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AN EMPIRICAL STUDY OF LOGISTICS ORGANIZATION, ELECTRONIC LINKAGE, AND PERFORMANCE

A Dissertation

by

KAREN WILLIAMS CURRIE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

December 1993

Major Subject: Business Analysis

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October 18, 1993

To: Survey Respondents, Logistics Management and EDI Questionnaires

From: Karen W. Currie

Subject: Executive Summary of Research Results

An Empirical Study of Logistics Organization, Electronic Linkage, and Performance

OVERVIEW

Successful participation in the global marketplace demands careful coordination and integration of a firm's logistics activities, which can be enhanced by electronic linkage. Electronic linkage is accomplished through electronic data interchange (EDI), the computer-to-computer exchange of standard business documentation in machine processable form. Previously cited benefits of EDI in domestic applications include increased data accuracy, reduced document preparation and handling costs, reduced inventory costs and higher inventory turnover rates, reduced lead times, better information management, more efficient utilization of transportation resources, and improved quality management.

Researchers have proposed an information technology (IT) implementation model for categorizing research into IT implementation. The present study adapts this IT implementation model for use in classifying a firm's progress in implementing electronic data interchange (EDI), the computer to computer exchange of standard business documentation in machine processable form. Previous empirical research has also suggested a typology for classifying the logistics operations of firms based on their logistics productivity measurement and improvement programs. The present study also adapts this logistics typology to classify a firm's logistics organization.

Through an empirical study of U.S. manufacturers, merchandisers, and distributors, this study examined relationships among the degree of EDI implementation, stage of logistics organization, relative logistics and overall performance, and achievement of competitive advantage, as well as the effects of several management initiatives such as Just-In-Time and Total Quality Management on those relationships. Data collection was accomplished through pairs of self-administered mail questionnaires directed to logistics

and EDI managers. Data were analyzed using t-tests and multiple and logistic regression. The outcomes of this research are indications of how EDI usage or non-usage affects individual relative logistics performance measures, and indications of the association between the degree of EDI implementation and stage of logistics organization (independent variables), and measures of relative logistics performance (dependent variables).

In comparison to nonusers, EDI users reported better relative performance on measures relating to inventory management, cycle time, customer service, and overall logistics performance. The strongest associations were found between the dependent variables representing labor, cycle time, costs, customer service, and overall logistics performance, and the predictor variables representing the business unit's stage of logistics organization, percentage of business transactions supported by EDI, and percentages of customer and supplier bases supported by EDI.

BACKGROUND

The primary sampling frame of the study was composed of Council of Logistics Management members who were employed by a manufacturing, merchandising, or distribution firm, in a capacity related to logistics, and whose level of responsibility was listed as "Corporate Officer" or "Director." The mailing list contained 1065 names of logistics directors (or those individuals in a related capacity) employed by firms located in the United States. Each logistics manager was asked to complete a questionnaire on his or her business unit's logistics organization and performance, and to forward an EDI questionnaire to the EDI manager of the same business unit, if that business unit used EDI. Both questionnaires included questions on the achievement and source of competitive advantage. Data collection was completed on June 29, 1993 with 100 usable questionnaire pairs and 171 usable logistics questionnaires returned. This data collection effort represented a 16.1 percent response rate for the logistics questionnaires. Since it was not known how many of the business units on the mailing list used EDI, it was not possible to determine a response rate for the EDI questionnaires. However, 100 usable EDI questionnaires were returned and matched with a logistics questionnaire from the same business unit.

The independent variables of the model represent a business unit's degree of EDI implementation and stage of logistics organization, and it was proposed that these independent variables have a positive impact on the dependent variables, which represent logistics performance, overall performance, and achievement of competitive advantage. It was also proposed that certain business practices and techniques of the business unit, such as the use of Just-In-Time and Total Quality Management techniques, serve as intervening variables in the relationship between the independent and dependent variables, and that these intervening variables also have a positive impact on the dependent variables.

FINDINGS

This research project has determined that:

1. EDI usage improves certain relative logistics performance measures: fill rate, stockouts, on-time delivery, backorders, cycle time, and composite measures relating to overall logistics performance, inventory management, and customer service.
2. EDI users place more importance on the use of bar code technology, use of EDI to support business process reengineering, and use of domestic supply partnerships than do nonusers.
3. A business unit's degree of EDI implementation and its stage of logistics organization have the strongest impact on measures of labor usage, cycle time, costs, customer service, and overall logistics performance.
4. A business unit's stage of EDI implementation as measured by the percentage of business transactions supported by EDI, and percentages of customer base and supplier base supported by EDI are the most significant measures of the business unit's overall progress in implementing EDI.
5. Just-In-Time techniques, Total Quality Management, and bar codes are used in conjunction with EDI to enhance logistics performance in the areas noted above.
6. While both logistics managers and EDI managers may state that their management believes their business units have achieved a competitive advantage, EDI managers definitely do not attribute that competitive advantage to EDI.
7. The use of international EDI is still very limited, even among users of domestic EDI and among those business units that trade internationally. The finding that only 10 percent of the respondents to both questionnaires use international EDI was not surprising.

