to determine the leading journals. Top logistics journals were provided by Gibson and Hanna (2003), Barman, Hanna, and LaForge (2001) provided operations management journal rankings, the Association for Information Systems website (AIS 2009) included journal rankings for information systems, environmental economics journal rankings were provided by Rousseau (2007), and Harzing (2008) provided the top business management journals. Journals ranked among the top journals in two or more disciplines, were included in only one discipline.

Table 2.1 presents a complete listing of the reviewed journals.

Practitioner focused journals were not included because they usually lack the in-depth discussion on methodology and analysis of the research; this would include the Harvard Business Review, as an example.

Table 2.1

*Journals reviewed*

<b>Logistics</b>	<b>Operations Management</b>	<b>Information Systems</b>	<b>Environmental Economics</b>	<b>Management</b>
Journal of Business Logistics	Journal of Operations Management	Management of information Systems Quarterly	Journal of Environmental Economics and Management	Strategic Management Journal
International Journal of Logistics Management	Production and Operations Management	Information Systems Research	Ecological Economics	Academy of Management Journal
International Journal of Physical Distribution & Logistics Management	Operations Research	Management Science	Resource and Energy Economics	Strategic Organization
Decision Sciences	International Journal of Production Research	Journal of Management Information Systems	Energy Journal	Organization Science
Supply Chain Management Review	International Journal of Operations and Production Management	European Journal of Information Systems	Environmental and Resource Economics	Journal of Management
Transportation Research: Part E	European Journal of Operational Research	Decision Support Systems	Environment and Development Economics	
Transportation Journal	Management Science		American Journal of Agricultural Economics	
Naval Research Logistics				

*Criteria for article selection.* This literature review focuses on a seventeen year window of reverse logistics research from 1992 through 2009. 1992 was chosen because this was the year Stock published his white paper on reverse logistics (Stock 1992). The selection of articles was not limited to empirical based research only. Because of the nature and immaturity of the reverse logistics field, all types of research papers were included, such as mathematical modeling projects and conceptual/framework building articles.



Using the outlined publication and time period constraints, electronic database queries for pertinent journal articles was performed. The literature search was limited to the use of the keywords, “reverse logistics”, “product recovery”, and “green logistics”. These sets of keywords allowed for maximum coverage of the reverse logistics concept in the varying journals and disciplines reviewed. This article query resulted in 92 articles. Each article was analyzed to confirm that its focus was indeed on reverse logistics. At this point it is important to mention that of the Environmental Economics journals searched, only three articles were found, spanning two journals. Also, zero articles were discovered within the business management journals reviewed. This could be explained by the immaturity of the reverse logistics field; it has not yet become an important topic in the top management journals. It could also be explained by the applied nature of a number of the articles analyzed, lending them to the more practitioner or mathematically oriented academic journals versus general topic journals.

The article selection criteria described resulted in a total of 92 articles for analysis. As shown in Table 2.2, the analysis of the articles published each year reveal an upward trend. Academic interest in reverse logistics has grown, so it is not surprising that an increasing number of articles are being written on reverse logistics and its impact on the supply chain.

Table 2.2

*Article Publication Trends*

<b>Year</b>	<b>Articles</b>	<b>Percent</b>
1992	0	0
1993	0	0
1994	0	0
1995	3	3.7
1996	1	2.4
1997	2	1.2
1998	1	1.2
1999	2	1.2
2000	4	3.7
2001	8	9.8
2002	7	7.3
2003	7	8.5
2004	6	6.1
2005	13	15.9
2006	14	15.9
2007	11	9.8
2008	10	11.0
2009 (Jan only)	3	2.4
Total	92	100

Based on this increasing interest and trend the researcher can assess that the interest of the academic community in this research topic has grown, contributing to its maturity and development. After the articles were collected, there were analyzed for content and aspect of reverse logistics addressed. These categorizations are covered in the next section.

*Categorization of articles.* The first step was to determine the type of academic research being performed. Based on the work of Gupta, et al, (2006), the articles were analyzed and placed into one of four categories: empirical research, modeling and analytical research, conceptual or general studies, and surveys or reviews of the field research. This allowed for the separation of empirical research, but also provides a sense of perspective against the rest of the published articles. Empirical research includes any

study that collects data from a source for use in the study. It does not include the use of mathematical models or if it is a review of the literature.

To provide a clearer picture of the types of research that can be expected in each journal, the analysis was partitioned out by journal. A majority of the articles consist of mathematical modeling focused research. This modeling research consists mostly of network transportation problems, evaluating inventory levels, and establishing production planning options in a remanufacturing and recycling environment. Basically, they are applied and attempting to solve practitioner related problems. Over 15% of the studies are conceptual and framework based. Because the field is immature, there needs to be adequate research to establish possible relationships and develop frameworks and propositions for future testing. Finally, 26.1% of the research is empirically founded. It shows there are attempts at testing various frameworks and theories as they relate to reverse logistics and is a positive trend. The field should start moving towards more empirically based research to provide organizations with factors for making decisions about their available resources and their allocation to the reverse logistics process.

After this analysis of the articles, they were then classified as to the primary purpose of the academic research. The categories was adapted from Gupta, et al, (2006) and are: theory building, theory verifying, application, and providing evidence. Because academic based research is being studied, it is important to ascertain the level of theory development of the articles. This analysis provides a grounding of where the published research resides when compared to the relatively young age of the formal field of reverse logistics.

The results of the analysis are shown in Figure 2.1. As expected, most of the research falls within application and providing evidence categories. This was expected based on the age of the field and types of journals analyzed. It highlights a majority of reverse logistics research is still applied research in an operational setting, looking to answer specific problems for specific locations or organizations. This may translate to the results not being very generalizable to the logistics community at large. On a positive note, nearly 20% of the studies test theory and construct relationships within a model or framework. Sixteen percent attempt to build theory and frameworks, but most of this work is not very recent. The review and analysis shows that researchers are attempting to test and validate the proposed frameworks within the field, but not with the numbers that could move theory development forward.

Next, the research articles were categorized based on their data collection techniques and is shown in Table 2.3.

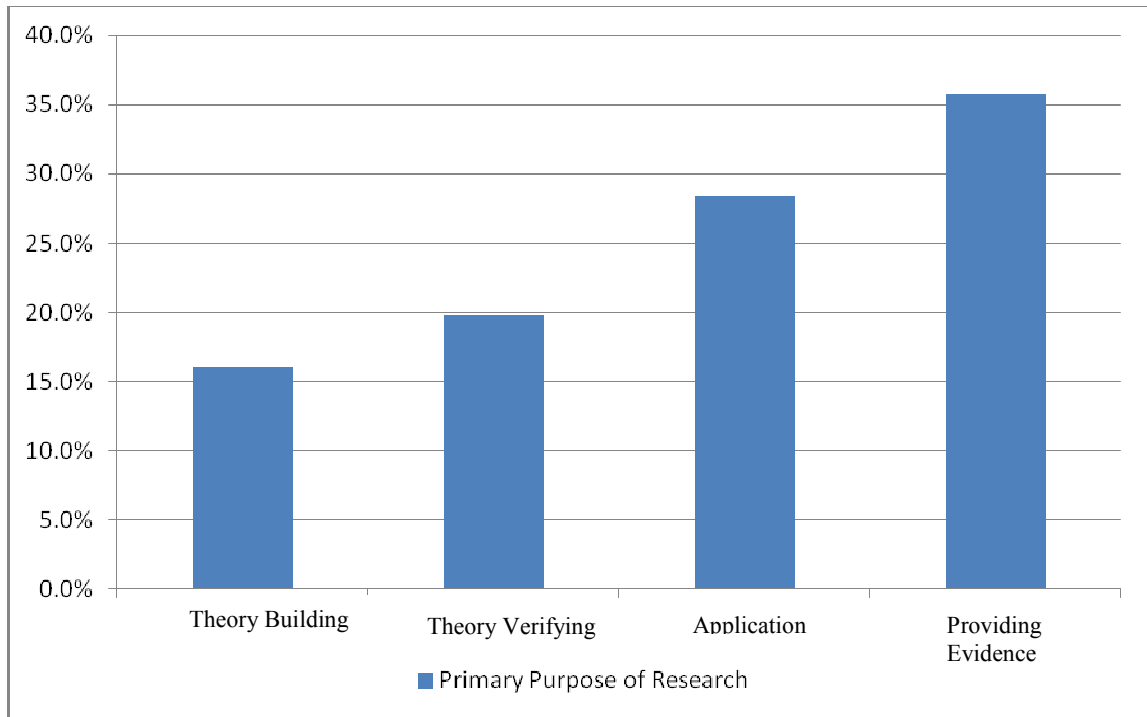


Figure 2.1 Primary purpose of the published research

Table 2.3

*Data Collection Approach*

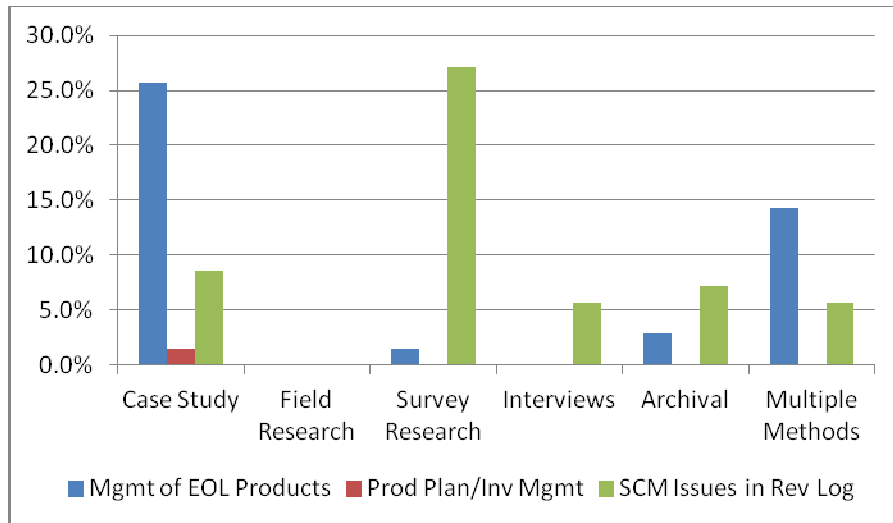
<b>Data Collection Method</b>	<b>Notes</b>
Case Study	Collecting data from one or more organizations over a period of time
Field Research	Collecting data from an organization, on an actual visit, does not require extended time or immersion in the organization
Survey Research	Use of questionnaires to gather data from subjects
Interviews	Face-to-face or over the phone questioning of subjects, can be structured or open ended
Archival	Compiling data from existing sources of information or reports

Adapted from (Gupta, Verma et al. 2006)

The categorization of methodologies are compared to reverse logistics focus area and seen in Figure 2.2. This categorization does not include research articles that rely on building a mathematical model and using it to determine optimal solutions to a problem.

This includes research that required actual data collection to perform an analysis or hypotheses testing.

Survey research appears to be the method of choice when dealing with the reverse logistics process. This data collection approach is expected since reverse logistics processes deal with traditional managerial issues and factors. A survey is a proven technique to collect information from individuals within an organization (Pinsonneault and Kraemer 1993). Surveys generate quantitative descriptions regarding a population of interest with the goal of generalizability in mind (Pinsonneault and Kraemer 1993). Case studies are overly represented in the management of end of life products. Researchers appear to address industry or organization specific problems in this reverse logistics area using case studies. This can originate from someone having contacts with an organization that has had success or failure regarding a process and would make a good candidate for a case study. Case study results are often not as generalizable as survey research, but can provide deep insight into a particular organization and its processes and may have some transferability and generalizability. There appears to be some use of multiple methods within the articles, but it is still minor and is expected at this stage of the field's development. Interviews were present in regards to supply chain management issues, and that should be expected. Asking the key logistics practitioners and managers about their reverse logistics process is a good first step toward determining key factors for success, benchmarking, and establishing frameworks for the field.



*Figure 2.2* Data Collection Method Utilized

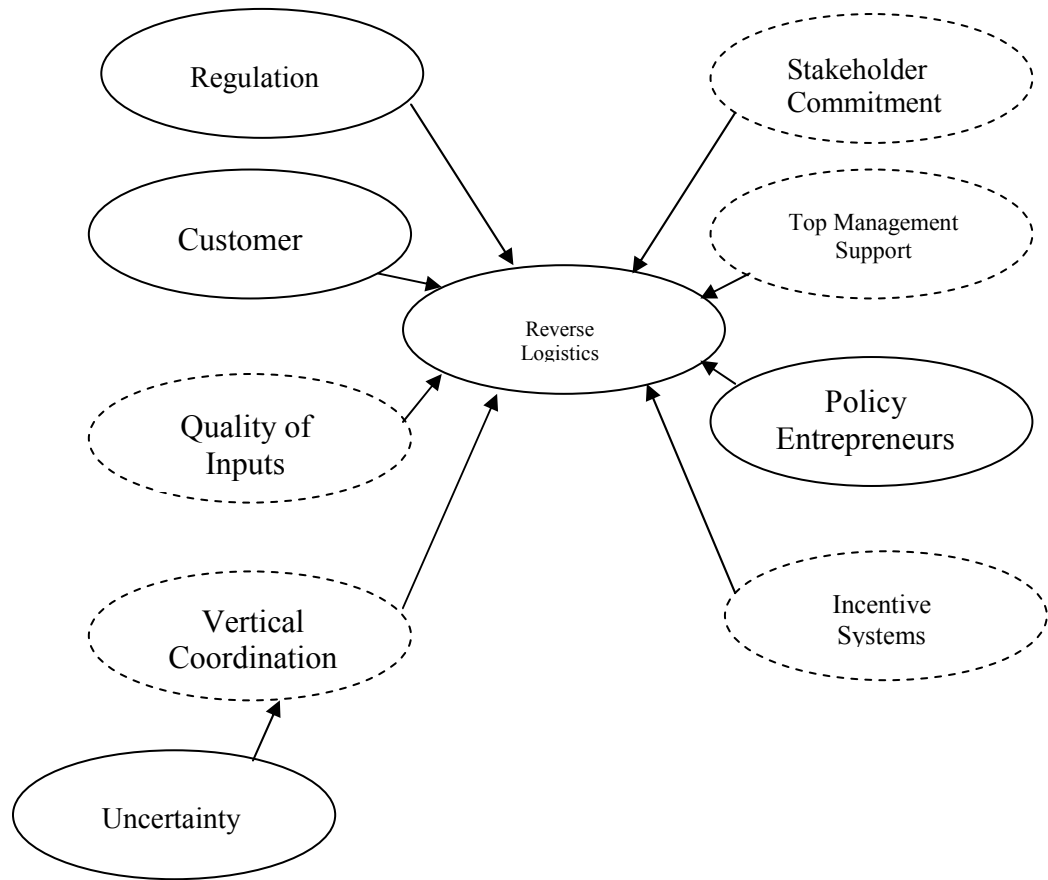
A data collection and analysis technique not present was the Delphi method. This technique has the potential to validate existing constructs and frameworks, or it can highlight missing constructs within existing frameworks of reverse logistics. There is an academic and practitioner need to ensure the requirements of the logistics managers are being appropriately addressed by the academic research, and this would be one method. The last step of the literature analysis is a subjective assessment of each article and how they compare to the framework and constructs established by Carter and Ellram (1998). All articles were reviewed to assess what reverse logistics constructs they addressed, using the framework and constructs proposed by Carter and Ellram (1998). Their framework established 9 constructs to reverse logistics process performance. Each article was reviewed to see which constructs they addressed, if any. The 9 drivers are listed in Table 2.4. If an article discussed and analyzed any of the constructs within the framework, it was categorized appropriately. The model and its constructs are represented in Figure 2.3 and were used as the basis of this analysis.

Table 2.4

*Framework constructs*

<b>Framework Construct</b>	<b>Note</b>
Regulatory Issues	Legislation, regulatory agencies & standards
Customers	Drive demands on the organization; firm must adapt to what the customer desires to remain competitive; includes intermediate customers/retailers
Policy Entrepreneurs	Political and managerial persuaders, gets buy-in from management and stakeholders
Uncertainty	Non-steady demand of returned goods, environmental policy changes, value of returned products
Top Management Support	Helps ensure continued success of the program and processes put in place
Incentive Systems	The process must reward desired behavior regarding employees and partners firms
Vertical Coordination	Reliance between buyers, suppliers, logistics service providers, customers
Quality of Inputs	Green purchasing; high quality, environmentally friendly inputs to production
Stakeholder Commitment	Desire by all members in value chain to advocate and support the process





*Figure 2.3 Reverse Logistics Construct and Framework (Carter and Ellram 1998)*

The results of the framework analysis are shown in Figure 2.4. The graphic displays the 9 constructs within the framework and displays the rate of occurrence among the academic articles reviewed. For example, vertical coordination was a construct of importance just over 13% of the time in the literature reviewed. This is one of the higher utilization rates and supports the need for coordination among firms and personnel within a reverse logistic chain. The chart highlights a fairly even distribution of construct use among the articles. The bottom three in utilization can likely be attributed to the immaturity of the discipline. Green supply chain and reverse logistics practices are fairly new concepts and these are often driven by regulatory pressures. Because there is often not much flexibility in obeying legislation, this construct may be seen as inflexible and

just an assumption in some studies. An incentive system is also an infrequent studied construct. The process is often times automated or driven by strict rules, or not standardized at all. Either extreme does not lend itself to establishing incentive options within the process to encourage entities within the chain to enhance the process. Research is still determining and testing the factors that impact the process and may not be to the point of being able to establish incentives to enhance an unstable and uncertain process.

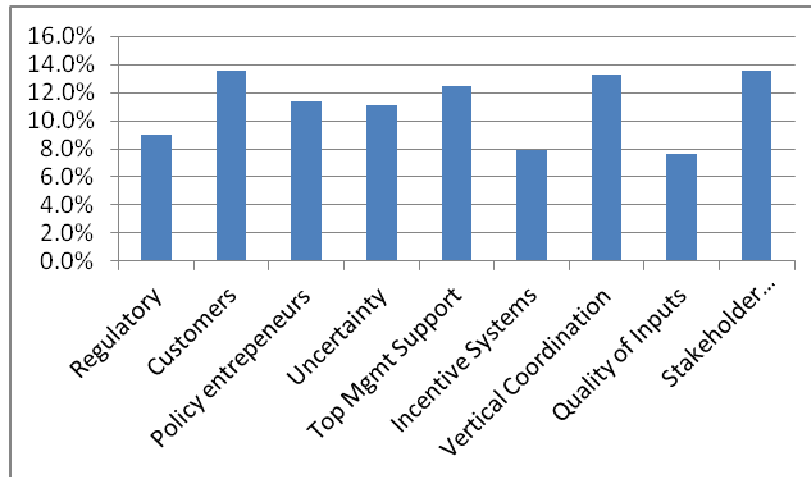


Figure 2.4 Framework constructs and utilization in reverse logistics literature

It appears that the established framework is being adequately and equitably utilized by the reverse logistics academic research analyzed. Areas that are new to the field are underrepresented, but areas that are established in other logistics fields and other disciplines are robustly represented; top management support, coordination, commitment, and customers.

This completes the multi-disciplinary review of the academic reverse logistics literature. It appears that the methods, constructs, and focus areas fall in line with what would be expected for such an immature field. Throughout the literature review, areas

were noted as gaps or opportunities for future research. One gap in the research methodology is the absence of any querying of practitioners for their input on key factors they experience regarding reverse logistics implementation and management. To attempt to fill this gap, the researcher utilized a Delphi technique that surveyed key logistics practitioners. Knowing what practitioners think are the key factors in the process can ensure that academic research is congruent with the key factors perceived in industry. Now that the literature has been thoroughly reviewed and assessed against the framework of Carther and Ellram (1998), obtaining and analyzing the inputs from practitioners regarding their opinion on key factors within the reverse logistics process is needed. What are the key factors, as considered by key logistics practitioners and how do they compare to the established framework set for the by Carter and Ellram (1998).

#### Methodology

This phase of the research began with a request of input from a panel consisting of logistics providers, manufacturers, and military logisticians regarding the reverse logistics challenges they face. The researcher then asked each of the panel members to reach consensus regarding the relative importance of the identified issues. Any identified issues not adequately addressed within the existing body of literature represent opportunities for future research and serve as a guide for future researchers seeking to contribute to the knowledge of reverse logistics management. Also, any factors that do not coincide with the reverse logistics framework are potential new constructs that have evolved over the 11 years since it was established and factors that match up with the framework would serve to bolster the framework from a practitioner point of view.

Due to the qualitative aspect of this study, the Delphi approach was chosen as the best technique for gaining key logistics practitioner input. The Delphi method is applicable for research that deals with uncertainty in an area of imperfect knowledge (Rowe and Wright 1999; Grisham 2009). The Delphi method creates opportunities to gain valuable insight from practicing managers, compare how their practical insights match up with academia, and to identify topics that need further investigation (Malhotra, Steele et al. 1994).

The primary objective of the technique is to reach consensus among a panel or group of experts regarding a specific topic (Taylor and Meinhardt 1985; Okoli and Pawlowski 2004). It has been shown that the Delphi technique can achieve greater levels of accuracy and consensus than other group techniques (Rohrbaugh 1979; Riggs 1983) and is appropriate when insight and consensus from a panel of experts is desired (MacCarthy and Atthirawong 2003; Lummus, Vokurka et al. 2005). There are examples in the supply chain literature of this method being utilized. Manufacturing and information system experts were questioned in two studies about their systems and processes and their key issues (Benson, Hill et al. 1982; Brancheau and Wetherbe 1987; Malhotra, Steele et al. 1994). Delphi has even been used to look at the trends and concerns facing logistics managers (McDermott and Stock 1980). More recently, research was accomplished regarding a flexible supply chain and utilized a web-based Delphi technique to examine the characteristics of a flexible supply chain.

*Data collection.* The Delphi began with the establishment of the panel and the identification of the initial set of issues via a survey question. Identification of the initial key issues allowed for the development of a follow on question asking them to rank order

the key issues in terms of importance. Panel member responses were used to provide feedback for the second round of ranking key issues. The study proceeded to and concluded with a third round because a sufficient level of consensus was reached. Each of these phases is discussed further in the sections that follow.

*Panel selection.* A goal of the research is to identify a set of reverse logistics challenges that would be as generalizable as possible and serve as a benchmark to ascertain the applicability of the Carter and Ellram (1998) framework. To accomplish this, a diverse panel of logistics practitioners was sought, encompassing varied logistics firms and organizations utilizing some manner of a reverse logistics process. The study consisted of a single, three-round Delphi process to reach consensus pertaining to the most important factors impacting their reverse logistics process. The Delphi was conducted via email correspondences and the use of an internet based questionnaire to solicit and collect inputs. Seventy-five potential participants who were employed in the logistics field or had experience with the reverse logistics process were initially selected. The potential subjects were derived from three primary sources: 1) respondent volunteers from previous research efforts, 2) references from senior supply chain professionals, and 3) personal experience in both supply chain management and reverse logistics management settings. There were 31 experts who agreed to initially participate in the study, but only 18 were able to participate through the final round due to expected participant attrition.

Round 1 began with each of the 31 potential panelists receiving an email describing the current study and an invitation to participate in the study by visiting a web site and responding to the following question:

What are the most important issues regarding the adoption of reverse logistics processes and programs for your organization?

Keeping the question general in nature and open ended allowed for a robust and varied response to the question. Based upon the completion of the Delphi technique, the analysis and results follow.

### Analysis and Results

The following section provides a description of the various phases of the Delphi technique as they pertain to this research effort. The final results of the Delphi ranking were then compared to the reverse logistics framework of Carter and Ellram (1998) to highlight potential differences between practitioner's key factors and the frameworks key constructs and generate propositions that could guide future reverse logistics research.

The first round was open for 14 days and 24 panelists responded and participated in the study, for an initial 77% response rate. The 24 panel members had a combined total of 303 years of experience, with the average panelist having 14.4 years of logistics experience, with 43% of them holding senior management positions, and 62% came from large organizations consisting of over 300 employees. As shown in Table 2.5, the panel possessed experience in managing logistics in a wide variety of industries, throughout all three rounds.

Table 2.5

*Background of Panel Members for all three Delphi rounds*

	Industry				Total	Avg Yrs of Experience			
	Govt/ Military	Manufacturing	Logistics Service Provider	Other		Log Exp	In Org	In current job	Total Yrs
Rd 1	9	1	10	4	<b>24</b>	<b>14.4</b>	12.1	6.8	<b>303</b>
Rd 2	9	1	9	2	<b>21</b>	<b>14.6</b>	12.5	6.7	<b>263</b>
Rd 3	8	1	8	1	<b>18</b>	<b>15.9</b>	13.1	6.7	<b>254</b>

Organizational Size			Position in Org	
Small (<100)	Medium (100-300)	Large (>300)	Sr. Mgmt	Middle Mgmt
3	6	15	10	14
3	4	14	9	12
3	2	13	7	11

After the panel member comments were collected, their content was reviewed by the research team and initial topics or focus areas were highlighted. As is expected with this data collection technique, many of the comments by the panelists were redundant (Rowe and Wright 1999; de Villiers, de Villiers et al. 2005; Grisham 2009). To appropriately categorize and assess the comments, the researcher established a four-member committee of practicing supply chain and management professionals to review all submitted comments. To maintain a high level of inter-rater reliability, each of the committee members individually reviewed all of the contributed comments and classified them into their own respective categories, as they interpreted them. After completing their individual classifications, this process resulted in a total of 39 issues or focus areas being provided by the practitioner panel members.

The committee held a face-to-face discussion to reconcile each of their classification schemes and subsequently agreed upon a single comment classification schema by combining similar groups, such as “asset visibility” and “visibility” or the combining of each panel member’s “customer service” area into one. This final

classification scheme served as the basis for the final rounds of the study. The final classification schema is a set of 7 critical reverse logistics factors shown in Table 2.6.

Table 2.6

*Challenges of Logistics Managers Regarding Reverse Logistics*

<b>Reverse Logistics Process Factors (Unranked)</b>
Environmental Issues
Costs
Communications
Top Management Support
Customer Support
Having a Formalized Program
Timing of Operations

To begin round two, the results from the panel input were distributed via email to each respondent with the instructions to review the unranked classification list and rank them in order from most important (1) to least important (7). A brief description, based on comments made by the interviewees, was provided for each factor:

**Environmental Issues:** Involves areas such as recycling, legal requirements, green practices, and disposal practices.

**Cost:** Involves areas of cost-benefit analysis, Return on Investment (ROI), financial metrics, operation costs, and asset/item value.

**Communication:** Involves areas of asset visibility, system integration, real-time information updating, and package tracking.

**Top Management Support:** Involves areas of organizational buy-in, continuous improvement, definition of mission for the system, and clear purpose.



**Customer Support:** Involves areas of effectively and efficiently meeting established customer service levels, resolving order disputes, product protection, and achieving established customer support metrics.

**Formalized Program:** Involves areas of establishing clearly defined responsibilities, standardization of processes and procedures, and adequately providing the knowledge to implement the program.

**Timing:** Involves areas of on-time delivery requirements, service requirements, cycle time, and effective use of transportation opportunities.

Round 2 was open for 14 days with 21 of the 24 panel members responding for an 87% response rate. The ranking of the challenges for the panel was computed using the weighted average method and the results are presented in Table 2.7. The top two factors were providing necessary customer support and having top management support. The lowest ranked factors were related to environmental issues (recycling, precious metals recovery, and regulatory requirements) and timing of operations issues (on-time delivery, cycle time, and service requirements).

Table 2.7

*Weighted Average Ranking of the Factors Following Round 2*

<b>Rank</b>	<b>Reverse Logistics Process Factor (Ranked)</b>
1	Customer Support
2	Top Management Support
3	Communications
4	Costs
5	Having a Formalized Program
6	Timing of Operations
7	Environmental Issues

The final phase of the study consisted of the panel members examining the group's ranking of the factors from round two. The panel rankings from round two were available via the study web site. The panel members received an email outlining the results from round 2 and were asked to review the group's weighted average ranking of the items and re-rank them in light of the group rankings or agree with the group's ranking of the factors. Round 3 was open for 14 days with 18 of 21 panel members responding for an 86% response rate. The round 3 rankings for the panel were computed using the weighted average. The results are presented in Table 2.8. This technique results in the final list, ranked by importance, based on the input from the panel members. Even though there are a number of ways to measure consensus among the panel, the final measure of consensus is reached by determining the Kendall's coefficient of concordance.

Table 2.8

*Ranking of the Factors Following Round 3*

<b>Rank</b>	<b>Reverse Logistics Process Factors (Ranked)</b>
1	Customer Support
2	Top Management Support
3	Communications
4	Costs
5	Having a Formalized Program
6	Timing of Operations
7	Environmental Issues

Based on the results from round 3, a decision was made to end the study after three rounds and proceed with the statistical analysis and assessment of the identified challenges and their rankings. Table 2.8 shows, there was no change in the weighted average rankings from round 2 to round 3; it appears a consensus has been reached among the panel members.

*Measuring Consensus.* The level of consensus was measured after each round using Kendall's coefficient of concordance (W), as recommended by Schmidt (1997). Kendall's W provides a coefficient of agreement among raters (Kendall and Gibbons 1990) based on the ranks assigned by the panel members. A significant W indicates that the participants essentially applied the same standard in judging the importance of the issues. Utilizing SPSS 16.0, for the round 2 rankings of the Delphi technique,  $W = 0.158, p < .01$  and for the round 3 rankings of the Delphi survey  $W = 0.900, p < .001$ , all statistically significant. According to Landis and Koch (1977), a Kendall's coefficient of concordance value of 0.10–.20 can be considered slight agreement while values of 0.81–1.00 are considered to represent near perfect agreement. Therefore, Kendall's Coefficient revealed a slight consensus existed among the participants on the panel with respect to the round 2 rankings and almost perfect consensus for round 3 rankings of the importance of the reverse logistics challenges.

*Public sector vs. private sector.* Based on the low initial consensus among the participants after round 2, an ANOVA was performed to see if there were significant differences between the types of industry the panel was a member of and the 7 factors. An alpha level of .05 was used for all statistical tests. The industry variable consisted of Govt/military, logistics service provider, manufacturing, and other. A one-way ANOVA was calculated on participants' ratings of each of the 7 categories. The analysis was significant,  $F(3, 17) = 3.459, p < .05$ , only for the factor of costs. All other factors were insignificant with  $p > .05$ . Panelists who were members of the Govt/military were more likely to rate the factor of costs as less important ( $M = 4.89, SD = 1.83$ ) than participants who were members of private logistics service providers ( $M = 2.78, SD = 1.64$ ) or

members who represented a manufacturing firm ( $M = 1.00$ ,  $SD = 0$ ), only 1 member was from manufacturing.

Direct comparisons were also made between Govt/military and logistics service providers. The comparisons indicated that the Govt/military group was significantly different from the logistics service provider group, in regards to only cost,  $t(17) = 2.60$ ,  $p < .05$ . This difference in ranking of nearly 2 positions, on average for the Govt/military and logistics service providers is a possible explanation for the low initial consensus on factor rankings. Both groups make up 18 of the 21 respondents in the round 2 and weigh heavily into the Kendall's W computation. Practically, this appears to make sense when comparing a publicly funded, non-profit organization to a for profit service provider. It would make sense that the for profit firm will put costs, or the goal to keep costs down, as a higher priority than an organization that does not pursue a profit or healthy bottom line.

From the significance of the measures of consensus, a conclusion can be made that there is strong consensus among the panel members concerning the ranked importance of the critical challenges, as a whole. Consequently, no additional Delphi rounds were necessary.

The objective of this portion of the research was to identify a set of challenges that spanned all facets of the reverse logistics process. Panel member comments suggested that a number of the challenges were more prominent in some reverse logistics systems than in others. For example, communication throughout the reverse process was an important factor for those operating in a remanufacturing environment. Managers repair and extract value from the returned product and therefore wanted constant status of

the asset. Those managers receiving damaged or mis-shipped product were primarily concerned with customer satisfaction and service.

*Limitations.* This reverse logistics literature review and Delphi analysis come with limitations. The limitations placed on journal inclusion, time frame of article publication and type of research limit the completeness of the reverse logistics research review. A limitation for this type of Delphi research is its cross-sectional nature. The responses provided by the panel members were collected during a specific timeframe. Although there is no indication that the key challenges highlighted will be resolved or altered in the future, the relative importance of the challenges may change over time. Researchers may seek to study specific facets of reverse logistics and compare results between them, such as recycling, product returns from customers, recalled products, or goods returned for remanufacture.

Another limitation may be the geographic bias of the panel members. Although many of the organizations represented by the panel members are responsible for supply chain and logistics management internationally, all of the organizations represented were based in the United States. Thus, the results of the Delphi may not be fully generalizable to other regions of the world.

This literature review and Delphi analysis are a foundation for future reverse logistics research. And despite these limitations, this effort acts as a bridge between practitioners and researchers. Academic researchers seeking to contribute to the understanding of reverse logistics can use these challenges as the basis for their studies. Practitioners, looking to academia for assistance, will then find research that is both rigorous and relevant to their managerial needs. Now that a consensus among sampled

key practitioners has been achieved, a comparison between the 7 key factors and the reverse logistics framework of Carter and Ellram (1998) is necessary to determine the timeliness of the framework constructs, if there are areas needing added to the framework that have been identified by the practitioners, and identify possible propositions to base future empirical research on.

### Discussion and Implications

Taking the 7 ranked factors from the Delphi analysis of practitioners and comparing them with the 9 constructs in the Carter and Ellram (1998) framework provide insight into the robustness of their framework. The comparison highlights similarities and differences between the two lists of reverse logistics factors.

*Customer Support.* The top ranked item from the practitioners is customer support. Of course this is the major driver behind any firm or organization, satisfying the needs of those who seek their business. This ranked item matches up nicely with the frameworks construct of customers. There is no real surprise in this outcome. Customers are the driving force behind any firm. Without the customer the organization has no purpose or need to exist. The customer is the driver of demand on the organization and this means that the firm must be able to adapt to the needs of the customer, especially if the organization wants to remain competitive. In today's marketplace, if one firm cannot meet the customer's demands, there is likely another one lined up to fill the need.

The need to satisfy the needs of the customer and measuring customer satisfaction has been thoroughly studied in the logistics and supply chain spectrum, from traditional manufacturer-customer relationships to e-commerce types of relationships (Autry, Daugherty et al. 2001; Wee Kwan Tan, Yu et al. 2003; Kulp, Lee et al. 2004;

Mukhopadhyay and Setoputro 2004; Savaskan and Van Wassenhove 2006; Srivastava and Srivastava 2006; Karaer and Lee 2007; Mollenkopf, Russo et al. 2007; Mollenkopf, Rabinovich et al. 2007).

These two factors match up as expected, highlighting the importance of satisfying customer demands. The importance of the customer cannot be understated, it is the reason the company is in business. Being able to efficiently and effectively meet customer demands is essential. To do this, organizations need to be able to measure and quantify how they are performing and meeting their various customer's needs. Developing and utilizing proper metrics for the information requirements needed to make sound decisions is essential. Very little research has been accomplished regarding the proper metrics and measures of reverse logistics performance. Also, research is lacking in determining what the key factors customers desire in a reverse logistics process. Determining what the customer thinks is important can be key to aligning your processes to meet that expectation, which may be different than what the organization initially planned.

*Top Management Support.* The second most important factor from practitioners is top management support. This factor also matches up with the same factor in the Carter and Ellram (1998) framework. This factor has been shown time and again to be a critical component to any logistics and business process (Daugherty, Autry et al. 2001; Guide Jr. and Van Wassenhove 2001; Daugherty, Myers et al. 2002; Richey, Genchev et al. 2005). The same can now be said for the reverse logistics process, according to the results of the Delphi and this comparison. Proper resource allocation by top management is always critical for operational success. But, resources in an organization are limited

and constrained. There are never enough resources available to properly support all processes in an organization; top management must make decisions based on institutional pressures for certain performance or goals and the strategic direction of the organization (Wu and Dunn 1995; Knemeyer, Ponzurick et al. 2002; Dowlatshahi 2005; Srivastava and Srivastava 2006; Mollenkopf, Russo et al. 2007; Zhu and Sarkis 2007). Because top management support for any program is critical, researchers need to account for its effect on reverse logistics system performance and implementation success.

This comparison highlights how essential top management support is in establishing effective reverse logistics programs and the continued success of the programs once they are established. Without this commitment, the programs will likely see reduced resource allocation towards the reverse logistics program and performance in that area will decline. Support is needed to secure the proper level of resources are focused on process. This includes proper funding, personnel allocation, training for employees and customer education, and effectively managing relationships with partners.

*Communication.* The third ranked factor of communication is comprised of being able to accurately and timely communicate the status of an asset within the reverse logistics process. The uncertainty of the reverse logistics process makes this factor essential to smooth process flows and helps to temper the lumpy demand pattern of reverse logistics. Comparing this factor to the framework generates a close relationship with vertical coordination, but not a real clear connection to any particular framework construct.

Within the Carter and Ellram (1998) framework, vertical coordination describes the network and reliance between buyers, suppliers, manufacturers, logistics providers,



and customers. It encompasses the entire reverse logistics network or process. As globalized as the marketplace is, it is essential that everyone throughout the chain from customer back to final disposition of the product is aware of what is going on and what to do next. This level of coordination will help ensure value is not lost and that all customers are satisfied. This aspect dives into the design and mechanics of the reverse logistics network design. The network design of a reverse logistics system pertains to distribution point locations, inventory levels and production locations. Research regarding logistics network design and managing inventory is one of the longest streams; dealing with inventory controls, logistics networks, facility locations, and transportation systems (Fleischmann and Kuik 2003; Kiesmuller 2003; Mahadevan, Pyke et al. 2003; Miranda and Garrido 2004; Richey, Genchev et al. 2005; Atasu and Cetinkaya 2006; DeCroix 2006; Schultmann, Zumkeller et al. 2006; Teunter, Bayindir et al. 2006).

According to the Delphi results, communication is the willingness to make strategic and tactical data and information available to others involved in the process, inside or outside of the organization (Mentzer 1993). Within the study, communication allows for the effective response to customer service problems, and allows for the timely resolution to the problem. Organizations must be willing to communicate and share information relevant to the process to prevent or mitigate problems and meet customer needs (Stank, Emmelhainz et al. 1996). Benefits are achieved when entities work together, share information and communicate with each other in order to achieve collective goals which can enhance the ability to meet customer (Stank, Keller et al. 2001).

Because a number of hand-offs can occur in a reverse logistics process, communication is essential. The reverse chain involves many entities and is not as refined as the forward chain and accurate, timely communication is important to success and maintaining customer satisfaction. This fact leads to the development of the first proposition.

***Proposition 1:** Due to the complexities of the reverse logistics process, communication and information sharing in the reverse logistics process has a direct influence on firm performance.*

According to one respondent, “communicating with customers, 3PLs, and vendors to coordinate the return is key to the reverse logistics process.” As another stated, getting everyone and their electrons (data) on the same page is critical for success. The right hand needs to know what the left is doing and what the next step will be.

It appears that communication relies heavily on relaying information from one party to another in a timely manner. This does differ from the structured, vertical coordination construct within the 1998 framework. The framework does not really address the issue of communication regarding visibility of assets or possessing accurate information regarding the reverse logistics process. It is possible that the framework developers saw this type of communication as an enabler to the other constructs in the framework and not an essential, separate construct within reverse logistics itself. But, do the complex nature of today’s globalized marketplace and intricate supply networks, it may actually be a critical construct within the framework and begs further research.

Additional research could address the implementation of specific technological advances in the area of information technology and how they may change some of the assumptions about the process. Integrated enterprise systems, radio frequency identification (RFID), mobile information technology, and global positioning systems and data may play a role in how a reverse logistics process is designed and the partners that make up the network. The use of information technology can allow for greater vertical coordination throughout the reverse logistics process, internal and external to the firm. How does the level of coordination impact reverse logistics performance and how does information technology implementation impact coordination among the entities in the process? What types of technology offer the biggest potential for improved process performance?