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Thank you very much for participating in our research project.
Your support is gratefully acknowledged.

AN EMPIRICAL STUDY OF LOGISTICS ORGANIZATION,

ELECTRONIC LINKAGE, AND PERFORMANCE

A Dissertation

by

KAREN WILLIAMS CURRIE

Submitted to Texas A&M University
in partial fulfillment of the requirements
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DOCTOR OF PHILOSOPHY

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December 1993

Major Subject: Business Analysis

ABSTRACT

An Empirical Study of Logistics Organization, Electronic Linkage, and Performance. (December 1993)

Karen Williams Currie, B.A., Duquesne University;
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Co-Chairs of Advisory Committee: Dr. Frank P. Buffa
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implementation. The present study adapts this IT implementation model for use in classifying a firm's progress in implementing EDI. Previous empirical research has also suggested a typology for classifying the logistics operations of firms based on their logistics productivity measurement and improvement programs. The present study also uses this logistics typology to classify a firm's logistics organization.

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performance, and the predictor variables representing the business unit's stage of logistics organization, percentage of business transactions supported by EDI, and percentages of customer and supplier bases supported by EDI.

This dissertation is dedicated to my husband,

Wayne Daniel Currie,

for his enthusiastic support of all my endeavors,

and to my parents,

Edward James and Hazel Drake Williams,

for their boundless love, encouragement, and support.

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

1.1 PROBLEM STATEMENT

As a result of increasing competition both at home and abroad, U.S. manufacturing firms are searching for new corporate strategies. They are also discovering that survival demands their participation in the international marketplace. International competition, cost pressures, shorter product development cycles, need for manufacturing flexibility, strict quality standards, and technology growth all prompt the firm to look for a way to manage change and to improve its competitive position (Carter and Narasimhan 1990). Logistics can provide the means to bind a company's activities together into a coherent whole through global sourcing, manufacturing, and distribution (Bowersox et al. 1986). Capacino and Britt (1991) explained how a global logistics strategy may become necessary to a firm's survival, with 70 percent of sales dollars devoted to purchased materials and services, in addition to reduced product life cycles and increasing new

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This dissertation follows the style and format of Management Science.

product development costs. To meet these challenges, Capacino and Britt (1991) stated that "effective logistics performance" is absolutely essential.

If logistics has the potential to guide and improve a firm's activities, then logistics also has the potential to enhance a firm's competitive position in the marketplace. Persson (1991) pointed out that emphasizing logistics must be linked to the overall business strategy in a necessary effort to improve performance, quality, and productivity. In a study of logistically excellent firms, Byrne and Markham (1991) observed that "logistics excellence" is a "management imperative" for the future. The benefits of logistics excellence, according to Byrne and Markham, are improved quality and service levels, faster cycle times, greater efficiency and productivity, and improved customer-company relations.

Several authors (Bowersox et al. 1990, 1992; Capacino and Britt 1991; Ellram 1992; Langley and Holcomb 1991; Persson 1991) have suggested that strategic alliances, and more specifically, strategic logistics alliances, have the potential to enhance a firm's competitive position. Others (Bowersox et al. 1989; La Londe and Cooper 1989) have suggested that state-of-the-art management information systems and information technology applications to logistics functions are vital to a firm's success. Still

others (Gray and Davies 1981; Masters et al. 1991; Nelson and Toledano 1979; Schary and Coakley 1991; Stock and Lambert 1987) have commented that the management of data and control of international documentation is one of the greatest challenges in international logistics management.

One way to meet this challenge is the formation of linkages, a concept proposed by Bowersox et al. (1989) as worthy of future research:

> To convey the full potential of EDI [electronic data interchange], the term linkage is indispensable. Linkage consists of tieing [sic] two or more firms together electronically so they can conduct full business operations in a paperless environment.

Linkages can be formed between channel members and service providers and/or between channel members themselves:

> The primary benefit of electronic linkage is the potential to remove variance from the order cycle and reduce the overall complexity of doing business. . . . A reasonable interpretation of the research findings is that electronic linkage will rapidly expand during the 1990's (Bowersox et al. 1989).

Electronic data interchange (EDI) is defined as:

> The computer-to-computer exchange of standard business documentation in machine processable form (Emmelhainz 1990).

Therefore, as this discussion has demonstrated, logistics has the potential to enhance a firm's global competitiveness, and EDI has the potential to significantly enhance a firm's logistics performance. The question

remains, how can the potential of logistics excellence and electronic linkage best be utilized?

1.2 SIGNIFICANCE OF THE PROPOSED RESEARCH

Goldhar and Lei (1991) described three features of fast-response, global manufacturing:

1. Computer-integrated manufacturing (CIM);
2. Strategic alliances and networks with suppliers around the world; and
3. Transforming manufacturing as a service.

According to Goldhar and Lei, the global supply network consists of quick-response manufacturers who compete by seeking out suppliers around the world and developing these relationships into long-term strategic alliances linked through information based networks. McGrath and Hoole (1992) supported the concept of global supply networks because a manufacturer can reduce its supplier base, choose the best suppliers, and, along with the suppliers, reap the benefits of economies of scale in stable purchasing relationships.