*Costs.* Cost is the fourth ranked key challenge in operating a reverse logistics process, and correctly so. If costs get out of control or the reverse process consumes more monetary and employee resources than expected, the process can diminish any level of profit within the organization. Managing the logistics costs of a company is already a difficult task, but managing the costs for a reverse logistics process can be even more difficult. The factor of costs encompasses many sub-items: costs of resources, cost benefit issues, asset value for return, and operating costs. Demand is uneven and hard to predict. Often times, items traveling through the reverse logistics pipeline are of an expedited nature. A customer has a broken asset and needs a replacement or repair, an incorrect order was received, or they just want a refund. This can lead to expedited and increased shipping, transportation, and handling costs for the receiving company.

Comparing the factor of costs to the framework exposes another mis-match or possible gap. A close match would be “quality of inputs” from the framework. That

encompasses purchasing quality and environmentally friendly raw materials and manufacturing materials upfront so they are fewer and less costly returns on the reverse logistics portion of the life cycle. This could reduce disposal costs if products are already environmentally compliant and reduce overall returns if the products are constructed of high quality components. Costs can also be related to “uncertainty” within the framework. Uncertainty is one of the major reasons for the increased level of costs in the reverse process. There is no steady, predictable stream of returns and the returns come back for any number of issues and these are difficult to predict and prepare for. Because costs can dramatically impact the performance and return on investment of the reverse process, it can be argued that it should be a contributing factor to reverse logistics performance within the framework.

As mentioned earlier in the analysis, panelists who were members of the Govt/military were more likely to rate the factor of costs as less important than participants who were members of private logistics service providers or members who represented a manufacturing firm. The comparisons indicated that the Govt/military group was significantly different from the logistics service provider group, in regards to only the cost factor. There is a difference in ranking of nearly 2 positions, on average for the Govt/military and logistics service providers. Practically, this appears to make sense when comparing a publicly funded, non-profit organization to a for profit service provider. It would make sense that a for profit firm will put costs, or the goal to keep costs down, as a higher priority than an organization that does not pursue a profit or healthy bottom line. This apparent difference in key factor importance among various

reverse logistics systems leads to the second proposition in regards to reverse logistics processes:

***Proposition 2:** The greater an organization is focused on performance rather than profit, the less importance they will place on reverse logistics costs, as compared to private sector or for profit organizations*

If costs are not monitored and contained, any reverse process can get out of control and eventually impact the forward logistics process and impact overall revenue. To maintain adequate levels of customer support, costs are often difficult to avoid. As a respondent succinctly stated, “we are primarily concerned with cost.” Internal financial auditors are always tracking and looking for ways to reduce costs and want to ensure processes are creating value. Controlling costs in the reverse process involves resource and top management commitment, but due to the sometimes lack of focus and lack of resources available to the reverse chain, this process is often neglected. As on panelists stated, “Many manufacturers are prepared to look at more effective and efficient ways of reducing both returns and their associated costs but are not prepared to allocate the necessary resources for this operation.”

*Formalized Program.* Establishing clearly defined responsibilities, standardization of processes and procedures, and adequately providing the knowledge to implement the reverse process was the fifth ranked key factor. It was surprising to see this item ranked this low, but most managers are daily bombarded with meeting customers’ demands, management demands, and maintaining process costs, it is apparent why it fits in at this position. Until the daily demands are met, trying to establish

standardization throughout the process and organization are secondary, even though have a formalized process may significantly help with the higher ranked challenges. In today's e-commerce environment, the increasing rise in product returns has prompted many companies to attempt to formalize their logistics processes (Malone 2004). In this situation, program or process formalization refers to the level to which rules, procedures, instructions, and communications are established and written, so that all entities involved know what to expect and what is expected of them (Pugh, Hickson et al. 1968).

Within the reverse logistics system, formalized decision rules can be developed to determine whether products should be scrapped, discarded, repaired, overhauled, or sold in a secondary market (Richey, Chen et al. 2005). Having a formal and standard reverse logistics process allows the firm to properly manage customer expectations regarding returns. As one manager stated, "Getting our reverse logistics process formalized helps to ensure expectations are clear to both internal and external stakeholders and is a primary ingredient for success."

Comparing the formalized program challenge with the framework model highlights an apparent gap in the framework, based on the inputs of the practitioners. While having a standardized framework will impart a number of the constructs in the framework, there is not one specific construct that addresses this need for standardization of the process itself. As stated earlier, having a standardized process can provide positive benefits to some of the current constructs in the framework, such as customers and vertical coordination. Also, having a formalized program may aide in the development and growth of incentive systems. If employees know how the process is supposed to work and are therefore properly informed on how to make it work more efficiently,

proper incentives can be employed to ensure the reverse logistics process is executed appropriately by the employees in the process. This leads to the third proposition in regards to the reverse logistics process.

***Proposition 3:** The performance metrics in a reverse logistics process must be standardized across the firm and directly translate to the goals of the firm.*

Future research in reverse logistics needs to focus on standards development and the metrics to monitor whether organizations and the process are meeting the standard. Achieving a standardized process will allow researchers to achieve greater levels of generalizability within the reverse logistics process and allow the field to continue to mature. Also, research should focus on how having a formalized reverse logistics process impacts the various constructs in the framework.

*Timing of Operations.* Within this research, timing of operations, the sixth ranked challenge, consisted of various measures and activities in the reverse logistics process; capacity planning, timing and continuity, asset availability, scheduling, efficiency, effective use of transportation opportunities, and time constraints. This factor is likely toward the bottom of the challenges since the research on reverse logistics is just gaining interest and industry is just starting to focus on reverse logistics management (Daugherty, Autry et al. 2001; Richey, Chen et al. 2005), there may not be enough manager focus and application of traditional forward logistics concepts on the reverse logistics chain. Managers may still be in the early stage of just developing a reverse logistic network and system to be able to effectively handle inventory in the reverse chain. As the practice of

actively managing and integrating the reverse logistics process into system wide operations gains ground, there may be more importance placed on the effective timing of operations. This could involve establishing disposition centers where all returned product is processed, so the main warehouse is not inundated with processing return shipments on a non-routine basis and they can focus on outbound distribution.

Comparing timing of operations to the established reverse logistics framework highlights a moderate relationship to vertical coordination and customers. Working with suppliers, shippers, manufacturers, and customers requires intense information and data relays. Being able to meet service level or delivery or re-manufacturing requirements is an essential portion of timing of operations and at the same time directly impacts customers and coordination up and down the reverse logistics chain. It appears that timing is likely a sub-factor within one of these, or both, constructs. It is essential to their success and positive influence on reverse operations, but at the practitioner level, it may have higher, more immediate importance. Again, future research may look at the impact timing of operations has on those two constructs within the framework and how it may impact overall reverse logistics performance.

*Environmental issues.* Lastly, environmental issues ranked seventh of all the logistics practitioners key challenges. The challenge was defined as issues regarding packaging, environmental factors, mandated requirements, recycling/repair/sustainment, expiration/disposal/destruction, and sustainability. As stated earlier, reverse logistics most likely originated with industry goals toward improving the environment (Carter and Ellram 1998; Dowlatshahi 2000; Rogers and Tibben-Lembke 2001; De Brito and Dekker 2003). Rogers and Tibben-Lembke (2001) also state that because of this, the terms green



logistics and environmental logistics have been used interchangeably with reverse logistics and although there is some overlap, there are differences between them. This possible confusion could explain why environmental concerns ranked last during all rounds of the Delphi panel. As government, industry, and customers become more environmentally aware, it would be expected that this facet of reverse logistics will grow and be more of a concern for reverse logistics managers. The factor may have also ranked last due to the fact managers in firms have little control over their actions and meeting environmental mandates or regulations. They are must do activities and it is difficult to cut costs or circumvent the laws without risking excessive fines or punishments. The panel members may see that they have little control over this area, so they stress the areas they can control and have impact on. This observation leads to the fourth proposition.

***Proposition 4:** The less direct control a reverse logistics manager has over the regulations and environmental directives, the least amount of importance will be placed on them.*

A respondent put it succinctly by stating, “Compliance with state and federal regulations and updating policies and procedures to meet current realities is one of our largest activities.” Compliance with regulations and staying aware of changes is not an option, it is a must. You cannot manage your way out of the situation or deviate from the policies put in place. Where importance may increase is at the most senior levels of an

industry or firm when it comes to lobbying and attempting to influence future environmental policy.

Now, comparing this factor with the framework highlights an obvious similarity and correlation with regulatory issues. Environmental issues are an ever growing factor on the effectiveness of a reverse logistics process and it is expected that it should show up as key challenge for practitioners, even though it ranked last. Firms need to have a green production and logistics presence to meet customer demands for these types of goods, but also meet regulatory guidance that often has monetary penalties attached for noncompliance. Firms need to have adequate processes in place to collect unwanted goods from their customers. It is now becoming the norm for a company to be responsible for the disposition of its product, even if it was routinely disposed of at the customer level. This strong involuntary push toward environmental awareness has caused more firms to focus on their reverse process and seek out avenues to attain value from the products they must take back. This can be in the form of recycling, remanufacturing, or even reuse by another firm. Reverse logistics is in a perfect position to directly impact the environmental consciousness of the firm, and the results of this impact can have profound monetary and environmental impact (Guide Jr. 2000).

This factor of reverse logistics is continuing to grow in importance. As the world modernizes, the value placed on being environmentally conscious grows and customers expect that the products they purchase and return are not dramatically impacting the environment. Asia remains an essential and wide-open area for reverse logistics research. The infrastructure requirements for handling returns should be properly analyzed, since most of the region has been setup for forward, outbound logistics. What are the cultural

and regional impacts environmental regulations will face as they expand to Asia? Also, regulatory issues and enhanced information systems need to be analyzed as to how they influence system performance together. Does being able to more accurately track the status, disposition, and location of returned products make compliance easier? Do information systems allow for stricter and timelier enforcement of regulatory guidelines or policies, since it is possible to know what products are where and what environmental issues they may pose?

Having compared all 7 of the key challenges identified by practitioners to the reverse logistics framework of Carter and Ellram (1998), it is clear that three of the identified factors appropriately match up with a framework construct. Those would be customer support, top management support, and environmental issues. This should not be surprising and expected. These three factors are prevalent in the forward supply chain as well, and nearly any business operation. The firm needs to meet customer demands and expectations, top management needs to support the process, and environmental regulations must be obeyed. These matches provide valid support for the constructs within the framework.

Next, two of the challenges identified by practitioners have a slight relationship to the framework. Communication and timing of operations have some relationship with vertical coordination and customer relationships. They actually appear to be sub-items of interest within the main constructs within the framework. Communication is essential to meeting customer needs and coordinating operations up and down the reverse logistics chain. So, while important to the manager or practitioner, communication and timing can be seen as sub-items within two constructs in the established framework.

Finally, the two practitioner challenges of cost and formalized program have no apparent relationship to the framework. The actual cost of operating the reverse process and achieving adequate returns on investment from the process are not part of the framework. Based on the movement towards higher implementation and spending on information technology and systems within the process, it is essential to know how much your process costs to operate and how much value you are achieving from its use. Key resource decisions are made regarding where to spend money and knowing how much bang for your buck you can get by allocating some to the reverse process is essential. Cost management is critical to successful operations and should be further researched to determine its appropriate relationship to the performance of the reverse process. Also, having a formalized program has shown positive benefit in the forward supply chain. Knowing what you are supposed to do and what your partners are supposed to do can alleviate a lot of lost productivity and streamline communication and coordination efforts. As stated earlier, having a formal process makes implementing an incentive system much easier. Expectations can be managed appropriately and drive the employee and partnership behavior that will result in efficient reverse logistics operations.

In summary, the framework of Carter and Ellram (1998) appears to still hold up to the needs of today's logistics practitioners operating in the reverse logistics process. A majority of the challenges either directly correlate or are sub-items within the nine constructs of the framework. Costs and having a formalized program do not have parallels, but they may be external drivers to some of the constructs within the framework.

*Contribution of this study.* The results of this study highlight the key factors in the reverse logistics process, as determined by the panel. All of these factors are critical and they provide a practitioner based framework for logistics managers to allocate necessary time and resources to various aspects of the reverse logistics process. Knowing which areas are relatively more important can allow for targeted allocation of scarce resources, money and time. Even though focusing on the reverse chain may be a relatively new, it is still important to never forget the customer and that without top management support and buy-in, the process will likely not succeed or it may become inefficient and costly. Controlling costs is essential in a reverse logistics chain since its demand is unpredictable and requires immediate attention to the customer. Having a formalized process ensures both the customer and organization know what to do and what to expect. And though it ranked last, environmental concerns and costs will continue to become more important and require necessary attention from top management and proper allocation of manpower and funds.

The findings of the study also provide a comparison of the practitioner framework, or challenges, and the framework of Carter and Ellram (1998). The comparison highlighted similarities and possible deficiencies in the existing framework. Some of the practitioner key factors have been researched and identified as important to reverse logistics performance (Blumberg 1999; Daugherty, Autry et al. 2001; Guide and Van Wassenhove 2001; Daugherty, Myers et al. 2002; Daugherty, Richey et al. 2005; Richey, Chen et al. 2005; Mollenkopf, Russo et al. 2007). The results provide an opportunity to assess how each of these seven key factors impact reverse logistics performance. Would an empirical study utilizing these same factors provide similar

results of importance to performance? Also, a possible enabler of several of the factors is the use and implementation of information technology systems. How does IT impact the specific factors and what impact does it have on reverse logistics performance. Is it a key to performance success or is it a mediator between some of these seven factors and performance? The results provide a basic scale of importance relative to each factor, but further research could determine how important each factor is within specific reverse logistics processes or frameworks, such as recycling, remanufacturing, or processing returned products. Each reverse logistics system may have different priorities and keys for successful performance.

These seven issues represent some of the most critical reverse logistics challenges. They also serve as a guide for future researchers seeking to contribute to the increasingly important area of reverse logistics management. In the final section, several specific opportunities for future research are presented.

Also, the reviews of the articles show that much of the reverse logistics research has been oriented at the design and planning phase of the reverse logistics process. There are still numerous opportunities in the later stages of process management that focus on implementation, information technology integration, process innovation, metrics and performance feedback of the reverse logistics process and how it impacts overall supply chain and/or organizational performance. Can focusing too much on increasing efficiency of the reverse process hamper the forward chain and may it actually lead to increased items in the return pipeline?

Further research needs to be accomplished that employs a broader scope of methodologies beyond surveys and mathematical modeling techniques. Increased use of

interviews, Delphi techniques, or multi-method research can assist in determining key management factors impacting reverse logistics and aid in standardizing the activities and definitions within the reverse logistics process. Researchers should also begin incorporating organizational, behavioral and policy theories to aid in investigating the strategic and environmental decisions within a firm.

Also, to develop more generalizable theories, there is a need for more studies across different industries and nations (McMichael, Mackay et al. 2000; Croom 2005) as well as longitudinal studies to determine the long-term effects of reverse logistics, green logistics, recycling efforts, and remanufacturing efforts on organizational performance, both locally and system wide (Georgiadis and Vlachos 2004; Rao and Holt 2005; Zhu, Sarkis et al. 2005; Bakal and Akcali 2006; Vachon and Klassen 2006; Field and Sroufe 2007).

Chapter 3  
Information Systems Support as a Coordination Tool of the  
Reverse Logistics Systems Process

Abstract

Reverse logistics is an essential supply chain capability in today's global marketplace. It can have a large impact on customer relations and the development of effective reverse logistics capabilities and its integration throughout the supply chain should be considered managerial priorities. This study examined the relationship between several information technology attributes of a reverse logistics process and organizational innovation and their impact on the service performance of the reverse logistics operation within the firm. Specifically, this study will examine the impact of information systems support capability, information systems support compatibility, information technology availability, information systems implementation, and reverse logistics innovation on two measures of reverse logistics service performance.

This study will utilize a survey instrument to gather empirical evidence to test the proposed model and its related hypotheses. Surveys are recognized as the most frequently used data collection method in organizational research for determining phenomena that cannot be directly observed by the researcher or where secondary data is



not already collected and stored (Gall, Gall et al. 2003), such as the perception of employees or the relationship between process attributes on an organizational attribute or capability.

This research methodology will be executed according to the guidelines suggested by Flynn, Sakakibara, Schroeder, Bates, and Flynn (1990). In the proposed study, a model consisting of five attributes is outlined and tested. The model consolidates existing literature on reverse logistics and logistics information systems and tests the relationship of five key attributes with two attributes of reverse logistics service performance. The model proposes that reverse logistics service performance is positively related to aspects of information system support capability, information system support compatibility, information system technologies, information system implementation and process innovation.

### Introduction

Reverse logistics is an essential supply chain capability in today's global marketplace. It can have a large impact on customer relations and the development of effective reverse logistics capabilities and its integration throughout the supply chain should be considered managerial priorities. The purpose of this study is to examine the relationship between several information technology attributes of a reverse logistics process and organizational innovation and their impact on the service performance of the reverse logistics operation within the firm. Specifically, this study will examine the impact of information systems support capability, information systems support compatibility, information technology availability, information systems implementation, and reverse logistics innovation on three measures of reverse logistics service performance. This effort develops a model that will provide both academicians and practitioners with a method of determining the information technology attributes with

strong relationships to performance effectiveness of a reverse logistics program. This knowledge will allow for prioritization of resources within the supply chain and how closely information systems impact reverse logistics and how the level of innovation can influence the impact of technology on the process.

Effective planning and development of the reverse logistics process in a supply chain is critical for a manager to effectively monitor and control its performance. The academic community has an important role to play in helping industries remain competitive through inventory management, transportation, disposition and storage costs. However, it has been suggested that academia fails to meet the ever evolving needs of the logistics practitioner (Mentzer and Flint 1997; Craighead, Hanna et al. 2007). This is of particular concern in the increasingly important area of reverse logistics. Therefore, an empirically based analysis of the reverse logistics process is necessary, especially as it pertains to information systems and technology use to enable the coordination and transmission of data and information.

This research effort will investigate the information technology relationships and process innovativeness used by organizations as members of a supply chain in dealing with returned product within the reverse logistics process. The need to further investigate this field of logistics is made more important in today's global business environment. This study of the reverse logistics process and information technologies impact on the process is designed to contribute to the growing body of evidence on the importance and impact of returns management in organizations. As a result, the goal of this study is to examine the information technology factors associated to reverse logistics and reverse logistics innovativeness and assess their impact on organizational reverse logistics

performance. The researcher will identify and measure the relationship between key components of information technology use and attempt to assess their relationship with organizational performance, pertaining to reverse logistics.

#### Motivation for Research

The importance of reverse logistics has been steadily increasing and therefore it is essential to understand how it operates and why. There are two main roles of a reverse logistics process, returning a product and returning packaging to the point of origin or manufacture (Rogers and Tibben-Lembke 2001). Research has provided evidence that products are either returned to the point of distribution for refurbishing, recycling, or disposal; dealing with the end of life of the product (Andel 1997; Carter and Ellram 1998; Blumberg 1999; Rogers and Tibben-Lembke 2001; De Brito and Dekker 2003). Another aspect inherent in many types of reverse logistics systems is they are part of a closed-loop system, assets flow outbound to a customer and those same assets flow in the reverse direction, usually in an altered state or condition (Jayaraman and Guide Jr 1999; De Brito and Dekker 2003).

Now that organizations have a stronger understanding of the roles of the reverse logistics process, they have started focusing on its operation and started to utilize it as a tool to differentiate themselves from their competition (Stock 2001). It is anticipated that this differentiation will enable them to gain market share, add revenue, and possibly reduce transportation and inventory costs through the continual monitoring and refinement of their reverse logistics process (Daugherty, Myers et al. 2002).

Another reason for the increase in importance is the need to reduce the costs and improve efficiency. Returns management has been identified as one of the eight major processes of supply chain management (Rogers, Lambert et al. 2002). Furthermore,

Andel (1997) notes that by ignoring the efficient return and refurbishment or disposal of product, many companies miss out on a significant opportunity to garner a larger return on investment. Banks (2002) also points out that the DoD and private industry has placed more importance on reverse logistics due to the fact that it makes the greatest and most efficient use of existing resources; if a firm can salvage an asset, or carcass, and refurbish it for a small fraction the cost of building a new asset, they can sell it for a lower price and still make a huge margin.

Nearly all organizations must deal with product returns for various reasons; customers change their minds, damage or quality problems, unsold merchandise, or merchandise that is brought back for overhaul or refurbishing.

This research effort will investigate the information technology relationships and process innovativeness used by organizations as members of a supply chain in dealing with returned product or assets within the reverse logistics process. This study of the reverse logistics process and information technologies impact on the process is designed to contribute to the growing body of evidence on the importance and impact of returns management in organizations. As a result, the goal of this study is to examine the information technology factors associated to reverse logistics and reverse logistics innovativeness and assess their impact on organizational reverse logistics performance. The study identifies and measures the relationship between key components of information technology use and assesses their relationship with organizational performance, pertaining to reverse logistics.

The next section of this paper outlines the theoretical foundation for the research effort, including a brief literature review and discussion of the resource based view of the

firm and reverse logistics process. Next, the conceptual development section includes hypotheses and discussion of the application of theory and planning components. Finally, the methodology section details how the current research will be conducted and provides a discussion of the results, provides conclusions, identifies managerial implications, and concludes with promising areas for future research.

### Theoretical Foundation of the Research

*Information technology.* A considerable amount of research has focused on information support for business and supply chain operations and this capability has been shown to positively influence an organizations performance level (Bharadwaj, 2000). In today's modern, global marketplace, having timely information about your products is a necessary competitive tool (Ives & Learmonth, 1984).

Recent research has provided empirical evidence that information systems and technology can be a differentiator in logistics performance (Closs and Savitskie 2003; Richey, Chen et al. 2005). Overall, information technology has shown to have a positive impact on the strategic contribution within a logistics organization, by gaining efficiencies or streamlining information flow (Stank, Daugherty et al. 1996; Closs and Goldsby 1997; Daugherty, Myers et al. 2002). Despite this benefit, it has been highlighted that these information technology systems are usually selected and setup with the forward distribution channel in mind, not much effort is given to the reverse logistics channel and therefore it receives less attention and resources (Stock and Lambert 2001). Even though reverse logistics processes comprise some of the same activities as forward logistics, such as transportation, inventory, and storage, the two possible product flows have different objectives and therefore the activities, while similar, are different and those

differences should be accommodated. To achieve the proper effectiveness, these differences in activities and objectives must be accommodated and included in the logistics information system within the organization. A study addressed the managerial decision of whether to buy a logistics system off the shelf or develop one in-house to fit the firms needs and how the choice impacts overall logistics performance (Richey, Chen et al. 2005). A few studies have looked at information technology acquisition, capability, compatibility and implementation and how it relates to organizational performance and certain aspects of reverse logistics performance (Iacovou, Benbasat et al. 1995; Daugherty, Myers et al. 2002; Russell and Hoag 2004; Daugherty, Richey et al. 2005). It is a key resource allocation decision for management to be able to procure and implement adequately designed information systems. The goal should be to make processes more efficient, reduce costs, and meet customer service requirements in a timely manner.

According to Daugherty, et al (2002) information systems support is comprised of three distinct dimensions: capability, compatibility, and technologies. It is the integration of these three dimensions that enable a logistics information system to achieve the efficiencies and cost savings top management desires when allocating resources to technology. If the three dimensions are not adequately addressed, it can cause the system to operate inefficiently or not to its fullest potential. Just purchasing bar coding technology and using it on all your products to track movement and transactions seems beneficial, but if it is not providing the necessary capability your employees and process need it is not of great use. The same applies to its compatibility with your reverse process and organizational setup. If the technology employed does not fit with your operations, it may represent as a waste of resources and not help out the process.

Because information support is critical to attaining efficient reverse logistics operations, it is essential that reverse logistics information systems perform well under the scrutiny of these criteria.

Reverse logistics can be characterized by the uncertainty of demand it possesses and a need for rapid timing and processing of returns to meet customer satisfaction requirements. Even in less predictable industries logistics managers need to have a system in place and be prepared to process and handle the products quickly and efficiently (Daugherty, Myers et al. 2002), even if they do not know when products will or may be returned. This is a key reason that prompt and accurate access and exchange of information should be considered a top management priority. Because the supply chain operates among multiple parties, processes, and external companies, this information coordination can be complicated. Blumberg (1999) notes that there is a great need for coordination between the parties to ensure maximum efficiency and that the customer is satisfied in a timely manner. Communication is essential to coordinating transactions and interactions and it helps to strengthen and grow business relationships. This is why an organization needs to adopt and implement an information system that will properly meet the needs of their reverse logistics process.

An effective reverse logistics program can be an opportunity for an organization to differentiate themselves in the marketplace and their ability ties to their corporate reputation and becomes part of the criteria when customers are choosing vendors to do business with (Daugherty, Myers et al. 2002). Some companies have devoted too few organizational resources and too little management oversight and effort to effectively handle the necessary reverse logistics needs of their customers (Andel 1997). The

following discussion highlights several important attributes of the reverse logistics process and describes a potential relationship with reverse logistics operating level effectiveness.

*Information system support capability.* Organizations need to strive to develop and nurture capabilities that are distinct, hard to imitate and provide them with a solid competitive advantage over other firms in the industry (Day 2000). In general, capabilities are defined as a set of skills and knowledge that help provide competitive differentiation and include behavior that enables timely customer service and reduced order processing cycle time (Morash, Droge et al. 1996; Daugherty, Myers et al. 2002).

Therefore, information systems must be accurate and responsive to disruptions in the system so they can possibly anticipate and accommodate change and fluctuating demand. The system needs to deliver information that is timely, useable and meet the needs of the managers in the organization. To accomplish this effort, information needs to be accessible to everyone in the reverse logistics process, both internal and external to the organization. This level of information support is critical for the reverse process to succeed and maintain customer satisfaction, especially when the organization is reacting to and accommodating non-routine events such as product returns (Ellram and Cooper 1990). Information support helps the reverse logistics system attempt to reclaim value that might otherwise be lost and it also serves to enhance customer service. This attribute leads to the first hypothesis in this study.

*Hypothesis 1a :* Employee's perceptions of information systems support capability in the reverse logistics process will be positively



related to their perceptions of reverse logistics cost effectiveness.

*Hypothesis 1b* : Employee's perceptions of information systems support capability in the reverse logistics process will be positively related to their perceptions of reverse logistics process effectiveness.

*Information system support compatibility.* As discussed, organizations realize the importance of information support within their organization and managers attempt to focus on both capability and compatibility when making resource allocation decisions. From the previous discussion, being capable is critical in a multi-organizational setting, such as the reverse logistics process. However, the information system also needs to be compatible with the organization and its reverse logistics process. Information systems support capability indicates a practical ability, information system compatibility refers to how easy it is to use by members within the organization, is the tool deemed appropriate by those using it for the required task (Daugherty, Myers et al. 2002). In the frame of reverse logistics, this would mean that external partners in the supply chain must possess or have access to information systems that are compatible with the firm's information requirements. This is necessary in both the forward and reverse processes. All parties involved in the supply chain must be able to effectively and quickly relay accurate and timely information to each other, this information exchange mitigates some of the issues stemming from infrequent and unstable demands in the reverse process. Regarding information systems support compatibility, it implies the existence of similar systems or and adequate middleware system that translates and facilitates information or data

exchange between the separate organizations (Richey, Chen et al. 2005). With globalization, the supply chain is ever increasing and highlights the need for this information exchange compatibility across organizations in the process (Williams, Nibbs et al. 1997). Given that most manufacturers and organizations in the supply chain have business arrangements with multiple suppliers, logistics providers, and distributors, systems compatibility between specific supply chain partners can be difficult to arrange, but is necessary for effective and efficient operation. Therefore, compatibility is necessary to increase the efficiency of reverse logistics efforts. This attribute leads to the second hypothesis in this study.

*Hypothesis 2a* : Employee's perceptions of information systems support compatibility in the reverse logistics process will be positively related to their perceptions of reverse logistics cost effectiveness.

*Hypothesis 2b* : Employee's perceptions of information systems support compatibility in the reverse logistics process will be positively related to their perceptions of reverse logistics process effectiveness.

*Information system technologies.* Information system technologies are recognized as an enabler to serving as competitive advantages necessary to support the goals of the organization. Pertaining to this study and the reverse logistics process, research has indicated that a common differentiator between leading edge and average organizations is the leading edge organizations ability and desire to invest modern technology (Daugherty, Myers et al. 2002). The global complexity and time sensitive characteristics

of reverse logistics processes make information support and its supporting technologies a key priority at the management and resource allocation level of the organization.

Organizations that utilize a reverse logistics process have utilized and increased the range of technologies employed within their operations. These specific technologies should provide some benefit to both the reverse logistics process and overall firm performance.

*Hypothesis 3a* : Employee's perceptions of information system technologies utilized in the reverse logistics process will be positively related to their perceptions of reverse logistics cost effectiveness.

*Hypothesis 3b* : Employee's perceptions of information system technologies utilized in the reverse logistics process will be positively related to their perceptions of reverse logistics process effectiveness.

*Information systems technology implementation.* In the globalized marketplace, information technology applications and implementations exist throughout the supply chain. These implementations and uses are transforming the way transactions and logistics activities are performed between organizations and service partners (Palmer and Griffith 1998). Information technology provides an organization with the capability to enhance supply chain efficiency by providing near real-time information, or status, on products within the supply chain. It has a great potential to streamline collaboration among reverse logistics partners by sharing critical product or shipment information. Therefore, it is essential to know and capture the level to which an organization and its process have implemented information systems technology. The more established their

information system, the more likely they will be a strong business partner and provide valuable service to your reverse logistics process.

As the business world and consumerism becomes more global, strategic partnerships and collaborative agreements between various organizations are developed. These partnerships force the implementation of information systems and the logistics integration of a company to extend outside the boundaries of the individual firm (Langley and Holcomb 1992). This implementation and integration links the entire supply chain, both forward and reverse. The more links in the supply chain that must share information, the more collaboration and logistics implementation need to be achieved across enterprise boundaries. The need for logistics implementation leads to the following hypotheses.

*Hypothesis 4a* : Employee's perceptions of information system implementation in the reverse logistics process will be positively related to their perceptions of reverse logistics cost effectiveness.

*Hypothesis 4b* : Employee's perceptions of information system implementation in the reverse logistics process will be positively related to their perceptions of reverse logistics process effectiveness.

*Reverse logistics process innovation.* With the increased focus on reverse logistics processes, some would say that new innovations are necessary to increase process performance. Performing operations the same way is not acceptable and will put a company behind their competitors who are using innovative processes and techniques. Based on the impact innovativeness can have on performance and firm competitiveness, the following innovation to performance relationship is proposed.

*Hypothesis 5a* : Employee's perceptions of innovation within the reverse logistics process will be positively related to their perceptions of reverse logistics cost effectiveness.

*Hypothesis 5b* : Employee's perceptions of innovation within the reverse logistics process will be positively related to their perceptions of reverse logistics process effectiveness.

The hypotheses for the current study are presented in Table 3.1.

Table 3.1

*Summary of Hypotheses*

<b>Hypotheses</b>	
1a	Employee's perceptions of information systems support capability in the reverse logistics process will be positively related to their perceptions of reverse logistics cost effectiveness.
1b	Employee's perceptions of information systems support capability in the reverse logistics process will be positively related to their perceptions of reverse logistics process effectiveness.
2a	Employee's perceptions of information systems support compatibility in the reverse logistics process will be positively related to their perceptions of reverse logistics cost effectiveness.
2b	Employee's perceptions of information systems support compatibility in the reverse logistics process will be positively related to their perceptions of reverse logistics process effectiveness.
3a	Employee's perceptions of information system technologies utilized in the reverse logistics process will be positively related to their perceptions of reverse logistics cost effectiveness.
3b	Employee's perceptions of information system technologies utilized in the reverse logistics process will be positively related to their perceptions of reverse logistics process effectiveness.
4a	Employee's perceptions of information system implementation in the reverse logistics process will be positively related to their perceptions of reverse logistics cost effectiveness.
4b	Employee's perceptions of information system implementation in the reverse logistics process will be positively related to their perceptions of reverse logistics process effectiveness.
5a	Employee's perceptions of innovation within the reverse logistics process will be positively related to their perceptions of reverse logistics cost effectiveness.
5b	Employee's perceptions of innovation within the reverse logistics process will be positively related to their perceptions of reverse logistics process effectiveness.

### *Methodology*

To best understand the relationship between constructs in the proposed model, it is beneficial to gather the data from actual organizations and companies (Bruns and Kaplan 1987). Therefore, a survey instrument was utilized to gather empirical evidence to test the proposed model and its related hypotheses. Surveys are recognized as the most frequently used data collection method in organizational research for determining phenomena that cannot be directly observed by the researcher or where secondary data is not already collected and stored (Gall, Gall et al. 2003), such as the perception of employees or the relationship between process attributes on an organizational attribute or capability.

This research tool will be executed according to the guidelines suggested by Flynn, Sakakibara, Schroeder, Bates, and Flynn (1990). In the proposed study, a model consisting of five attributes is outlined and tested. The model consolidates existing literature on reverse logistics and logistics information systems and tests the relationship of five key attributes with two attributes of reverse logistics service performance, as shown in Figure 3.1. The model proposes that the two aspects of reverse logistics service performance is positively related to aspects of information system support capability, information system support compatibility, information system technologies, information system implementation and process innovation.

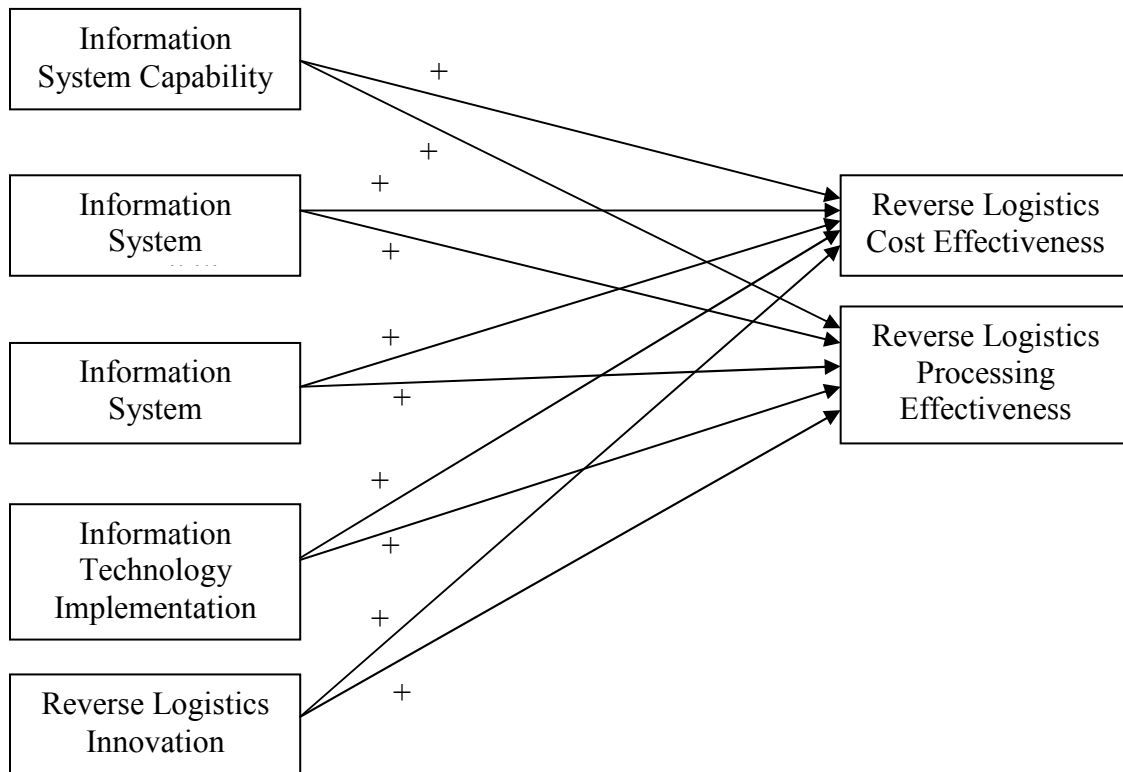


Figure 3.1 Reverse Logistics Performance and Information Technology Model

*Participants.* The sample for this effort consisted of 89 logisticians from a large service organization and practitioners in the logistics industry. The individuals were asked to fill out a questionnaire in order to measure their perception of the relationship between selected logistics information systems and innovation attributes and two organizational performance attributes or indicators. The participants represent a wide range of functions within an organization at multiple facilities within numerous departments. They possess responsibility levels from technicians, to middle management, to senior management executives. Due to the nature of the study and the varying levels and degrees of logistics operations throughout the organization, the population of interest was limited to those individuals that have some knowledge, role, or control within the reverse logistics process. Survey respondents were reminded to focus



on the reverse logistics process and logistics information systems within their realm of activity; the goal was to reduce cross contaminating attributes and opinions on other logistics processes. The individuals took the survey electronically via an internet link distributed via an email invitation. All respondents were offered a copy of the results of the study and asked to forward the survey link to possible respondents who they feel are qualified to answer the questions. A summary of the sample demographics is shown in the following tables.

Table 3.2

*Respondent Knowledge*

	<b>As Shipper</b>	<b>As Recipient</b>	<b>As Both</b>
Percentage of Sample	19.1%(17)	38.2% (34)	42.7%(38)

Table 3.3

*Respondent Experience*

	<b>Yrs in Current Position</b>	<b>Years in Organization</b>	<b>Years of RL Experience</b>
Percentage of Sample	6.2	11.8	8.7

Table 3.4

*Respondent Position*

	<b>Sr. Mgmt</b>	<b>Middle Mgmt</b>	<b>Professional</b>	<b>Technical</b>	<b>Other</b>
Percentage of sample	25.8%(23)	50.6%(45)	18.0%(16)	2.3%(2)	2.3%(2)

Table 3.5

*Respondent Industry*

	<b>Percentage of Sample</b>
Technology	6.7% (6)
Manufacturing	44.9% (40)
Aerospace/Aviation	46.1% (41)
Heavy Equipment	1.1% (1)
Utility	0.0% (0)
Automotive	5.6% (5)
Telecom	0.0% (0)
Medical	2.2% (2)
Logistics Provider	14.6% (13)
Rail	5.6% (5)
Other	12.4% (11)

Table 3.6

*Respondent Type of RL Function*

	<b>Percentage of Sample</b>
B2B	80.2% (69)
B2C	14.0% (12)
Hybrid	5.8% (5)

Table 3.7

*Respondent Organizational Size*

	<b>Dept Size</b>	<b>Org Size</b>
Mean	100.13	3992.36
Median	46.00	550.00
Mode	10	350
Range	642	99980
Min	3	20
Max	645	100000

*Measures.* The measurement instrument for this study is a combination of previously used and well-established scales. The first construct is the dependent variable,

reverse logistics performance, composed of two separate factors. In order to measure the factor of reverse logistics cost effectiveness, this study will utilize a four-item scale based on the one developed by Christman (2000). The factor measures employees' perceptions of their organizations ability to control costs within the reverse logistics process, and incorporates a seven-point Likert scale with an original Cronbach's alpha of .85. The next measure of reverse logistics performance is reverse logistics processing effectiveness. To measure this factor, the study will use a three-item scale developed by Autry et al.,(2001). This factor measures employees' perceptions of their organizations ability to effectively process transactions within the reverse logistics process, and incorporates a seven-point Likert scale with an original Cronbach's alpha of .82.

The first independent variable is information system support capability. It is a construct designed to measure an employee's perceptions of the affect of the companies' information system support capability on the reverse logistics process within their organization. The study will use the scale developed by Daugherty et al., (2002); a two-item, seven-point Likert scale with a reported Cronbach's alpha of .90.

Next, information system support compatibility is a construct designed to measure employee's perceptions of the affect of the companies' information system support compatibility on their organizations' reverse logistics process. Again, Daugherty et al., (2002) developed a seven-item, seven-point Likert scale with a reported Cronbach's alpha of .93.