In order to successfully manage a global supply network, firms must develop global communications and information capabilities. In their 1989 study, La Londe and Cooper explained that EDI is possibly "the most pervasive change" to affect logistics currently, and that rapid, accurate communications are essential for good

logistics service. Also, increasing globalization, according to La Londe and Cooper, makes the quick transmission of business documents necessary. A typical international trade transaction can involve 30 to 40 different documents, passing among up to 27 different parties in over 360 copies (Bellego 1991). La Londe and Cooper asserted that EDI capabilities can provide a short-term strategic advantage in some industries, while in other industries EDI capabilities are a requirement for doing business.

In a recent empirical study of the logistical practices of 117 "leading edge" firms, Bowersox et al. (1989) found significant differences between the leaders and average firms in three main areas: organization structure, strategic posture, and management behavior. Bowersox et al. summarized the similarities among the leading edge logistics organizations by stating that they perform the following tasks:

> Exhibit an overriding commitment to customers.
> Place a high premium on basic performance.
> Develop sophisticated logistical solutions.
> Emphasize planning.
> Encompass a significant span of functional control.
> Have a highly formalized logistical process.
> Place a premium on flexibility.
> Commit to external alliances.
> Invest in state-of-the-art information technology.
> Employ comprehensive performance measurement.

Significantly, the eighth and ninth tasks relate to the concepts of supply chain management and electronic linkage.

A number of well-known U. S. firms are using EDI in the international environment. Liz Claiborne, a clothes manufacturer, uses EDI to communicate between its offices in New York and New Jersey and six Far East operating sites. Ford Motor Company uses EDI to transmit inventory requests to its European suppliers. Caterpillar, Inc., uses EDI to exchange documents with approximately 800 suppliers worldwide, a fact which was kept secret until late 1989, because this use of EDI was considered to be a "strategic competitive weapon" by the company (Snapp 1990).

Besides facilitating the flow of information and the coordination of worldwide logistics operations, EDI also has great potential for simplifying the management of international customs documentation. The rising costs of processing paperwork for international trade will help to convince companies all over the world to adopt EDI. EDI is seen as a way to reduce traditional barriers to international trade, and as a means to counter increasing global competitiveness (Emmelhainz 1990).

1.3 RESEARCH QUESTIONS

The importance of logistics excellence and electronic linkage to achieving a globally-competitive firm has been

shown. Scholars and practitioners alike need to understand more clearly the relationship between logistics excellence and electronic linkage. The purpose of this study is to examine empirically the following questions:

1. Can certain characteristics of firms be used to predict whether or not they use EDI? In comparison to nonusers:

a. Do EDI users achieve a higher degree of relative logistics performance?

b. Do EDI users achieve a higher degree of relative overall performance?

c. Are EDI users more likely to achieve competitive advantage?

2. Can certain characteristics of firms be used to predict whether or not they use international EDI? In comparison to domestic-only EDI users:

a. Do international EDI users achieve a higher degree of relative logistics performance?

b. Do international EDI users achieve a higher degree of relative overall performance?

c. Are international EDI users more likely to achieve competitive advantage?

d. Are international EDI users more likely to achieve a higher degree of EDI implementation within the firm?

f. Are there other characteristics of international EDI users that are significantly different from domestic-only EDI users?

3. Can a firm's stage of logistics organization development and degree of EDI implementation be used to predict the firm's relative logistics performance, overall performance, and/or achievement of competitive advantage?

4. Does the use of certain management techniques or other information technologies change the relationship between the degree of EDI implementation, stage of logistics organization, relative logistics performance, overall performance, and competitive advantage?

a. Does the use of Just-In-Time (JIT) management techniques change this relationship?

b. Does the use of Total Quality Management techniques change this relationship?

c. Does the use of supply chain management/supply partnership techniques change this relationship?

d. Does the use of bar code technology change this relationship?

e. Does a change in logistics operating procedures (basic business practices) to accommodate business process reengineering change this relationship?

1.4 ASSUMPTIONS

Four basic assumptions form the foundation of this research project. First, the possibility of identifying a significant number of individuals willing to participate fully and honestly in the data collection process is assumed. Second, it is assumed that the individuals who receive the questionnaires will have sufficient knowledge of logistics management and EDI procedures and results to respond accurately. Third, it is assumed that respondents are well-enough acquainted with the conditions prevailing within their own industries so that they may make the comparisons and relative judgments demanded by the survey instrument, especially regarding the achievement of competitive advantage. Fourth, it is assumed that a research instrument can be developed to measure a business unit's progress in implementing EDI and in developing a logistics organization, and that this research instrument can be used as a self-administered mail questionnaire.

1.5 ORGANIZATION OF THE PAPER

This section explains how the remainder of this paper is organized. Chapter II gives a literature review of key topics, including business logistics processes and international logistics, strategic alliances and supply chain management, competitive advantage, electronic data

interchange (EDI), and an information technology research framework.

Chapter III explains the research model to be tested in this study. After defining the key variables, the research model is described and the hypotheses are given.