Third, information system technologies available within the reverse logistics process is a measure designed to record employee's perceptions of the affect of the types of technologies available and their impact on their organizations' reverse logistics

process. The study will use the scale developed by Chen and Paulraj (2004); a four-item, seven-point Likert scale with a reported Cronbach's alpha of .75.

Next, information system implementation is designed to measure employee's perception of the influence of logistics information integration on the service performance of an organizations' reverse logistics process. This factor is measured with a six-item, seven point Likert scale with a reported Cronbach's alpha of .84 (Chen and Paulraj 2004).

Finally, reverse logistics innovation is designed to measure the employee's perception of the organization's innovativeness toward the reverse logistics process. The factor is measured with a three-item, seven point Likert scale with a reported Cronbach's alpha of .82 (Christmann, 2000).

Table 3.8 includes a summary of the constructs, source, number of items, and reported Cronbach's alpha for each scale. As suggested by established literature references, an alpha of .70 or higher is indicative of good reliability (Nunnally 1978); all of the constructs selected for this study meet this requirement. Only minor modifications were made to the items to ensure face validity and maintain common reference for respondents. The instrument (see Appendix A) consists of 33 items plus demographic information.

Table 3.8

*Utilized constructs*

<b>Construct</b>	<b>Source</b>	<b># of items</b>	<b>Cronbach's alpha</b>
Reverse Logistics Cost Effectiveness	Christmann, 2000	4	.85
Reverse Logistics Processing Effectiveness	Autry, Daugherty, & Richey, 2001	3	.82
Information System Support Capability	Daugherty, Myers & Richey, 2002	2	.90
Information System Support Compatibility	Daugherty, Myers & Richey, 2002	7	.93
Information System Technologies	Chen & Paulraj, 2004	4	.75
Information Systems Implementation	Chen & Paulraj, 2004	6	.84
Reverse Logistics Innovation	Christmann, 2000	3	.82

Table 3.9 provides the results of the factor analysis of each of the constructs and the respective loadings for each of the questions. The reliability analysis results are also displayed with the respective computed Cronbach's Alpha for each construct.

Table 3.9

*Factor Analysis of Construct Items*

<b>Construct</b>	<b>Items</b>	<b>Factor Analysis (Computed)</b>	<b>Cronbach's alpha (Computed)</b>	<b>Cronbach's alpha (Literature)</b>
Reverse Logistics Cost Effectiveness	Item 20	.75	.92	.85
	Item 21	.85		
	Item 22	.86		
	Item 23	.90		
Reverse Logistics Processing Effectiveness	Item 31	.87	.91	.82
	Item 32	.82		
	Item 33	.81		
Information System Support Capability	Item 27	.75	.83	.90
	Item 28	.87		
	Item 29	.81		
	Item 30	.84		
Information System Support Compatibility	Item 13	.84	.90	.93
	Item 14	.83		
	Item 15	.85		
	Item 16	.64		
	Item 17	.85		
	Item 18	.79		
Item 19	.76			
Information System Technologies	Item 1	.82	.83	.75
	Item 2	.86		
	Item 3	.76		
	Item 4	.79		
	Item 5	.80		
	Item 6	.30		
Information Systems Implementation	Item 7	.79	.84	.84
	Item 8	.83		
	Item 9	.82		
	Item 10	.67		
	Item 11	.66		
	Item 12	.70		
Reverse Logistics Innovation	Item 24	.88	.75	.82
	Item 25	.89		
	Item 26	.90		

*Control variable.* Additional demographic information was requested for potential use as a control variable, specifically, size of the respondent's organization. Organizational size has been shown to have an impact on resource allocation within the organization and therefore may impact the results of this study, therefore it has been included due to its possible importance to the results (Gargeya and Thompson 1994; Claycomb and Germain 1999).

*Moderating variable.* Respondents were asked for basic demographic information such as years of reverse logistics experience, years in current position, and duty position within the organization. To further account for any possible disparity or differences in responses, respondents were asked whether their primary reverse logistics involvement is in the role of receiving products through reverse channels, sending product back to vendors or experience with both aspects of the reverse logistics process.

They were also asked various questions regarding the framework for their reverse logistics process such as environmental guidance, company or country mandates, or other requirements. Respondents were also asked to label whether they dealt primarily in a business-to-business, business-to-customer, or hybrid environment. This information is requested for potential use as a moderating variable. A moderating variable is a variable that impacts the direction or strength of a relationship between a predictor and an dependant variable; it represents an interaction where the effect of one variable depends on the level of another (Baron and Kenny 1986; Frazier, Tix et al. 2004).

*Common method bias.* The survey was conducted via internet link distributed by email to respondents. The data was captured and was representative of a moment in time. This methodology increases the likelihood of common method bias. Podsakoff,

MacKenzie, Lee, and Podsakoff (2003), provide a list of sources and methods for dealing with common method bias issues. According to them, when survey data is collected at the same time from the same source for both the predictor and response variables, the tool should be designed to physically separate the predictor and dependant variables and guarantee respondent anonymity. Table 3.10 provides a summary of the most apparent sources and the attempts to control common method bias.

To mitigate method bias a number of actions were accomplished. Survey scales with fewer items were selected for inclusion into this survey, if available. Next, scale items were carefully reviewed to ensure they clearly defined and conveyed the question. Third, no heading or categorical labels were used to group questions according to the variables. Removing, or minimizing, this type information helps to separate the dependent and independent variables and to remove potential priming effects. Lastly, in an attempt to ensure anonymity, respondents were not asked for any identifying information and all data will be appropriately handled and disposed of when research is complete.

Table 3.10

*Common Method Bias*

<b>Possible Sources of Bias</b>	<b>Method to Mitigate the Bias</b>
Scale Length	Scales with few items was utilized to reduce respondent fatigue.
Item Complexity	Items were clearly defined and clarified to ensure question understanding by respondents.
Item Priming Effect	Removal of construct headings and construct definitions.
Potential Identification of Respondents	Respondent's answers were anonymous; no tracking info was collected or stored.



*Model estimation.* Taken together the constructs and associated measures allows the researcher to develop the following models for each of the dependent variables.

$$Y_{ij} = \beta_0 + \beta_1(ISSC) + \beta_2(ISSC2) + \beta_3(IST) + \beta_4(ISI) + \beta_5(RLI)$$

Where:

Y = dependent variable, reverse logistic service performance

i = Reverse logistics cost effectiveness

j = Reverse logistics processing effectiveness

ISSC = Information System Support Capability

ISSC2 = Information System Support Compatibility

IST = Information System Technologies

ISI = Information Systems Implementation

RLI = Reverse Logistics Innovation

*Results of the hypothesis test.* Model 1 was tested first to determine the impact of the independent variables on the reverse logistics cost effectiveness variable. The data was analyzed using multi-linear regression techniques to determine the combined effects of the variables on the model and the individual impact of the variables on cost effectiveness. The first hypothesis predicted a positive relationship between IS Support Capability and reverse logistic cost effectiveness. The computed coefficient of .14 is positive with a p-value of .30; not significant at alpha level .05. Hypothesis 1a is not supported.

The second hypothesis predicted a positive relationship between IS Support Compatibility and RL cost effectiveness. With a negative coefficient of -.05 and reported

p-value of .73, hypothesis 2a is not supported at a .05 statistical significance level. The third hypothesis predicted a positive relationship between IS technology use and RL cost effectiveness. A positive coefficient of .23 and reported p-value of .04 leads to the hypothesis 3a being supported at a .05 statistical significance level. The fourth hypothesis predicted a positive relationship between IS Implementation and RL cost effectiveness. A positive coefficient of .08 was reported with a p-value of .55, leading to hypothesis 4a not being supported. Finally for model 1, reverse logistics innovation was predicted to positively relate to RL cost effectiveness. The analysis results produce a positive coefficient of .62 at a p-value of .00. Hypothesis 5a is therefore supported. The summarized results of model 1 are shown in Table 3.11.

Table 3.11

*Hypothesis Results for Model 1*

<b>Construct</b>	<b>Coefficient</b>	<b>Std Error</b>	<b>P-Value</b>	<b>Hypothesis Support</b>
Information System Technologies	.23	.10	.04 <sup>1</sup>	Yes
Information Systems Implementation	.08	.13	.55	No
Reverse Logistics Innovation	.62	.12	.00+ <sup>1</sup>	Yes
Information System Support Capability	.14	.13	.30	No
Information System Support Compatibility	-.05	.15	.73	No

1. Significant at the .05 level

Next, Model 2 was tested first to determine the impact of the independent variables on the reverse logistics processing effectiveness variable. The data was also analyzed using multi-linear regression techniques to determine the combined effects of the variables on the model and the individual impact of the variables on cost

effectiveness. The first hypothesis predicted a positive relationship between IS Support Capability and reverse logistic processing effectiveness. The computed coefficient of .07 is positive with a p-value of .61; not significant at alpha level .05. Hypothesis 1b is not supported.

The second hypothesis predicted a positive relationship between IS Support Compatibility and RL processing effectiveness. With a positive coefficient of .40 and reported p-value of .015, hypothesis 2b is supported at a .05 statistical significance level. The third hypothesis predicted a positive relationship between IS technology use and RL processing effectiveness. A negative coefficient of -.14 and reported p-value of .26 leads to the hypothesis 3b not being supported at a .05 statistical significance level. The fourth hypothesis predicted a positive relationship between IS Implementation and RL processing effectiveness. Again, a negative coefficient was reported, specifically -.13 was reported with a p-value of .36, leading to hypothesis 4b not being supported. Finally for model 2, reverse logistics innovation was predicted to positively relate to RL processing effectiveness. The analysis results produce a positive coefficient of .46 at a p-value of .001. Hypothesis 5b is therefore supported. The summarized results of model 2 are shown in Table 3.12.

Table 3.12

*Hypothesis Results for Model 2*

<b>Construct</b>	<b>Coefficient</b>	<b>Std Error</b>	<b>P-Value</b>	<b>Hypothesis Support</b>
Information System Technologies	-.14	.12	.26	No
Information Systems Implementation	-.13	.15	.36	No
Reverse Logistics Innovation	.46	.13	.001 <sup>1</sup>	Yes
Information System Support Capability	.07	.14	.61	No
Information System Support Compatibility	.40	.16	.015 <sup>1</sup>	Yes

1. Significant at the .05 level

### Discussion

Upon completion of the analysis of both models for each of the dependant variables, it is shown that the 5 constructs in question explain varying amounts of variance for each model. For model 1 and RL cost effectiveness, the model explains nearly half of the variance with a reported  $R^2$  of .49. In model 1, two of the constructs were measured to be significant; IS technologies use and reverse logistics innovation. Both significant constructs also supported the predicted hypothesis of providing a positive relationship.

For model 2, the analysis shows that again, 2 of the 5 constructs have a significant, positive relationship with the dependant variable RL processing effectiveness. All 5 constructs in the model explain a smaller amount of variance in this model than model 1. Model 2 has a calculated  $R^2$  of .30, showing the 5 variables are accounting for less than 1/3 of the variance in the model. Again, only 2 of the variables had a significant

relationship with RL processing effectiveness. IS support capability and again, RL innovation had the significant, positive relationships to RL processing effectiveness.

Even though both models had 2 statistically significant factors, only 1 was common for both models. Reverse logistics innovation was statistically significant to both dependant variables, with relatively high coefficient values. Based on the relative infancy of formal reverse logistics programs and the newness to academic research, it can be understood as to why innovation within an organization can be positively related to RL performance. Because the processes are new, unstandardized and hard to difficult to force into a IS framework designed for the forward logistics process, it can be seen that companies that can produce and solve their own reverse logistics problems and processes will have a higher perceived ability to reduce costs and effectively process returns, but inbound and outbound. This result for both models supports the belief that organizations that are innovative will be creative in implementing new processes and techniques to positively impact performance (Tushman and Nadler 1986). Again, Bello, Lohtia, and Sangtani (2004) examined supply chain related innovations and they characterize these innovations as the process of combining information technologies with new logistics processes to improve operational efficiency and responsiveness. This is precisely what the reverse logistics process is, a new logistics process that attempts to take advantage of information technologies, for the betterment of the organization.

Utilization of IS technologies positive, significant relationship with cost effectiveness can also be understood due to the belief that technology (RFID, barcodes, IT systems for processing, the internet, etc.) is an enabler to streamlining processes and reducing overhead costs; making things more efficient overall. Also, a firm that is not

sure or has a formalized reverse process may not have the confidence or belief they need to spend resources on technologies to support the reverse logistics process. Those companies who have a clearer understanding of their process and realize there are savings to be had with reducing costs and increasing efficiency of the system may procure necessary technologies for the reverse logistics process and thereby create a cost reduction in the organization. This finding is supported by the research of Daugherty, et al (2002) which identifies information system technologies as an enabler to serving as competitive advantages necessary to support the goals and processes of the organization. It supports the idea that a common differentiator between leading edge and average organizations is the leading edge organizations ability and desire to invest modern technology.

In addition, for model 2, IS support compatibility has a significant, positive relationship to processing effectiveness, along with innovation. This can be viewed by the fact if a firm thinks it is receiving timely updates, return authorizations, and credit processing from their vendor they will likely have a IT systems that communicate and relay information in a similar manner. Whether by design or not, this established compatibility between systems among various companies will allow for more effective processing of returns, both for the shipper of returned products or the receiver. Less information and transactional details have to be physically handled and tracked and can lead to faster, more accurate and efficient processing of the returned goods. This is supported by research that this practical ability is essential and the level of compatibility directly translates to how easy it is for employees to use the system and process transactions (Daugherty, Myers et al. 2002). It also supports the highlighted need for

information exchange compatibility across organizations in today's globalized marketplace (Williams, Nibbs et al. 1997). Given that most manufacturers and organizations in the supply chain have business arrangements with multiple suppliers, logistics providers, and distributors, systems compatibility between specific supply chain partners can be difficult to arrange, but is necessary for effective operation.

*Contribution of the Study and Future Research.* This research effort will contribute by adding academic rigor to practitioner relevance in this area of reverse logistics and information technology use and implementation. Practically speaking, this information would primarily help senior managers and information technology personnel in an organization to develop and implement appropriate levels of information technology support and infrastructure as it relates to the reverse logistics process. This study analyzes and accounts for the necessary impact and implementation of information systems and related technologies into the reverse logistics process. It also looks at the impact on innovation on the effectiveness of a reverse logistics process. This effort allows managers at multiple levels to improve their understanding of the key attributes required to increase reverse logistics effectiveness via the effective implementation of an information system. Primarily, it appears to be more effective to establish technologies and systems that are most compatible with your key suppliers and partners. It was shown that the more compatible the systems are, the more effective the reverse logistics process will be. This would also guide the purchase and implementation of specific technologies in the organization. A firm should not buy or invest in technology or systems that are not compatible with key suppliers. If it is only beneficial internally, the gains received will not be as major or significant as they could be. It should enable them to develop a system

or alter an existing system to effectively integrate necessary logistics data and information so that process performance is enhanced and customers are satisfied.

Additionally, in many situations when both time and fiscal resources are constrained, managers must carefully choose where to spend scarce monetary and personnel resources. The results of this effort should help to enable managers to target aspects or areas of information technology that may provide the most bang for their dollar, allowing them to properly prioritize their efforts. This study could provide the information necessary to support the purchase and implementation of an information system to support reverse logistics processes. In the world of academia, this effort meets an important need of filling a gap in the reverse logistics literature.

Finally, in regards to the impact of innovation, senior leaders and management should take this impact seriously. Since firms are just starting to realize the importance and potential efficiencies within their reverse processes, now is the time to ensure you assign the appropriate, innovative type personnel to the new process. Being able to develop your own system to best fit your products, personnel, and IT framework will help get the biggest bang for the company's buck.

As discussed earlier in this research, the area of reverse logistics is an immature field in the supply chain realm, not much effort has been applied to enterprise planning and integration of information with regards to shipping goods back to a supplier or repair facility. This study should add to the growing body of literature regarding reverse logistics and how to establish an effective program that positively affects organizational performance on more than one level or aspect.



Future research areas could include the research of additional management level factors or areas that impact process development and actual IT procurement. A longitudinal study could also be implanted to follow a company as it starts to look at and establish standardized reverse logistics processes and moves towards implementing IT systems. Impact on the reverse process performance over time will be essential to understanding the effective implementation and integration of a formalized reverse logistics process. The methods used for data analysis might also be modified to include more powerful statistical techniques.

*Limitations.* By the very nature of academic research, this study has limitations that may impact the generalizability and validity of the results. In this study, the respondents were primarily representatives of the federal government and DoD. A wider range of respondents could enhance the ability for the research results to be more generalizable. Having a limited sample limits the generalizability to primarily the facets of the government and DoD reverse logistics practices. Due to the fact of the survey administered at one point in time the validity of the research could be affected by common method bias (Podsakoff, MacKenzie et al. 2003). Overall, model 1 produced an  $R^2$  of .49, explaining nearly half the variance. Despite this, there is room for more explanation within the model. Other factors are contributing to RL cost effectiveness and need to be captured by future research. This model had provided a key step toward understanding cost effectiveness and the role IS technologies and innovation play. For model 2, an  $R^2$  of .30 was calculated, again, less than 1/3 of the variance was explained by the variables within the model and only 2 had significant influence on processing effectiveness. Again, innovation is stressed as important along with IS compatibility.

Regarding processing effectiveness, future constructs may address the actual relationships and communication channels and systems between the various entities in the reverse logistics process. To be effective, communication is key and the importance of IS compatibility between firms is established; now we need to look at how and possibly what is being communicated via the systems, when they are in place.

## Chapter 4

### Performance Metrics and the Reverse Logistics Process

#### Abstract

An organization operating in the logistics field must continuously identify, measure, and evaluate supply chain performance. Global supply chains can be very interdependent and complex, with a single disruption creating a ripple effect that can dramatically impact the entire operation. One preemptive solution to a potential disruption is the establishment of a formal reverse logistics process that enables an organization to be more effective in their prevention of and response to disruption due to product recalls or customer dissatisfaction.

The effective planning and control of the reverse logistics process is critical to successfully managing a supply chain. The academic community has an important role to play in helping industries remain competitive through inventory management, transportation, disposition and storage costs. This is of particular concern in the increasingly important area of reverse logistics management. Reverse logistics is a fairly new process that has received attention within the logistics and business community. Therefore, being able to identify necessary performance objectives and any underlying challenges to confronting logisticians, pertaining to the reverse logistics process, is key. Therefore, an exploratory type study is needed to determine and analyzed the various

objectives and challenges to the reverse logistics process within an organization is needed.

### Introduction

A goal of senior management in an organization is to establish meaningful goals for the organization. Doing this allows the conveyance of priorities and what matters to the bottom line of the firm. These priorities are then adapted by each area of the organization and they determine what it is they do that contributes positively to the priorities and goals of the organization. This allows managers to begin establishing performance measures for their workers and processes. The key task in developing performance metrics is to ensure what they are measuring directly relates to the main goals of the company. There should be an obvious relationship between the metric a low-level worker or process is measured on and a stated goal of the company. This relationship between metrics and firm goals is what makes it real and concrete to the workers and managers; they know how they are contributing to the bottom line.

The key to performance metrics and their effective use is they must have a direct relationship to an overarching goal of the firm. Collecting and monitoring metrics that have no bearing on the information needs and performance of the organization is an exercise in futility and will frustrate the workers and process managers if they are being measured in facets of the process that are not relevant to an obvious organizational goal or management need. Metrics are a tool for personnel that allow them to assess how the task or process they are part of is performing and how it relates to overall organizational goals. Proper information and metrics allow managers and senior executives to make

informed decisions about the current and future state of operations and highlight areas needing focus.

Reverse logistics is an essential capability for any business that operates in today's global marketplace. It impacts customer relations and the firm's reputation. Therefore, the development of effective reverse logistics capabilities and its integration throughout the supply chain should be considered managerial priorities. This logistics capability has many processes that are have the capacity to promote effective logistics management operations and service quality. To ensure that the processes are operating as they should and producing results that impact the goals of the firm, performance metrics are necessary to gauge and make adjustments to changes as the uncertainty of the reverse logistics process creates unexpected returns. Managers need reliable and effective supply chain management processes, systems, and metrics in order to keep costs down and remain competitive (Closs 1989). The growing importance of the reverse logistics process in a supply chain and the need to be able to accurately measure and assess the process performance at various stages of the reverse logistics system served as the motivation for this study.