Chapter IV details the methodology to be followed. The survey instrument, study population, sample size, and data collection procedures are given.

Chapter V describes the data analysis and research results, including descriptive data relating to the survey respondents and data analyses undertaken prior to hypotheses testing.

Chapter VI provides a summary of results, discusses the limitations and contributions of the research, and offers some suggestions for future research.

CHAPTER II

LITERATURE REVIEW

2.1 OVERVIEW

The purpose of this chapter is to provide a review of basic logistics concepts and describe research on logistics performance. Following these topics, the discussion will cover strategic alliances and competitive advantage, general EDI concepts and related research, and a research framework for evaluating EDI implementation in a firm.

2.2 LOGISTICS AS A KEY BUSINESS PROCESS

2.2.1 Introduction

Before beginning a review of critical logistics issues, it is necessary to give a basic definition of logistics. Bowersox et al. (1986) provided the following definition:

> (Modern logistics) is a single logic to guide the process of planning, allocating and controlling financial and human resources committed to physical distribution, manufacturing support and purchasing operations. The objective of logistics is to arrange delivery of finished inventory, work in process inventory, and material assortments, when required, in usable condition, to the location where needed, and at the lowest total cost.

Bowersox et al. also explained that integrated logistics, or the performance of value-added inventory and

requirements information flows, is achieved through the coordination of (1) facility structure, (2) forecasting and order management, (3) transportation, (4) inventory, and (5) warehousing and packaging. The three major operating objectives of integrated logistics are physical distribution, manufacturing support, and purchasing.

Precisely how does a firm coordinate the components of its logistical system? By developing and implementing a logistics strategy. While Bowersox et al. (1986) did not use this exact terminology, the meaning is quite clear:

> The main strength of logistics results from treating system components on an integrated basis. . . . A systems orientation stands in direct contrast to the traditional approach of treating the activities of logistical management on a separate or diffused basis.

If the firm proposes to integrate its logistics activities through the development of a logistics strategy, it must have an objective to guide this process. This objective may be called the "logistical mission," which, as Bowersox et al. (1986) described it, consists of providing a desired level of performance at the lowest total cost.

Bowersox et al. concluded their discussion of the logistical mission with these words:

> Progressive firms have begun to realize that a well-designed and operated logistical system can create a strategic differential among competitors. . . . As a general rule, firms that obtain a strategic advantage from logistical

> operations establish the nature of industry competition.

Indeed, as Blanchard (1986) pointed out in the context of weapon systems acquisition:

> . . . one of greatest challenges facing industry, businesses, government agencies, and the general consumer of products and services today is the growing need for more effective and efficient management of our resources. The requirement to increase overall productivity in a resource-constrained environment has placed emphasis on all aspects of the system/product life cycle, and logistics has assumed a major role comparable to research, design, production, and system performance during operational use.

In fact, the increasing interdependence of the world economy and the necessity to compete in the global market may provide the needed impetus to persuade firms to develop logistics strategies to streamline their entire operations, both domestic and international. Bowersox et al. (1989) explained that the international environment is more challenging, complex, and expensive to operate in, and that a network of strategic relationships will be essential for international logistics success.

2.2.2 The Strategic Value of Logistics

Williamson et al. (1990) conducted a survey of logistics managers to determine what activities were included under the term "logistics" in actual business practice and to discover how satisfied logistics managers

were with their span of control and organization of logistics activities. Williamson et al. discovered that logistics managers wanted more control over logistics activities and a more integrated, streamlined logistics process. The researchers concluded that the logistics function has evolved from a cost-controlling utilitarian task to a more strategic process, wherein an emphasis on customer service linked to the business strategy provides a means for developing and sustaining competitive advantage.

Langley and Holcomb (1991) echoed this theme by presenting several propositions, suggesting that: logistics should serve a strategic role and be part of a firm's overall strategic management process, that logistics is uniquely suited to provide customer value, and that recent management initiatives such as an emphasis on customer service, supply chain management, and the development of strategic alliances demonstrate the key roles logistics can play in the overall strategic management of a firm.

Persson (1991) described how logistics can be used strategically, to compete through time, flexibility, and quality. He discussed how logistics has been linked to the business strategy in previous research, and the changing role of logistics as a result of changes in the environment: increasing globalization, greater product variety, shorter product life cycles, the economic and

political integration of Europe, and new developments in information and communication technology. He then described several strategies companies can use to increase their competitiveness through logistics.

2.2.3 International Logistics

Nelson and Toledano (1979) described the basic differences between domestic and international logistics: distances, modes of transportation, documentation, intermediaries (third-party logistics agents), and the collection, transmission, and handling of data. Nelson and Toledano also listed those country-specific differences found in every country: cultural, political, and infrastructure. In discussing the design of an international logistics system, Nelson and Toledano explained that the end objective may not be minimum cost, but rather maximum after-tax profit, requiring close cooperation with the international finance department. Factors important in the international perspective include transfer prices, tax rates, duties, exchange rates, and inflation.

Slater (1980) discussed the basic characteristics of the international physical distribution process, the role of physical distribution in supporting the marketing function, the various stages of international marketing

development, and problems that can arise in international physical distribution management. He then outlined the key elements of an international physical distribution strategy.

Zinn and Grosse (1990) reported the results of a survey undertaken to determine the extent of globalization of distribution in U.S. multinational firms. They concluded that while a global approach to distribution is not yet a major factor, and while managers do not expect any major changes in this to occur during the next five years, the managers do expect an increase in the centralization of manufacturing facilities. Also, the chief barriers to globalization of distribution are local government regulations and competition from other multinationals. This information was collected via a mail survey of U.S. multinational firms with direct investment in or exports to Latin America. The authors recommended additional research on what they identified as the principal barriers to global distribution: government regulations and country-specific economic and political situations.

Capacino and Britt (1991) listed six future imperatives for successful global firms: building a North-South logistics infrastructure, integrating operations across distribution channels, achieving differentiation

based on superior customer service, building speed into the logistics system, achieving organizational harmony and interfunctional integration, and developing win-win relationships with suppliers, carriers, and customers. In the authors' opinion, successful global companies must work to lower all transactions costs and build effective EDI networks.

Min and Galle (1991) conducted an empirical study of international purchasing practices via mail survey of U.S. purchasing managers. Two significant findings were that quality was the most important factor in selecting a supplier and that logistics caused the most problems for U.S. buyers, given the distance between the United States and the rest of the continents.

Schary and Coakley (1991) discussed the impacts of information technology on logistics operations, by reviewing the transaction cost model, the dimensions of the communications network, organizational outcomes, and the role of leadership in the organization.

2.2.4 A Logistics Typology

In 1984, A. T. Kearney published a typology for classifying the sophistication of firms based upon their productivity measurement and productivity improvement programs. In stage I, "Inactive" firms measure

distribution costs as a percentage of sales. There are no productivity improvement programs, no meaningful planning of distribution operations, and no distinguishing logistics operations. "Reactive" firms in stage II focus on cost reduction with an emphasis on actual vs. budgeted costs. Distribution planning efforts are based on available historical financial data. "Proactive" firms in stage III concentrate on logistics productivity measurement and improvement. Actual performance is compared to engineered standards and "should" or expected costs. Stage IV "Integrated" firms differ mainly from stage III in that they work with other functions such as marketing and manufacturing in planning to achieve the firm's overall goals. Byrne and Markham updated this classification scheme in 1991 as part of a study to determine how firms use logistics to improve quality and productivity. Firms were evaluated across the following eight key factors:

Service goal setting,
Long-range planning,
Operations planning,
Ongoing improvement process,
Relationships between employees and management,
Information capabilities,
Measurement approach, and
Vendor/supplier relationships.

Based upon their progress towards integration in each of these areas, the firms were assigned to stage I, II, or III. In stage III firms, the various logistics functions

are considered to be "functionally excellent." Their information systems are user-friendly and support long-range and operational planning, while vendor and supplier relationships are based on partnerships and are results-oriented. This research project will use Byrne and Markham's typology to rate a firm's logistics organization development.

2.3 STRATEGIC ALLIANCES AND SUPPLY CHAIN MANAGEMENT

A report on leading edge-logistics (Bowersox et al. 1989) also emphasized the importance of forming strategic alliances. Porter (1985) referred to them as coalitions. Ohmae (1989) discussed the need for global strategic alliances. He explained how customer need, technology dispersion, and immense fixed costs, and "the relentless challenges of globalization," make strategic alliances imperative yet hard to manage. Bowersox (1990) described the benefits of logistics alliances. In his view, there were four forces encouraging the development of U. S. logistics alliances:

1. Deregulation of transportation and communications, and relaxed enforcement of antitrust laws.
2. Wide availability of computers, which hold logistics alliances together.
3. Leaner organizations, encouraging more logistics outsourcing.
4. An increasingly competitive operating environment, forcing the players to become lowest

> cost competitors, especially in the international context.

According to Bowersox, "Companies committed to strategic use of logistics usually outperform the competition in speed and consistency of order cycle." Also, Bowersox continued, "... information sharing is the glue that holds these ventures together."

Ellram and Cooper (1990) reviewed the concept of supply chain management, discussed the relationship between supply chain management and partnership ventures, and developed a framework for analyzing the risks and rewards of logistics partnerships from the perspective of both shippers and third parties, based on an empirical study of shippers, carriers, and warehousers. The principal question of supply chain management is where in the supply chain to hold inventory. This decision is based on timely, accurate flows of information: "Clearly, exchanging information for inventory is central to the supply chain management concept." Ellram and Cooper classified the benefits of partnership relationships in supply chain management as economic, managerial, or strategic. The authors examined the strategic relationships in terms of "positioning the supply chain for competitive advantage."

Braithwaite and Christopher (1991) discussed the need for global logistics and supply chain management

strategies, and summarized the central elements of each. They listed several factors "critically important" to the development of global supply chains, including extended supply lead times and uncertain transit times, multiple freight modes, and opportunities to ship intermediate components for local assembly. The greatest challenge, in their view, is to determine what information is needed for a global supply chain strategy and to use it effectively for planning. According to Braithwaite and Christopher, "The management of global logistics is in reality the management of information flows."