There are two basic roles of a reverse logistics process; returning a product and returning packaging to the point of origin or manufacturer (Rogers and Tibben-Lembke 2001). Studies have indicated that products are either returned to the point of distribution for refurbishing, recycling, or disposal; in other words, dealing with the end of life of the product (Andel 1997; Carter and Ellram 1998; Blumberg 1999; Rogers and Tibben-Lembke 2001; De Brito and Dekker 2003). Another facet that is inherent to some reverse logistics processes is that it is part of a closed-loop system. In such a system, assets flow outbound to a customer and those same assets flow in the reverse direction, usually in an altered state or condition (Jayaraman and Guide Jr 1999; De Brito

and Dekker 2003). A key difference is that the reverse flow is not just the mirror image of the outbound distribution flow. They contain similar activities, but they are often not related or performed by the same vendor or partner; transportation, disposition decisions, warehousing, and inventory control are just the main examples of the similar yet different aspects.

In 2001, retail customer returns accounted for approximately 6% of revenues, or nearly \$44 billion and accounted for nearly 4% of a firm's logistics costs (Rogers, Lambert et al. 2002). This further indicates the need for companies to focus and measure the performance of their reverse logistics processes. The more efficient and effective they make their process the more likely they are to reduce logistics costs for the organization.

*Reverse logistics and metrics.* The increased uncertainty regarding supply and demand, shorter product life cycles, and more products introduced and the increased reliance on complex networks of suppliers, manufacturers, distributors, retailers, and customers creates a process manager's nightmare. Overseeing the reverse logistics operations requires the constant monitoring of the process. The tool that managers utilize is a performance measurement system; it tracks, monitors, and reports the status and results of their respective processes.

In essence, a performance measure is data or information on a process that is generated and defined or benchmarked against a standard or constant point of reference, this allows for determining if there is excess variation or the process is out of control or set limits. Their main goal is to explain or display how a certain process or operation generates value for the organization (Melnyk, Stewart et al. 2004). Regarding reverse logistics, the field is very immature and it is just recently been receiving attention, thus the metrics it utilizes are often misused or wrong, in regards to the process they are

measuring. The priorities of the organization are different when focusing on reverse logistics versus forward logistics, thus the metrics used to quantify process results should be different (Griffis, Goldsby et al. 2007). The key is to be able to assess the information that management needs in order to adequately make decisions on the reverse logistic process.

The literature regarding metrics and reverse logistics is mainly anecdotal and not particularly grounded in academic rigor. Different industries, organizations, and logistics providers outline different metrics they can monitor and utilize to enhance firm performance. Very few of these measures have been empirically studied and most logistics measures are focused within internal processes within the firm, there are few tangible metrics that span the supply chain or go beyond one partner up or down the supply chain (Lambert and Pohlen 2001; Melnyk, Stewart et al. 2004). Often times, the particular industry determines which metrics will be used to measure and manage the reverse chain. Table 4.1 shows a representative example of various reverse logistics metrics taken from research articles and trade publications.

Table 4.1

*Reverse Logistics Metrics*

<b>Sample Performance Measures</b>	
Customer Wait Time	Net Asset Recovery Rate
Return Rate	Personnel costs of Reverse Process/Revenue
Return Cycle Time	Total Process Costs/Revenue
Scrap Rate	Scrapped/Annual Sales
Inventory Carrying Costs	Returned Product Inventory Value
Returns/Annual Sales	Boomerang Rate (returned 2x)

These metrics are just some of the key metrics identified and may not apply to every firm that operates a reverse logistics process.

Even though logistics metrics have been studied in-depth, there is still little agreement as to the most important measures and the breadth of each measure (Caplice and Sheffi 1994). Many measures are still focused at internal processes and do not span the supply chain, as senior managers desire. To best measure and monitor customer service levels, process managers and firms need to be able to monitor and adjust the many processes and hand-offs from manufacturer to customer. For example, having an on-time delivery metric that is always met may sound good, but it may hide process problems between various firms in the supply chain that, if highlighted and addressed, may actually speed up product delivery and provide greater value to the customer at the same or reduced cost. Hoffman (2004) addresses logistics measures as a hierarchy and breaks them into groups with the ability to assess, diagnose, and correct problems within the supply chain. She addresses this hierarchy primarily from traditional, forward logistics processes and metrics, focused on meeting customer expectations and demands. This same type of approach could be applied to the operation of the reverse logistics portion of the supply chain. But, to accomplish this hierarchy, it is necessary to determine and assess the key reverse logistics indicators being utilized by organizations. Even though some reverse logistics metrics are determined by the industry focus or final disposition options for the returned product, there should be some underlying set of baseline logistics metrics that measure customer satisfaction and overall operational performance of the reverse channel. These metrics may be similar to forward logistics processes, but the differences may lie in their particular importance and how the manager applies the resulting information provided by the metric. Determining and knowing these reverse logistics metrics will allow for the future development of a hierarchy of metrics



for the reverse channel and allow for the adequate information reporting traits of the utilized metrics. In addition to knowing what metrics are utilized in the reverse logistics processes, it is also necessary to understand the key challenges firms have when trying to measure the performance of the reverse process. They may have metrics in place, but they may not provide the manager the information to make critical decisions, but they may be the only data that is currently captured by the organizations information system. Finally, it is key to understand the reverse logistic manager's perspective on the goal of the firm's reverse process. This stated goal should directly tie into captured metrics and relate to tangible activities that can be changed or managed based upon the results.

Regarding the reverse logistics processes, there is a gap of available metrics that span beyond the internal operations of the firm or the basic customer to manufacturer relationship. Because the reverse process is just gaining momentum, many logistics providers treat returned products as a problem and fail to extract as much value as possible out of returns. By establishing sets of proper metrics, a firm may be able to monitor and control the reverse logistics process, despite its high levels of uncertainty. There is a need to determine what practitioners and firms think is the primary goal of reverse logistics in the organization, the key reverse logistics metrics in their organization, and how well they and how well their chosen metrics actually meet the information needs of the organization.

To determine the appropriateness of reverse logistics metrics, there needs to be a framework to use as a guideline for assessment. Throughout the logistics literature there have been a number of frameworks developed for performance measurement (Mentzer and Firman 1994; Rafele 2004; Namji, Rigas et al. 2005). These frameworks develop

various decision criteria to establish metrics and attempt to tie them to strategic goals of the organization. The frameworks take a product and production based focus to help choose which types of metrics are best for the organizations; they provide frameworks that work as guides for a manager in selecting appropriate measures for his processes (Scott and Westbrook 1991; Fisher 1997).

Being product and production based, the frameworks do not function as well in a general logistics environment. Many metrics and decisions need to be made that do not relate directly to the product or production. Often, the needs are related to a specific goal for a specific point in time or to meet a specific contingency situation within the supply chain.

To assist in determining what practitioners and organizations think are key goals and metrics of their reverse logistics process, they will be surveyed to assess what they feel the main goal of the reverse logistics process is, how they measure and monitor its performance, and what are significant challenges to managing the process. This survey of the field should provide a set of reverse logistics metrics that are commonly utilized by practitioners. The researcher expects to see some differences in the types of metrics used by various industries and based upon how the final disposition of returned products is handled. Once the most prevalent metrics in use are determined, they will be categorized using a grounded theory approach to determine a basic model or framework of the reverse logistics goals and metrics being used by practitioners. The researcher expects to see a model that balances the needs of the customer vs. the needs of the manufacturer or supplier, with costs and customer satisfaction weighing high on metric usage. The outcome of the data collection and analysis is a generalized, descriptive model of the

reverse logistics goals of firms and the metrics and challenges they utilize in daily operations.

### Methodology

To appropriately collect, code, and sort the responses, the grounded approach was utilized. This technique is very helpful because the generated model will be grounded and guided by the data collected from the respondents, not from existing theory or literature. It aids in the generation of theory or frameworks from the collected data (Martin, 1986). A major benefit to utilizing the grounded approach is it puts significant weight on the input and responses of actual practitioners in a particular field (Glaser, 1992). The practitioner inputs are the empirical data that is driving the model or theory development.

Grounded theory is primarily utilized within the social sciences, but it has been utilized more frequently outside of that realm, particularly within the logistics and supply chain fields. For example Jutner, et al (2003) utilized grounded theory to analyze the concept of supply chain risk management utilizing inputs from practitioners based on existing risks and risk management strategies. Also, grounded theory was used in the research of the integration of various business processes and supply chain management processes. The goal was to determine how far business processes within organizations extended into the supply chain and its processes and a conceptual model of a possible integrated business process was developed (McAdam and McCormack, 2001). This effort is similar to these studies in that it seeks to collect the goals, metrics, and challenges of the reverse logistics process through the input of practitioners within the reverse logistics field.

The grounded theory approach utilizes the views and inputs of participants to develop a theory or conceptual model by analyzing their responses using three types of coding; open, axial, and selective (Strauss & Corbin, 1994; Cook and Kumar, 1998).

Once the participant responses are collected, they go through the phase of open coding. In this step the data is categorized into overarching themes or groups (Strauss & Corbin, 1994). The developed categories are self-defined from the respondents input from the data collection, thus grounding the developing results from the data and not predetermined theories (Glasser & Strauss, 1967). After coding is completed, there is an examination for relationships or connections among all of the defined categories. This is the axial coding step of the methodology. The goal is to develop the relationships among the categories to create a more robust, consolidated model or relationship structure. Selective coding is the last step of the methodology and it has the goal of further integrating the categories and using the results to develop the background discussion that further integrates the axial coding results. It puts the finishing touches on the final descriptive model.

*Participants.* The sample for this effort consisted of 89 logisticians from a large service organization and practitioners in the logistics industry. The individuals were asked to fill out a questionnaire in order to capture their input on the goals of their reverse logistics process, metrics utilized for reverse logistics, and any challenges they have with their reverse process. The participants represent a wide range of functions within an organization at multiple facilities within numerous departments. They possess responsibility levels from technicians, to middle management, to senior management executives. Due to the nature of the study and the varying levels and degrees of logistics operations throughout the organization, the population of interest was limited to those individuals that have some knowledge, role, or control within the reverse logistics process. Survey respondents were reminded to focus on the reverse logistics process and logistics information systems within their realm of activity; the goal was to reduce cross contaminating attributes and opinions on other logistics processes. The individuals took

the survey electronically via an internet link distributed via an email invitation. All respondents were offered a copy of the results of the study and asked to forward the survey link to possible respondents who they feel are qualified to answer the questions.

A summary of the sample demographics is shown in the following tables.

Table 4.2

*Respondent Knowledge*

	<b>As Shipper</b>	<b>As Recipient</b>	<b>As Both</b>
Percentage of Sample	19.1%(17)	38.2% (34)	42.7%(38)

Table 4.3

*Respondent Experience*

	<b>Yrs in Current Position</b>	<b>Years in Organization</b>	<b>Years of RL Experience</b>
Percentage of Sample	6.2	11.8	8.7

Table 4.4

*Respondent Position*

	<b>Sr. Mgmt</b>	<b>Middle Mgmt</b>	<b>Professional</b>	<b>Technical</b>	<b>Other</b>
Percentage of sample	25.8%(23)	50.6%(45)	18.0%(16)	2.3%(2)	2.3%(2)

Table 4.5

*Respondent Industry*

	<b>Percentage of Sample</b>
Technology	6.7% (6)
Manufacturing	44.9% (40)
Aerospace/Aviation	46.1% (41)
Heavy Equipment	1.1% (1)
Utility	0.0% (0)
Automotive	5.6% (5)
Telecom	0.0% (0)
Medical	2.2% (2)
Logistics Provider	14.6% (13)
Rail	5.6% (5)
Other	12.4% (11)

Table 4.6

*Respondent Type of RL Function*

	<b>Percentage of Sample</b>
B2B (Business-to-Business)	80.2% (69)
B2C (Business-to-Customer)	14.0% (12)
Hybrid	5.8% (5)

## Results and Discussion

The results of this research produced three main effects. First, was the identification of an organizations reverse logistics objectives and goals. The second effect sought to determine the performance metrics being utilized by reverse logisticians. And finally, the last effect established the identification of challenges reverse logistics practitioners are facing in today's globalized marketplace. Each area is discussed in-depth in the proceeding sections.

*Reverse Logistics Objectives and Goals.* Participants provided a variety of inputs regarding the primary performance goals of their organizations reverse logistics process. Once open and axial coding were completed, it resulted into the classification into one of five primary concepts: minimize the processing cost of returned goods, maximize customer service levels, minimize inventory levels of returned products, minimize the processing time of returned products, and minimize disposition time of returned product. Figure 4.1 displays the five concepts in an integrated descriptive model and their respective relationships and impact on each other are displayed. Each of the five concepts is discussed and how they relate to the other performance objectives.

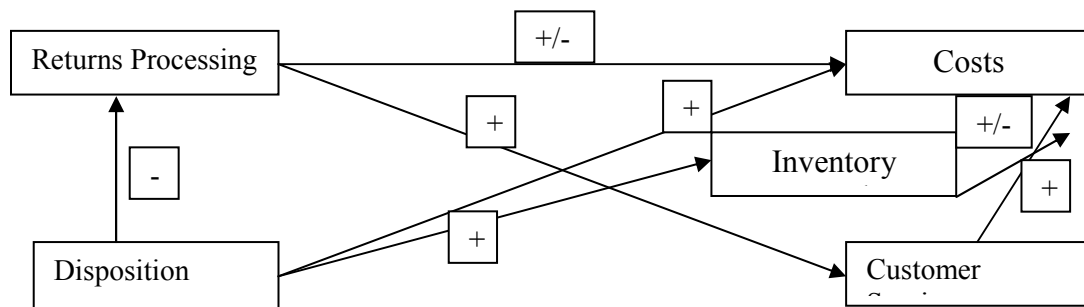


Figure 4.1 Reverse Logistics Metrics Concepts

*Minimizing the processing time of returned products.* This goal of the organization was mentioned by a majority of the respondents. It is the essential part of any returns management process in a firm. The faster a firm can process a return the better outcome for all involved, the organization and the customer. As shown in the model, with the goal of minimizing processing time for returns a firm can positively impact customer service and overall costs related to the return. By keeping the processing time to a minimum through the use of effective information systems and using standardized processes for handling all returns, a firm can ensure that chargebacks are

handled in a timely manner and customers receive either proper credit for their return, or they receive a replacement product or part in a timely manner. Returns processing can have either a negative or positive impact on costs. By handling product fast and efficiently to meet customer needs, certain expedited costs may increase due to increased number of personnel required or having to purchase and maintain more elaborate tracking and information systems, or having to utilize expedited transportation methods. It can also have a positive impact on reducing costs by moving damaged goods out of the warehouse sooner and not having to store items longer on the shelf. It also may increase firm costs by having to maintain larger levels of finished goods and parts to quickly ship to customers as replacements for the defective merchandise. This balancing act associated with costs was noted by participants. They want to meet customer needs as fast as possible, but not so much as to the detriment of their firm. This is where knowing their customers and having solid relationships can pay dividends. If they know what their customers are willing to accept in terms of timeliness, they can plan appropriate levels of finished goods to meet anticipated return demands and keep it at a minimum.

*Minimize disposition time of returned product.* When a firm receives a returned product, they must have appropriately trained personnel and processes to quickly determine what is wrong with the product and what to do with the product. If the product is defective there are several options available and they can have impacts on costs, inventory levels, and returns processing time. Being able to quickly determine proper disposition greatly enhances customer service because it allows for a faster returns processing of the item and the customer receives either a credit or new product sooner. Costs are significantly impacted by keeping disposition time to a minimum. The longer



carcasses of unknown problems languish on shelves, the greater the carrying and inventory costs to the firm and the less space and resources available for finished goods. Respondents state the faster they can determine the usability of the returned product, the more value they can extract from it. Value can come from just reducing inventory costs to being able to refurbish and resell the item, sell the item for scrap, cannibalize usable components off the product, or send it back to a supplier further back in the supply chain and receive their proper credit or new component in return. They are finding there is more value than once perceived in the items being returned. They used to not get very much attention, but some respondents are seeing them as possible value or profit centers, if they can minimize the time it takes to dispose of the defective product.

*Minimize inventory levels of returned products.* Keeping inventory levels of returned products at a minimum is an essential goal for many of the respondents. Returned products are given a disposition and sit in a warehouse not generating any revenue and not being sold for any value as refurbished or as scrap. Efficient and streamlined reverse logistics processes need to be in place so that costs are kept to a minimum by keeping inventory levels of returned products low. Without a formalized reverse logistics process, inventory levels can rise over time and eat into carrying costs and reduce usable warehouse space and become even more obsolete than when they were first returned. Keeping inventory down will help keep reverse logistics costs down for the organization. Respondents agreed that more often than not, returned inventory levels can become neglected if the reverse process is not adequately formalized and proper information systems are not in place. On the other hand, it is essential to have necessary

inventory levels available for replacing returned products. Having this level of safety stock for returned goods is necessary to adequately maintain customer service levels.

*Minimize the processing cost of returned goods.* The respondents stated that being able to effectively control and minimize costs is essential to an effective reverse logistics process. As can be expected, financials are constantly measured in a firm and being able to keep costs down in an area that is not a revenue generator is essential. Controlling costs associated with returned products is very important and difficult to manage. Companies that pay for return shipment of product face increasing costs regarding hiring employees to properly handle and process returns, increased fuel/transportation costs for sending damaged goods back (often times expedited), and increasing customer demands for faster returns processing can negatively impact costs in a firm. It was noted that a main method to reduce costs in the return process is to manufacture or purchase quality components and products, initially. By possibly spending more on higher quality inputs into the manufacturing process the overall costs for the reverse process may likely be reduced by having to handle fewer returns.

*Maximize customer service levels.* The most cited response was regarding maximizing customer service levels, often times to the detriment of other performance goals in the organization. In the reverse logistics process, dealing with customer returns, complaints, and defective products is priority one with practitioners. Making sure the customer is happy and satisfied is essential to effective customer relationship management. This goal is tied to customer relations and knowing how much your various customers are costing you to maintain their relationship. Tracking and knowing how much each are costing you in regards to return rates, return inventory values, and

other associated costs of doing business is essential to controlling your costs and ensuring effective customer service levels for the organization.

*Reverse Logistics Metrics Utilized.* In the second part of the research participants provided a number of key metrics they utilize to monitor their reverse process. The metrics utilized focused heavily on measuring various costs attributed to reverse logistics processes and to measuring customer satisfaction regarding various processes within the reverse system. Table 4.7 highlights the reverse logistics metrics as reported by the respondents.

Table 4.7

Reverse Logistics Metrics Reported by Respondents

<b>Metric</b>	<b>Objective and Goal</b>
Customer wait time	Customer service; Processing time
Return rates	Costs; Customer service
Scrap rates	Customer service
Scrap value	Costs
Return cycle time	Customer service; Returns processing; Disposition
Returned product inventory value	Costs; Inventory levels
Customer Satisfaction	Customer service
Account processing time	Returns processing; Disposition
Velocity/throughput of returned goods	Disposition; Returns Processing
Return rate by supplier/vendor	Costs; Inventory levels; Customer service
Inventory levels of scrap/carcasses	Inventory levels
Credit processing	Customer service; Returns processing; Disposition
Cost of returned goods	Costs

The metrics identified by the practitioners appear to fit into each of the main organizational reverse logistics goals or objectives. This is congruent with the need for firms to apply appropriate metrics so that they can effectively monitor their progress towards their goals. A key here is that these metrics are solely focused at the firm level,

local level. No one reported any metric that expanded through multiple layers of the supply chain or looked at suppliers above or below 1 step in the supply chain. As the importance of the process expands within firms, this could be one possibility for expansion of metrics to cover larger portions of the supply chain. This type of metric could create even more efficiencies or cost reductions if quality of inputs is tracked back even further within the supply chain.