Ellram (1992) discussed international strategic alliances, especially those formed for logistics purposes, using a database developed from reports of international alliances appearing in The Wall Street Journal. She analyzed the characteristics of international logistics alliances and the implications for logistics management. Approximately 18 percent of the alliances in the total database were formed for logistics purposes, and the reasons for forming these alliances were reported to be technological, managerial, economic/regulatory, and strategic in nature.

2.4 COMPETITIVE ADVANTAGE

Michael Porter (1985) introduced the concept of competitive advantage as the difference between the value a firm creates for its customers and the cost of creating this value. The firm's product is created through the value chain, a series of value activities which are the "physically and technologically distinct activities a firm performs." The value chain is composed of five primary and four support generic activities. The importance placed on each of these activities and how they are performed is an outcome of the nature of the firm, the development of its particular industry, and the firm's business strategy. The way each firm configures its value chain gives rise to its competitive advantage.

Porter's concept of the value chain as essentially a flow of materials through the firm is complementary to Bowersox et al. (1986) view of the logistical process as two interrelated flows: the value-added inventory flow and the requirements information flow.

Porter and Millar (1985) explained that information technology is transforming the value chain, changing the way value activities are performed, the way they are linked, and the way products are meeting buyer needs. Information technology, in its strategic importance, is unique among other technologies used in business, and is

especially influential in its application to links between suppliers and buyers. As Porter (1986) pointed out, coordination among complex, worldwide networks of dispersed operations is becoming "a prime source of competitive advantage."

One way to accomplish this coordination is through EDI.

2.5 ELECTRONIC DATA INTERCHANGE

2.5.1 Introduction

As defined earlier, EDI is "The computer-to-computer exchange of standard business documentation in machine processable form (Emmelhainz 1990)." In logistics operations, EDI is used to exchange purchase orders, bills of lading, and invoices in prespecified formats, to name the most common applications. In 1988, the number of U. S. companies using EDI was estimated to be 5,000, with 12,000 users projected by 1992. The use of EDI is widespread in the railroad, automobile manufacturing, pharmaceutical, motor carrier, and grocery industries, because they have had long-standing, powerful industry associations to promote the use of EDI and the establishment of standard document formats for EDI transactions (Bohl 1989).

The two fundamental components of an EDI system are software and third-party, value-added networks (VANs). EDI

software facilitates the transfer of data between trading partners and internal company applications. VANs provide communications and data management networks to assist the exchange of EDI data between companies. EDI works only if companies exchange information in standard electronic document formats. Two kinds of "standards" are involved: communications standards, to establish computer to computer communications (such as line speed and protocols), and document content standards, to establish the order of data transmittal and reception (Bohl 1989).

There are four kinds of document standards: proprietary, industry-specific, cross-industry, and international. Proprietary standards are imposed by a single company on its trading partners. Industry-specific standards are developed by an industry trade group and used by that industry. For example, the warehousing industry uses Warehouse Information Network Standards (WINS) and the transportation industry uses the Transportation Data Coordinating Committee (TDCC) standard. One cross-industry format is used in the United States: ANSI X12, approved by the American National Standards Institute (Bohl 1989). The most common international standard is the UN/EDIFACT, Electronic Data Interchange for Administration, Commerce, and Transport, approved by the United Nations in 1988. Other international standards are in use in various regions

and industries (La Londe and Cooper 1989).

While trading partners can communicate directly via EDI, it is often more efficient to use third-party value-added networks. Direct communication requires compatible document and communications standards, as well as prespecified document exchange times and separate connect/disconnect actions for separate trading partners. VANs serve as old-fashioned pigeon-hole mailboxes, where data can be sent and retrieved at the user's discretion. VANs provide data accumulation and sorting services, as well as error-checking and transaction reports, among other functions (La Londe and Cooper 1989).

The most commonly cited benefits of EDI involve cost reduction and increased data accuracy. The same data need not be re-keyed over and over, reducing personnel costs and increasing accuracy. Manual preparation and handling of documents is reduced, which can slash transaction costs by an estimated eighty percent. A reduction in "information float" provides for reduced inventories and higher turnover ratios. Reduced lead times and fewer returned goods promote improved customer service. In summary, EDI supports more efficient use of resources and time (Emmelhainz 1990, La Londe and Cooper 1989).

2.5.2 Implementation of EDI

A number of summary discussions of EDI applications are available. The American Management Association sponsored a research report on the business implications of EDI (Bohl 1989), which included a manager's introduction to EDI, a task-oriented checklist for EDI implementation, and four case studies of EDI implementation in major firms such Texas Instruments and Westinghouse Electric Corporation. A number of other "how-to" guides for managers planning to implement EDI have been published recently: EDI: The Competitive Edge (Sokol 1989), Electronic Data Interchange: A Total Management Guide (Emmelhainz 1990), and EDI: What Managers Need to Know about the Revolution in Business Communications (Baker 1991). La Londe and Cooper (1989) provided a summary of the uses, benefits, and applications of EDI within the context of an overall study of customer service provided by third-party logistics agencies. Others (Clarke et al. 1991, Bowersox et al. 1992) have provided useful summaries of the basics of EDI.

A stream of articles and studies have addressed the question of how to implement EDI and what kinds of advantages and disadvantages can be expected. A 1985 study of purchasing executives by La Londe and Emmelhainz found the most often cited advantages of EDI to be increased speed and accuracy in processing transactions, reduced

costs because of reduced paperwork, and better information management. In the same study by La Londe and Emmelhainz, purchasing managers expressed concerns that EDI would "lock" them into relationships with a small number of suppliers, that proprietary data in systems linking buyers and sellers would compromise security, and that EDI would threaten close, personal buyer-seller relationships. The high cost of implementation was also seen as a disadvantage.

A series of surveys conducted by Hill and Ferguson (1988) in 1985 and 1986 showed that managers felt that system costs, security problems, lack of accepted standards, and organizational inertia were the most serious problems encountered during the course of implementing EDI. Monczka and Carter (1987, 1988) conducted a study of the implementation of EDI in a purchasing environment. They discussed potential benefits of EDI, proposed an approach for analyzing the EDI "opportunities" in a firm and conducting a cost-benefit analysis, and developed a model for implementing an EDI system.

Under the auspices of their study of leading edge logistics organizations, Bowersox et al. (1989) reported EDI application usage percentages for manufacturers, wholesalers, and retailers. According to the study results, "Manufacturers anticipate the greatest future EDI

expansion."

Carter and Fredenhall (1990) conducted an empirical survey of purchasing organizations which had implemented EDI with a subset of their suppliers. The survey was designed to measure the degree of EDI implementation, actual cost savings, changes in the purchasing professional's work habits, and reasons for implementing EDI. Carter and Fredenhall used four dimensions to measure a firm's implementation of EDI: the percentage of the firm's suppliers linked through EDI, the percentage of annual dollar volume of purchases made using EDI, the number of different purchasing forms transmitted via EDI, and length of time since EDI implementation. Survey respondents attributed their primary cost savings to reduced paperwork, data input errors, inventories, and lead times. The two most frequently cited reasons for implementing EDI were desire to reduce costs (42 percent) and customer pressure (21 percent).

Ferguson, Hill, and Hansen (1990) conducted a telephone survey of 1,094 U. S. firms in 1988 designed to determine the degree and characteristics of EDI use. These findings were reported:

> 1. Nearly one-third of business firm[s] are either EDI users, or planning to implement EDI within two years.
> 2. This same group expects significant growth in EDI trading partners, in document volume, in EDI

sites, and in the use of EDI in international trade.
3. EDI is customer driven -- the key benefits are better customer service, quick response, and control or access to customer information.
4. The significant barriers to EDI are perceived to be hardware and software development cost, along with negotiating operating details with trading partners.
5. EDI growth is severely constrained by lack of knowledge. Even among EDI users and planners a significant percentage of respondents don't understand the capabilities of EDI VANs and EDI translation software.

Carter and Ragatz (1991) studied the implementation of supplier bar codes and EDI, explaining that bar codes are necessary to close the internal information loop in an automated purchasing and materials handling operation. The authors described the flow of paper in a traditional manual purchasing environment and demonstrated how an integrated EDI/supplier bar code system can benefit the entire firm. The example of Honda of America (East Liberty, Ohio) was given to show how EDI and bar codes are critical to Honda's JIT manufacturing system.

A 1991 study by Cleveland Consulting Associates of logistics professionals in the U. S. and Europe found that 43 percent of respondents' firms used EDI to enhance quality management of supply chain partners. Emmelhainz and Emmelhainz (1992), after describing how EDI applications and Total Quality Management (TQM) can complement each other, provided several specific examples

of how organizations have linked EDI and TQM to achieve "superior organizational performance."

In a rare industry-specific study, Johnson et al. (1992) surveyed motor carriers to determine their current and expected use of EDI. The study concluded that the carriers surveyed are not using EDI extensively, that shippers are driving the use of EDI in the motor carrier industry, and that respondents anticipate a move away from the Transportation Data Coordinating Committee (TDCC/EDIA) data format to ANSI X12.

2.5.3 The Strategic Value of EDI

EDI is not just a technical issue, but an element of business strategy:

> EDI should be viewed as a process by which strategic partnerships and linkages are formed and through which the efficiency of the entire logistics chain is improved. The process of EDI allows a company to achieve long-term strategic benefits because those improved relationships and logistical efficiencies continue beyond the transmission of electronic messages (Emmelhainz 1990).

While EDI has strategic value in some industries at this time, in others it is already a requirement for doing business (La Londe and Cooper 1989).

Bowersox et al. (1990, 1992) described the role of EDI in the formation of strategic alliances and the development of competitive advantage. The authors described the three

characteristics of strategic linkage, a concept they first mentioned in Leading Edge Logistics (1989). The three characteristics are information access, connectivity, and formalization. Information access means that firms participating in an EDI system must develop formal agreements for freely sharing specific, critical information on a regular basis. Connectivity refers to the degree of speed and precision in sharing information needed for strategic decision-making. Formalization is the process of developing rules for interorganizational operations. When routine tasks are performed under set policies and procedures, then managers have time to create better solutions for non-routine problems. A three-dimensional model was given to demonstrate the interaction of the three attributes during the evolution of strategic alliances.