*Reverse Logistics Challenges.* The final portion of the research focuses the participants on identifying any key challenges they have encountered. Since the formalization and field of reverse logistics is relatively young, there are many challenges firms have when dealing with customers. Once the responses were collected and coded, they developed into three distinct categories of challenges for practitioners in dealing with the reverse logistics process.

*Process challenges.* The category and idea of process challenges is in reference to the actual lack of a standardized process. Many respondents stated that because reverse logistics is a fairly new concept, many firms and organizations attempt to just treat it like the forward channel, just in reverse. This has been stated and shown to be a fallacy. Reverse logistics processes need to be designed or re-designed from the ground up, with input from all key players in the reverse supply chain. This would include customers, vendors, suppliers, transportation carriers, workers, managers, and anyone else within the process. Just like forward channels were established for efficiencies, the reverse process deserves the same consideration within each organization. One step in the redesign mentioned by respondents was to ensure that the process aligns with the goals of the organization and that appropriate metrics are established or created to

accurately assess the performance of the process. Too often metrics from the forward channel are just utilized as adequate measures in the reverse process. This may not be the most appropriate use of those metrics and may not serve the reverse process well. Firms need to standardize their reverse logistics process so that all workers and customers are aware of how the process works within the organizations and how they will be measured.

*Communication challenges.* The second challenge noted by the practitioners related to the concept of communication issues. This deals with communicating with suppliers and customers, anyone who can receive or send back products to the firm. It also deals with communication challenges within the organization. It was stated that because of the infancy of reverse logistics and it being primarily seen as a cost center from management, it is often difficult to effectively communicate problems with the process or relay how much inefficiencies are costing the firm. This ties back to having a standardized process, without that no one can concisely explain the problems to management and get satisfactory resolution.

Communicating with customers is critical to reverse logistics success. It is vital to know what is wrong and the customer is the conduit to this information. The more clear the communication, the easier and faster the firm can attempt to satisfy the needs of the customer. Respondents stated actual language differences created a lot of the communication problems. Globalization of the supply chain forces firms to deal with foreign countries on a regular basis and that makes it difficult to understand the complaints with the product.

*Information challenges.* The final challenge brought up by the participants was in regards to information within the reverse logistics process. This concept actually covers

numerous aspects of information availability. The inherent non-predictable demand level of returned products creates a challenge in being able to effectively establish a formalized reverse process. It is difficult to know what and when products will be returned.

Respondents stated this many times as a challenge in managing their process.

It was often stated that there is a lack of information systems support for the reverse logistics process within many organizations, thus making it challenging to collect, process and interpret information regarding returned products. Information systems are setup and great at collecting forward channel data, but very underutilized when it comes to collecting and validating data for the reverse process. This lack of data regarding tracking, in-checking, disposition, and returns management make it difficult to meet customer demands and manage an efficient process. This lack of data makes it even more difficult to forecast any type of product return demand. More robust data collection and processing may lend itself to some level of being able to better manage product returns.

Visibility of products in the return channel is another area discussed by respondents. By relying on customers to package and ship product back, there is a large gap in having visibility into the items location and estimated arrival. There is also a lack of consistency and accuracy in packaging and filing out product return forms. It was stated this poor information creates more work for proper disposition and meeting customer needs in a timely manner.

#### Contribution of this Proposed Study

This research effort contributes in two areas: practice and research. First, the research contributes to the practitioner base by providing managers with a listing of top reverse logistics metrics in use and then provides current challenges being faced by

reverse logistics managers. Also, the results of this effort should enable managers to focus on certain metrics where they can receive the most “bang” for their “buck” and properly apply the most useful metric to certain situations and not waste time and manpower tracking the inappropriate metric, or highlight the inadequacy of reverse metrics in use and provide them with information to properly adjust reverse metrics to focus on the appropriate information needs of managers to meet organizational goals.

Second, this effort meets an important need by filling a gap in reverse logistics literature. As discussed earlier in this research, reverse logistics is an immature field and its organizational and corporate importance is growing. The descriptive model of the relationship between key reverse logistics areas displays how they rely and interact off of each other. It lays the ground work for future testing of hypothesis. However, little academic research has been applied specifically to the assessment and establishment of performance metrics, this effort seeks to be a step in filling that gap.

#### Limitations and future research

As with any research effort, this study has limitations that could impact the generalizability and validity of the results. In this effort, the respondents were primarily representatives of the federal government. While they did represent multiple organizations and were from a wide range of locations, they do belong to the same larger organization. A wider range of respondents could enhance the ability for the research results to be generalized

Future research opportunities might include developing hypothesis to test the relationships in the descriptive model of organizational goals regarding reverse logistics. Additionally, efforts might include a longitudinal study to determine if the certain reverse

logistics measurement attributes change over time or during certain activities or contingency events, such as product recalls.



## Chapter 5

### Conclusions

The volume and value of product moving throughout the reverse logistics process within the supply chain has been and continues to be increasing due to environmental, legal, and marketing initiatives (Guide Jr, Souza et al. 2006). It has been reported that the value of product returns in the commercial sector have exceeded \$100 billion annually and is continuing to increase year to year (Stock, Speh et al. 2002; Guide Jr, Souza et al. 2006). Some may think the reverse process is just the opposite movement from standard forward/outbound logistics, but the differences primarily lie in the disposition activities and final action taken on the product. Basically, the more value remaining in the returned product, the more important the reverse logistics process is within the organization.

In the past, industry has not focused on the management and development of the reverse process, returns were seen as burdensome and an activity managed more by exception than as a key process (Guide Jr, Souza et al. 2006). The potential neglect of the reverse logistics process can reduce the amount of value the firm may extract from returned product, negatively impact customer relationships, and possibly increase reverse logistic costs due to inadequate management oversight of the process (Guide Jr, Souza et al. 2006).

Properly developed and monitor reverse logistics processes can be a mutually beneficial situation for both the firm and the customers (Stock and Mulki 2009). Organizations have come to recognize that inadequate management of the reverse logistics process can have potentially catastrophic effects on costs, quality, customer satisfaction and ultimately revenues. The goal of this dissertation was to explore this growing, strategic area of importance through three distinct yet related essays, each was presented as a separate chapter of this dissertation. Each essay builds on the common theme of reverse logistics in order to make a distinct contribution to the knowledge and understanding of reverse logistics process management.

The first essay, Chapter 2, describes and analyzes the key characteristics of academic research within the realm of the field of reverse logistics. Because the field is relatively young and the topic has relevance in several different fields, there has been little academic research surrounding the topic. Most research is anecdotal or based on specific case studies of firms. This varied list of disciplines and perspectives from which reverse logistics research arises complicate the efforts of those seeking to develop a comprehensive understanding of the subject.

This essay provided a multidisciplinary review of the existing literature and assessed the progress of reverse logistics research as it pertains to these five fields of research: operations management, logistics, information systems, environmental economics, and business management. This allowed for the identification of research gaps and areas needing inspection. This identification of gaps led to the next phase, the use of the Delphi technique to determine what key logistics practitioners thought were driving factors in the reverse logistics process development and implementation. The key

factors, as identified by reverse logistics practitioners, were then compared to the reverse logistics construct framework as developed by Carter and Ellram (1998). The Delphi technique produced 7 ranked, key reverse logistics factors, determined by logistics practitioners. They were: Customer support, top management support, communications, costs, having a formalized program, timing of operations, and environmental issues. When these 7 key factors are compared to Carter and Ellram's (1998) framework, 5 of the 7 factors directly relate to one of the 9 constructs. The two factors not represented are cost and having a formalized program.

Although there is no indication that the key challenges highlighted will be resolved or altered in the future, the relative importance of the challenges may change over time. Now that practitioners have been surveyed and heard from, researchers may seek to study specific facets of reverse logistics and compare results between them, such as recycling, product returns from customers, recalled products, or goods returned for remanufacture.

This essay resulted in an extensive review of the research that has created and developed the reverse logistics concept, a comparison of practitioners' key concerns and the key constructs as outlined by academia, and providing directions of research for the near future. The research allowed for a validation of the Carter and Ellram (1998) framework and showed that academic research in the field is utilizing it. A list of 7 key factors was determined based on practitioner input, something lacking in the research. Also, knowing a relative ranking of key factor importance can provide managers with information as to where to focus scarce resources if they are trying to improve their

reverse logistics process. This Delphi result adds to the growing body of literature in the reverse logistics field and provides managers with a prioritized list of focus areas.

The next essay, presented in Chapter 3, examined the relationship between several information technology attributes of a reverse logistics process and organizational innovation and their impact on the service performance of the reverse logistics operation within the firm. The research examined the impact of information systems support capability, information systems support compatibility, information technology availability, information systems implementation, and reverse logistics innovation on two measures of reverse logistics service performance. A survey instrument was used to gather empirical evidence to test the proposed model and its related hypotheses. In this study, a model consisting of five attributes was outlined and tested. The model consolidated existing literature on reverse logistics and logistics information systems and tested the relationship of five key attributes with two attributes of reverse logistics service performance. The model proposed that reverse logistics service performance is positively related to aspects of information system support capability, information system support compatibility, information system technologies, information system implementation and process innovation.

The results for the model regarding RL cost effectiveness show that the factors reverse logistics innovation and information systems technology use is positively related and statistically significant to RL cost effectiveness. The results for the model regarding RL processing effectiveness show the factors of reverse logistics innovation and information systems support compatibility as positively related and statistically significant.

This research developed a model that provides both academicians and practitioners with a method of determining the information technology attributes with strong relationships to performance effectiveness of a reverse logistics program. This will assist and allow for prioritization of resources within the supply chain and how closely information systems impact reverse logistics and how the level of innovation can influence the impact of technology on the process.

The last essay, presented in Chapter 4, provided for a grounded theory investigation into the current use and importance of metrics within the reverse logistics field. Practitioners in the reverse logistics field were queried on what they thought were their firm's goals for the reverse logistics process, how they measured progress toward those goals, and challenges they perceive in measuring their reverse logistics process.

The researcher utilized and coded the practitioner's input to develop a model that highlighted the balancing act between customer service, cost, and process performance within a reverse logistics process in a firm. This model showed the tradeoffs that must be analyzed and made, using appropriate metrics, to best meet the performance and fiscal needs and constraints of the organization. Using the same technique, the researcher analyzed the reported metrics utilized by the managers and paired them with their respective portion of the performance metrics model. These are shown in Table 5.1.

Table 5.1

*Reported Metrics Utilized by Practitioners*

<b>Metric</b>	<b>Objective and Goal</b>
Customer wait time	Customer service; Processing time
Return rates	Costs; Customer service
Scrap rates	Customer service
Scrap value	Costs
Return cycle time	Customer service; Returns processing; Disposition
Returned product inventory value	Costs; Inventory levels
Customer Satisfaction	Customer service
Account processing time	Returns processing; Disposition
Velocity/throughput of returned goods	Disposition; Returns Processing
Return rate by supplier/vendor	Costs; Inventory levels; Customer service
Inventory levels of scrap/carcasses	Inventory levels
Credit processing	Customer service; Returns processing; Disposition
Cost of returned goods	Costs

Finally, the researcher examined the challenges that managers must address and find solutions to when trying to achieve the firm's goals and various metrics. The key challenges were under the categories of process, communication, and information challenges. The challenges represent the diversity within how various firms in the same supply chain can address reverse logistics processes and how important it is for them to communicate their goals and motivation for doing the activities they do and implementing the metrics they utilize.

This research contributed to the practitioner base by providing managers with a listing of top reverse logistics metrics in use and provides current challenges being faced by reverse logistics managers. The results should enable managers to focus on certain metrics where they can receive the most "bang" for their "buck" and properly apply the most useful metric to certain situations and not waste time and manpower tracking the

inappropriate metric, or highlight the inadequacy of reverse metrics in use and provide them with information to properly adjust reverse metrics to focus on the appropriate information needs of managers to meet organizational goals. Finally, this effort meets an important need by filling a gap in reverse logistics literature. The descriptive model of the relationship between key reverse logistics areas displays how they rely and interact off of each other. It lays the ground work for future testing of hypothesis. However, little academic research has been applied specifically to the assessment and establishment of performance metrics, this effort seeks to be a step in filling that gap.

Each of these three research endeavors have made significant contributions to the academic and practitioner body of knowledge in regards to reverse logistics processes. Despite these contributions outlined above, there is much more research and testing to be done. The field is young and more empirical analysis and hypothesis development and testing needs to be performed to continue moving the field forward and continue the utilization of the Carter and Ellram (1998) framework. As the supply chain globalizes even further, the value of an effective, measurable, and efficient reverse logistics process and system will prove invaluable to a firm. It can turn cost and loss centers into value centers and possibly generate more and different revenue for the organization. Therefore, both academic researchers and managers need to continue to understand and develop the many factors and challenges within the reverse logistics process in hopes of moving the field and their firms further ahead.

## References

- AIS. (2009). "Journal rankings provided by association of information systems."  
Retrieved 10 January, 2009, from  
<http://ais.affiniscape.com/displaycommon.cfm?an=1&subarticlenbr=432>.
- Andel, T. (1997). "Reverse logistics: A second chance to profit." Transportation & Distribution **38**(7): 61.
- Atasu, A. and S. Cetinkaya (2006). "Lot Sizing for Optimal Collection and Use of Remanufacturable Returns over a Finite Life-Cycle." Production and Operations Management **15**(4): 15.
- Autry, C. W., P. J. Daugherty, et al. (2001). "The Challenge of Reverse Logistics in Catalog Retailing." International Journal of Physical Distribution & Logistics Management **31**(1): 26.
- Bakal, I. S. and E. Akcali (2006). "Effects of Random Yield in Remanufacturing with Price-Sensitive Supply and Demand." Production and Operations Management **15**(3): 14.
- Banks, R. (2002). "Defining and improving reverse logistics." Army Logistician **34**(3): 3.
- Barman, S., M. D. Hanna, et al. (2001). "Perceived relevance and quality of POM journals: A decade later." Journal of Operations Management **19**(3): 367.



- Baron, R. M. and D. A. Kenny (1986). "The Moderator-Mediator Variable Distinction in Social Psychological Research : Conceptual, Strategic, and Statistical Considerations." Journal of Personality and Social Psychology **51**(6): 1173-1182.
- Bello, D. C., R. Lohtia, et al. (2004). An institutional analysis of supply chain innovations in global marketing channels. Industrial Marketing Management. **33**: 57.
- Benson, P. G., A. V. Hill, et al. (1982). "Manufacturing Systems of the Future: A Delphi Study." Production & Inventory Management **20**(6): 656-674.
- Blumberg, D. F. (1999). "Strategic examination of reverse logistics and repair service requirements, needs, market size, and opportunities." Journal of Business Logistics **20**(2): 141-159.
- Brancheau, J. C. and J. C. Wetherbe (1987). "Key Issues in Information Systems Management." MIS Quarterly **11**(1): 23-45.
- Bruns, W. J. and R. Kaplan (1987). Accounting and Management Review: Field Study Perspectives. Boston, MA, Harvard Business School Press.
- Caplice, C. and Y. Sheffi (1994). "A Review and Evaluation of Logistics Metrics." International Journal of Logistics Management **5**(2): 11-28.
- Carter, C. R. and L. M. Ellram (1998). "Reverse logistics: A review of the literature and framework for future investigation." Journal of Business Logistics **19**(1): 85-102.
- Chen, I. J. and A. Paulraj (2004). "Towards a theory of supply chain management: the constructs and measurements." Journal of Operations Management **22**(2): 119.

Christmann, P. (2000). EFFECTS OF "BEST PRACTICES" OF ENVIRONMENTAL MANAGEMENT ON COST ADVANTAGE: THE ROLE OF COMPLEMENTARY ASSETS. Academy of Management Journal, Academy of Management. **43**: 663-680.

Claycomb, C. and R. Germain (1999). "Total System JIT Outcomes: Inventory, Organization and Financial Effects." International Journal of Physical Distribution & Logistics Management **29**(9/10): 612.

Closs, D. J. (1989). "Inventory management: A comparison of a traditional vs. systems view." Journal of Business Logistics **10**(2): 90-105.

Closs, D. J. and T. J. Goldsby (1997). "Information technology influences on world class logistics capability." International Journal of Physical Distribution & Logistics Management **27**(1/2): 4.

Closs, D. J. and K. Savitskie (2003). Internal and External Logistic Information Technology Integration. International Journal of Logistics Management. **14**: 63-76.

Craighead, C. W., J. B. Hanna, et al. (2007). "Research approaches in logistics Trends and alternative future directions." International Journal of Logistics Management **18**(1): 22-40.

Croom, S. R. (2005). The impact of e-business on supply chain management: An empirical study of key developments. **25**: 55.

- Daugherty, P. J., C. W. Autry, et al. (2001). "Reverse Logistics: The relationship between resource commitment and program performance." Journal of Business Logistics **22**(1): 107-123.
- Daugherty, P. J., M. B. Myers, et al. (2002). "Information support for reverse logistics: The influence of relationship commitment." Journal of Business Logistics **23**(1): 85-106.
- Daugherty, P. J., R. G. Richey, et al. (2005). "Reverse logistics: superior performance through focused resource commitments to information technology." Transportation Research: Part E **41**(2): 77-92.
- Day, G. S. (2000). Managing Market Relationships. Journal of the Academy of Marketing Science. **28**: 24.
- De Brito, M. P. and R. Dekker (2003). A framework for reverse logistics.
- de Villiers, M. R., P. J. T. de Villiers, et al. (2005). "The Delphi technique in health sciences education research." Medical Teacher **27**(7): 639-643.
- DeCroix, G. A. (2006). "Optimal Policy for a Multiechelon Inventory System with Remanufacturing." OPERATIONS RESEARCH **54**(3): 532-543.
- Dhanda, K. K. and R. P. Hill (2005). "The role of information technology and systems in reverse logistics: A case study." International Journal of Technology Management **31**(1-2): 140(11).

- Dowlatshahi, S. (2000). "Developing a theory of reverse logistics." Interfaces **30**(3): 143(1).
- Dowlatshahi, S. (2005). "A strategic framework for the design and implementation of remanufacturing operations in reverse logistics." International Journal of Production Research **43**(16): 3455-3480.
- Ellram, L. M. and M. C. Cooper (1990). "Supply Chain Management, Partnerships, and the Shipper -Third Party Relationship." International Journal of Logistics Management **1**(2): 1-10.
- Field, J. M. and R. P. Sroufe (2007). "The use of recycled materials in manufacturing: implications for supply chain management and operations strategy." International Journal of Production Research **45**(18/19): 4439-4463.
- Fisher, M. L. (1997). What Is the Right Supply Chain for Your Product? Harvard Business Review, Harvard Business School Publication Corp. **75**: 105-116.
- Fleischmann, M. and R. Kuik (2003). "On optimal inventory control with independent stochastic item returns." European Journal of Operational Research **151**(1): 25.
- Flynn, B., S. Sakakibara, et al. (1990). "Empirical Research Methods in Operations Management." Journal of Operations Management **9**(2): 250-284.
- Frazier, P. A., A. P. Tix, et al. (2004). "Testing Moderator and Mediator Effects in Counseling Psychology Research." Journal of Counseling Psychology **51**(1): 115-134.

- Gall, M. D., J. P. Gall, et al. (2003). Education Research: An Introduction Boston, MA, Allyn & Bacon.
- Gargeya, V. B. and J. P. Thompson (1994). "Just-In-Time Production in Small Job Shops." Industrial Management **36**(4): 23.
- Gentry, C. R. (1999). "Reducing the Cost of Returns." Chain Store Age **75**(10): 124.
- Georgiadis, P. and D. Vlachos (2004). "The effect of environmental parameters on product recovery." European Journal of Operational Research **157**(2): 449.
- Gibson, B. J. and J. B. Hanna (2003). "PERIODICAL USEFULNESS: THE U.S. LOGISTICS EDUCATOR PERSPECTIVE." Journal of Business Logistics **24**(1): 221-240.
- Griffis, S. E., T. J. Goldsby, et al. (2007). "ALIGNING LOGISTICS PERFORMANCE MEASURES TO THE INFORMATION NEEDS OF THE FIRM." Journal of Business Logistics **28**(2): 35-56.
- Grisham, T. (2009). "The Delphi technique: a method for testing complex and multifaceted topics." International Journal of Managing Projects in Business **2**(1): 112.
- Guide Jr, V. D. R., G. C. Souza, et al. (2006). Time Value of Commercial Product Returns. Management Science, INFORMS: Institute for Operations Research. **52**: 1200-1214.

- Guide Jr., D. R. (2000). "Supply-Chain Management for Recoverable Manufacturing Systems." Interfaces **30**(3): 125-142.
- Guide Jr., D. R. and L. N. Van Wassenhove (2001). "Managing product returns for remanufacturing." Production and Operations Management **10**(2): .
- Guide, V. D. R. and L. N. Van Wassenhove (2001). "Managing product returns for remanufacturing." Production and Operations Management **10**(2): 142.
- Gupta, S., R. Verma, et al. (2006). "Empirical Research Published in Production and Operations Management (1992-2005): Trends and Future Research Directions." Production and Operations Management **15**(3): 432.
- Harzing, A.-W. (2008). Journal quality list. Parkville, Australia, University of Melbourne. **32**.
- Hofman, D. (2004). "The HIERARCHY of SUPPLY CHAIN METRICS." Supply Chain Management Review **8**(6): 28-37.
- Iacovou, C. L., I. Benbasat, et al. (1995). "Electronic Data Interchange and Small Organizations: Adoption and Impact of Technology." MIS Quarterly **19**(4): 465.
- Jayaraman, V. and V. D. R. Guide Jr (1999). "A closed-loop logistics model for remanufacturing." Journal of the Operational Research Society **50**(5): 497.
- Karaer, Ö. and H. L. Lee (2007). "Managing the Reverse Channel with RFID-Enabled Negative Demand Information." Production and Operations Management **16**(5): 21.

- Kendall, M. and J. D. Gibbons (1990). Rank correlation methods. New York, Oxford University Press.
- Kiesmuller, G. P. (2003). "A new approach for controlling a hybrid stochastic manufacturing/remanufacturing system with inventories and different leadtimes." European Journal of Operational Research **147**(1): 62.
- Knemeyer, A. M., T. G. Ponzurick, et al. (2002). "A qualitative examination of factors affecting reverse logistics systems for end-of-life computers." International Journal of Physical Distribution & Logistics Management **32**(6): 455-479.
- Kulp, S. C., H. L. Lee, et al. (2004). "Manufacturer Benefits from Information Integration with Retail Customers." Management Science **50**(4): 431-444.
- Lambert, D. M. and T. L. Pohlen (2001). "Supply Chain Metrics." International Journal of Logistics Management **12**: 1-19.
- Landis, J. R. and G. G. Koch (1977). The Measurement of Observer Agreement for Categorical Data, International Biometric Society. **33**: 159-174.
- Langley, C. J. and M. C. Holcomb (1992). "CREATING LOGISTICS CUSTOMER VALUE." Journal of Business Logistics **13**(2): 1-27.
- Lummus, R. R., R. J. Vokurka, et al. (2005). "Delphi study on supply chain flexibility." International Journal of Production Research **43**(13): 2687-2708.

- MacCarthy, B. L. and W. Atthirawong (2003). "Factors affecting location decisions in international operations--a Delphi study." International Journal of Operations & Production Management **23**(7): 794-818.
- Mahadevan, B., D. F. Pyke, et al. (2003). "Periodic review, push inventory policies for remanufacturing." European Journal of Operational Research **151**(3): 536.
- Malhotra, M. K., D. C. Steele, et al. (1994). "Important Strategic and Tactical Manufacturing Issues in the 1990s." Decision Sciences **25**(2): 189-214.
- Malone, R. (2004). Supply Chain Loop: Reverse Logistics and the SCOR Model. Inbound Logistics. **24**: 217-222.
- Mason, S. (2002). "Backward progress." IIE Solutions **34**(8): 42.
- McDermott, D. R. and J. R. Stock (1980). "An application of the project Delphi forecasting method to logistics management." Journal of Business Logistics **2**(1): 1-17.
- McMichael, H., D. Mackay, et al. (2000). "Quick response in the Australian TCF industry." International Journal of Physical Distribution & Logistics Management **30**(7/8): 611.
- Melnyk, S. A., D. M. Stewart, et al. (2004). Metrics and performance measurement in operations management: dealing with the metrics maze. Journal of Operations Management. **22**: 209-218.



- Mentzer, J. T. (1993). "Managing Channel Relations in the 21st Century." Journal of Business Logistics **14**(1): 27-42.
- Mentzer, J. T. and J. Firman (1994). "Logistics control systems in the 21st century." Journal of Business Logistics **15**(1): 215-227.
- Mentzer, J. T. and D. J. Flint (1997). "Validity in logistics research." Journal of Business Logistics **18**(1): 199-216.
- Miranda, P. A. and R. A. Garrido (2004). Incorporating inventory control decisions into a strategic distribution network design model with stochastic demand. Transportation Research: Part E. **40**: 183.
- Mollenkopf, D., I. Russo, et al. (2007). "The returns management process in supply chain strategy." International Journal of Physical Distribution & Logistics Management **37**(7): 568-592.
- Mollenkopf, D. A., E. Rabinovich, et al. (2007). "Managing Internet Product Returns: A Focus on Effective Service Operations." Decision Sciences **38**(2): 215-250.
- Morash, E. A., C. L. M. Droge, et al. (1996). "Strategic logistics capabilities for competitive advantage and firm success." Journal of Business Logistics **17**(1): 1-22.
- Mukhopadhyay, S. K. and R. Setoputro (2004). "Reverse logistics in e-business: Optimal price and return policy." International Journal of Physical Distribution & Logistics Management **34**(1): 70-88.

- Namji, M., J. Rigas, et al. (2005). "A framework to review performance measurement systems." Business Process Management Journal **11**: 109-122.
- Nunnally, J. C. (1978). Psychometric Theory. New York, McGraw-Hill.
- Okoli, C. and S. D. Pawlowski (2004). "The Delphi method as a research tool: An example, design consideration and applications." Information & Management **42**(1): 15(15).
- Palmer, J. W. and D. A. Griffith (1998). "Information Intensity: A Paradigm for Understanding Web Site Design." Journal of Marketing Theory & Practice **6**(3): 38.
- Pinsonneault, A. and K. L. Kraemer (1993). Survey Research Methodology in Management Information Systems: An Assessment. Journal of Management Information Systems, M.E. Sharpe Inc. **10**: 75-105.
- Podsakoff, P. M., S. B. MacKenzie, et al. (2003). "Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies." Journal of Applied Psychology **88**(5): 879.
- Pugh, S., D. J. Hickson, et al. (1968). "Dimensions of Organization Structure." Administrative Science Quarterly **13**(1): 65.
- Rafele, C. (2004). "Logistic service measurement: a reference framework." Journal of Manufacturing Technology Management **15**: 280-290.

- Rao, P. and D. Holt (2005). "Do green supply chains lead to competitiveness and economic performance?" International Journal of Operations & Production Management **25**(9/10): .
- Richey, R. G., H. Chen, et al. (2005). "Developing effective reverse logistics programs." Industrial Marketing Management **34**(8): 830-840.
- Richey, R. G., S. E. Genchev, et al. (2005). "The role of resource commitment and innovation in reverse logistics performance." International Journal of Physical Distribution & Logistics Management **35**(4): 233-257.
- Riggs, W. E. (1983). "The Delphi technique: An experimental evaluation." Technological Forecasting and Social Change **23**(1): 89-94.
- Rogers, D., D. Lambert, et al. (2002). "The returns management process." International Journal of Logistics Management **13**(2): 1.
- Rogers, D. S. and R. Tibben-Lembke (2001). "An examination of reverse logistics practices." Journal of Business Logistics **22**(2): 129-148.
- Rohrbaugh, J. (1979). "Improving the quality of group judgment: Social judgment analysis and the Delphi technique." Organizational Behavior and Human Performance **24**(1): 73-92.
- Rousseau, S. (2007). Journal evaluation by environmental and resource economists: A survey. Energy, Transport and Environment, Kuleuven, Belgium: 18.

- Rowe, G. and G. Wright (1999). "The Delphi technique as a forecasting tool: issues and analysis." International Journal of Forecasting **15**(4): 353-375.
- Russell, D. M. and A. M. Hoag (2004). "People and Information Technology in the Supply Chain: Social and Organizational Influences." International Journal of Physical Distribution & Logistics Management **34**(2): 102-122.
- Savaskan, R. C. and L. N. Van Wassenhove (2006). "Reverse Channel Design: The Case of Competing Retailers." Management Science **52**: 1-14.
- Schmidt, R. C. (1997). "Managing Delphi Surveys Using Nonparametric Statistical Techniques." Decision Sciences **28**(3): 763-774.
- Schultmann, F., M. Zumkeller, et al. (2006). "Modeling reverse logistic tasks within closed-loop supply chains: An example from the automotive industry." European Journal of Operational Research **171**(3): 1033-1050.
- Scott, C. and R. Westbrook (1991). "New strategic tools for supply chain management." International Journal of Physical Distribution & Logistics Management **21**(1): 23-33.
- Srivastava, S. K. and R. K. Srivastava (2006). "Managing product returns for reverse logistics." International Journal of Physical Distribution & Logistics Management **36**(7): 524-546.

- Stank, T. P., P. J. Daugherty, et al. (1996). "Information Exchange, Responsiveness and Logistics Provider Performance." International Journal of Logistics Management 7(2): 43-57.
- Stank, T. P., M. A. Emmelhainz, et al. (1996). "The Impact of Information on Supplier Performance." Journal of Marketing Theory & Practice 4(4): 94.
- Stank, T. P., S. B. Keller, et al. (2001). "Supply Chain Collaboration and Logistical Service Performance." Journal of Business Logistics 22(1): 29-48.
- Stock, J., T. Speh, et al. (2002). "Many happy (product) returns." Harvard Business Review 80(7): 16-17.
- Stock, J. R. (1992). Reverse logistics : white paper. Oak Brook, IL (2803 Butterfield Road, Oak Brook 60521), Council of Logistics Management.
- Stock, J. R. (2001). "The 7 deadly sins of reverse logistics." Material Handling Management 56(3): MHS5.
- Stock, J. R. and D. M. Lambert (2001). Strategic logistics management. Boston, McGraw-Hill/Irwin.
- Stock, J. R. and J. P. Mulki (2009). PRODUCT RETURNS PROCESSING: AN EXAMINATION OF PRACTICES OF MANUFACTURERS, WHOLESALERS/DISTRIBUTORS, AND RETAILERS. Journal of Business Logistics, Council of Supply Chain Management Professionals. 30: 33-62.

- Taylor, R. E. and D. J. Meinhardt (1985). "DEFINING COMPUTER INFORMATION NEEDS FOR SMALL BUSINESS: A DELPHI METHOD." Journal of Small Business Management **23**(2): 3-9.
- Teunter, R. H., Z. P. Bayindir, et al. (2006). "Dynamic lot sizing with product returns and remanufacturing." International Journal of Production Research **44**(20): 4377-4400.
- Tushman, M. and D. Nadler (1986). Organizing for Innovation. California Management Review, California Management Review. **28**: 74-92.
- Vachon, S. and R. D. Klassen (2006). "Extending green practices across the supply chain." International Journal of Operations & Production Management **26**(7): .
- Webster, J. and R. T. Watson (2002). "Analyzing the past to prepare for the future: Writing a literature review." MIS Quarterly **26**(2): R13.
- Wee Kwan Tan, A., W. S. Yu, et al. (2003). "Improving the performance of a computer company in supporting its reverse logistics operations in the Asia-Pacific region." International Journal of Physical Distribution & Logistics Management **33**(1): 59.
- Williams, L. R., A. Nibbs, et al. (1997). "Logistics integration: The effect of information technology, team composition, and corporate competitive positioning." Journal of Business Logistics **18**(2): 31-41.
- Wu, H.-J. and S. C. Dunn (1995). "Environmentally responsible logistics systems." International Journal of Physical Distribution & Logistics Management **25**(2): 20.

Zhu, Q. and J. Sarkis (2007). "The moderating effects of institutional pressures on emergent green supply chain practices and performance." International Journal of Production Research **45**(18/19): 4333-4355.

Zhu, Q., J. Sarkis, et al. (2005). "Green supply chain management in China: pressures, practices and performance." International Journal of Operations & Production Management **25**(5/6): .

## Appendix A: Reverse Logistics Information Systems and Performance Survey

This study is being conducted by Joe Huscroft, a Ph.D. student at Auburn University, under the supervision of Dr. Dianne Hall and Dr. Joe Hanna. We hope to learn about factors which influence reverse logistics process performance and to guide efforts to improve the reverse logistics process and research. You were selected as a possible participant because you are employed in and have practical experience in the logistics industry. Your responses to the questionnaire will be anonymous. The questionnaire contains 31 short questions and should take less than 15 minutes of your time.

Your participation is strictly VOLUNTARY. If you decide to participate, you will need to complete the survey included in this packet and return it to the survey administrator. The survey should take 15-20 minutes to complete. It is important that your answers be frank and honest; there is no “right” or “wrong” answers. You may withdraw from completing the questionnaire at any time (without penalty). Your decision of whether to participate or not, or to withdraw later will not jeopardize your relations with your employer or Auburn University.

Your answers to this survey will be ANONYMOUS, so your identity will not be known.

If you would like an executive summary of the results, please provide an email address. You are welcome to use an anonymous email address from Yahoo, Hotmail, or another source. I will only release aggregated results of the study. No responses will be traceable to an individual or organization. Summary results will be sent to you upon completion of the study.

Your decision to participate will not affect your future relations with Auburn University. As stated above, I will not track responses to specific individuals or organizations. For more information regarding your rights as a participant you may contact the Office of Human Subjects Research by phone at (334) 844-1462.

If you have any questions we invite you to ask them now. If you have questions later, please contact: Dr. Hall, 334-844-6443, [halldia@auburn.edu](mailto:halldia@auburn.edu), Dr. Hanna, 334-844-2468, [hannajb@auburn.edu](mailto:hannajb@auburn.edu) or Joe Huscroft, 334-844-6538, [huscjr@auburn.edu](mailto:huscjr@auburn.edu).

For more information regarding your rights as a research participant, you may contact the Auburn University Office of Human Subjects Research or the Institutional Review Board by phone (334) 844-5966 or email at [hsubjec@auburn.edu](mailto:hsubjec@auburn.edu) or [IRBChair@auburn.edu](mailto:IRBChair@auburn.edu).



Demographic information.

**My position within the organization is (check one):**

Senior Management \_\_\_\_\_ Middle Management \_\_\_\_\_  
Professional \_\_\_\_\_ Technical \_\_\_\_\_  
Other \_\_\_\_\_ (please specify)

**Please select the industry below that best describes the industry within which you deal with reverse logistics.**

Technology/Computers/Networks       Manufacturing      \_\_\_\_\_  
**Aerospace/Aviation**  
 Heavy Equipment       Utility       Automotive  
 Telecommunications       Medical       Logistics Service  
**Provider**  
 Rail

**Experience**

I have \_\_\_\_\_ # years in my current position.  
I have \_\_\_\_\_ # years with this organization.  
I have \_\_\_\_\_ # years logistics experience.

**What is the primary focus of your reverse logistics operation(s) (Check all that apply)?:**

Recycling       Remanufacturing       Product Returns/Recall  
 Shipping containers       Resource reduction       Disposal

**What is the highest level of education you have completed?**

Less than High School       High School/GED       Some  
College  
 2 Yr college (Associates)       4 Yr college (BA, BS)       Masters  
Degree  
 Doctoral Degree       Professional Degree (MD, JD)

**What is your gender?**

Female       Male

**What is the size of your local organization?**

Less than 250 personnel       251 to 500 personnel  
 501 to 750 personnel       751 to 1000 personnel  
 Greater than 1000 personnel

**To what extent are these hardware and software technologies utilized to assist with returns handling? (1 = not used: 7 = used extensively)**

1	Automated material handling equipment.	1	2	3	4	5	6	7
2	Barcodes.	1	2	3	4	5	6	7
3	Electronic Data Interchange (EDI).	1	2	3	4	5	6	7
4	Radio frequency Identification (RFID).	1	2	3	4	5	6	7

**Please assess your firm's information systems usability in the following areas: (1 = not capable: 7 = highly capable)**

5	Timeliness of information.	1	2	3	4	5	6	7
6	Daily download of information.	1	2	3	4	5	6	7
7	Formatted on exception basis.	1	2	3	4	5	6	7
8	Formatted to facilitate usage.	1	2	3	4	5	6	7
9	Real-time information.	1	2	3	4	5	6	7
10	Internal connectivity.	1	2	3	4	5	6	7
11	External connectivity.	1	2	3	4	5	6	7
12	There are direct computer-to-computer links with key suppliers.	1	2	3	4	5	6	7
13	Inter-organizational coordination is achieved using electronic links.	1	2	3	4	5	6	7
14	We use information technology-enabled transaction processing.	1	2	3	4	5	6	7
15	We have electronic mailing capabilities with our key suppliers.	1	2	3	4	5	6	7
16	We use electronic transfer of purchase orders, invoices and/or funds.	1	2	3	4	5	6	7
17	We use advanced information systems to track and/or expedite shipments.	1	2	3	4	5	6	7

**To what extent do you agree with the following statements related to the cost effectiveness? (1=strongly disagree and 7=strongly agree)**

18	We incur lower compliance costs with environmental regulations due to our returns handling method.	1	2	3	4	5	6	7
19	Our strategy for dealing with returned merchandise improves our cost position relative to our closest competitors.	1	2	3	4	5	6	7
20	Our reverse logistics program is saving us money.	1	2	3	4	5	6	7
21	We are realizing cost savings because of our reverse logistics activities	1	2	3	4	5	6	7

**How capable is your firm in the following areas related to reverse logistics/returns handling services provided to customers? (1=not capable and 7=highly capable)**

- |    |                                  |   |   |   |   |   |   |   |
|----|----------------------------------|---|---|---|---|---|---|---|
| 22 | Quality of re-work or repair.    | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 23 | Timeliness of re-work or repair. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**To what extent do you agree with the following statements (1=strongly disagree and 7=strongly agree)**

- |    |   |   |   |   |   |   |   |   |
|----|---|---|---|---|---|---|---|---|
| 24 | To better handle returns, we created our own systems and procedures.              | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 25 | When products are returned, we are good at finding our own ways of handling them. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 26 | We address reverse logistics issues mainly with technologies we have developed.   | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**How capable is your firm in the following areas related to reverse logistics/returns handling services provided to customers? (1=not capable and 7=highly capable)**

- |    |  |   |   |   |   |   |   |   |
|----|--|---|---|---|---|---|---|---|
| 27 | Ease of obtaining return authorization.  | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 28 | Handling reconciliation of charge-backs. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 29 | Length of time for credit processing     | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Please assess your firm's information systems capabilities in the following areas: (1 = not capable: 7 = highly capable)**

- |    |                              |   |   |   |   |   |   |   |
|----|------------------------------|---|---|---|---|---|---|---|
| 30 | Accuracy of information.     | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 31 | Availability of information. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

Appendix B: Example of Survey instrument for assessing reverse logistics performance measures

**Introductory Remarks:** Your participation in this research effort would be greatly appreciated. I value both your knowledge and experience.

**Purpose:** The purpose of this research effort is to provide insight into the management of the reverse logistics process and its performance measures.

Your participation in this research is voluntary and your responses to these questions will be kept strictly confidential. Neither you nor your organization or company will be named in any output (e.g. summary reports, or publications) of this project.

Information about the Interviewee

Name:

Job title:

Primary functions of job:

How long have you been involved in the reverse logistics activity (How many years experience)?

Survey/Interview questions:

1. What is the primary goal of your approach to managing the reverse logistics process/program in your organization (e.g. cost reduction, customer service, returned product inventory value, return rate minimization)?
2. What are your primary measures of the reverse logistics process/program performance (e.g. customer wait time, return cycle time, scrap rate, returned product inventory value, etc.)?
3. What are the most significant/critical challenges related to managing service part inventory in your supply chain?