Benjamin et al. (1990) analyzed three case studies from 1987 to determine the possible competitive advantage to be derived from EDI applications. They concluded that EDI can be a source of competitive advantage only if the organization integrates the EDI applications into its basic business processes, in order to reduce costs and improve service. The use of EDI must be viewed as a process of continuous development and improvement in order to sustain any competitive advantage achieved.

Senn (1992) described changes in the business environment that have fostered the growth of EDI, strategic reasons for implementing EDI (it supports compressed business cycles and Just-In-Time techniques), and key questions for organizations planning to implement EDI. He emphasized that the full value of EDI cannot be realized unless firms are willing to reorganize fundamental business practices, such as the way orders are processed or funds are transferred.

Pokorney, Kekre, and Mukhopadhyay (1992) examined the impact of EDI on the order processing operation of Kennametal Inc., and concluded that the beneficial results of EDI can be enhanced by reworking the structure and design of the original business process.

2.5.4 Logistics Implications of EDI

According to Emmelhainz (1990b), there are two principal benefits for applying EDI to logistics operations: improved customer service and improved productivity. Practitioner journals frequently cite the benefits of EDI to supply chains and distribution systems. For example, reports have been published on the application of EDI and electronic point of sale systems (McKinnon 1990) and the application of EDI to retail JIT inventory systems (Ogilvie 1991). According to Gillen (1992), there are four

essential elements for applying EDI to logistics operations: total logistics management, data interchange, data capture, and standards; and, three major categories of benefits: cost savings, productivity improvements, and improvement in the quality of information. He also emphasized the need to reengineer business processes in order to capture all possible EDI benefits.

Leenders et al. (1989) listed the benefits of EDI to the purchasing process, including support for JIT, bar coding, improved communications with suppliers, and improved inventory management.

Researchers at Carnegie Mellon University's Graduate School of Industrial Administration have conducted several empirical studies of the results of EDI on manufacturing operations. Kekre and Mukhopadhyay (1991) studied the impact of EDI on the quality improvement and inventory reduction programs of 65 outside processors used by LTV Steel. They found that routine EDI use enhances JIT operations, while the interaction between quality improvement and inventory reduction programs enhances the benefits of EDI applications. In a companion study, Srnivasan, Kekre and Mukhopadhyay (1992) analyzed the effects of EDI on the shipment performance of automobile parts suppliers in a JIT environment. Srnivasan et al. concluded that EDI can "significantly reduce" the level of

shipment discrepancies in vertically-integrated JIT environments.

Reduced inventory management costs have often been cited as a benefit of EDI. Anvari (1992) provided a quantitative analysis of how EDI affects inventories through reductions in lead time, lead time uncertainty, and ordering cost. He also discussed the interaction of EDI with ordering patterns and JIT inventory management techniques.

2.5.5 EDI as an Interorganizational Information System

Stern and Kaufmann (1985) provided one of the first studies of EDI as an interorganizational information system (IOS), those systems based on information technology that cross organizational boundaries. Stern and Kaufmann took a case study approach to examining the impact of EDI on manufacturer-distributor relationships and described EDI benefits, factors affecting EDI use, changes in interorganizational relations, and roles of the sales force, purchasers, and third-parties.

Kavan and Van Over (1990) provided a general introduction to EDI as an IOS, summarized possible EDI benefits, described the impact of EDI on a firm's competitive advantage and its value chain, and suggested a number of research topics.

Bakos (1991) showed how economic models can explain the impact of IOS. According to Bakos, there are two types of IOS: information links and electronic marketplaces. Information links represent bilateral relationships, whereas electronic marketplaces are multilateral relationships established to make information available which encourages the formation of information links. Bakos discussed transaction costs, vertical integration, and competition within the context of IOS, and gave examples of how electronic data interchange (EDI) serves as an IOS.

Meier and Chismar (1991) proposed a framework relating transaction volume and process benefits to use in analyzing the introduction of vertical EDI systems. Chung (1992) gave a brief overview of EDI and described some of the issues involved in EDI implementation, such as integration with internal company applications, control of EDI processes, and external relationships. Saunders and Clark (1992) studied the influence of interorganizational power and benefits and costs on the decision to adopt EDI, using a written survey of 600 randomly selected vendors of Chaparral Steel. The major finding was that perceived costs are negatively related to the intention to adopt EDI.

Mukhopadhyay (1993) outlined research into the economic benefits of EDI. He reviewed problems associated with research into information technology issues and

suggested that the traditional disciplines of information economics, microeconomic production theory, and industrial organization should be utilized to examine the economic benefits of EDI. Mukhopadhyay also suggested that EDI researchers should be aware of the relationship between EDI and Just-In-Time techniques. He then proposed a research framework to use in assessing the economic benefits of EDI. He also reviewed recent studies examining the strategic and operational benefits of EDI as an IOS, and discussed the resulting management implications.

Nault and Dexter (1993) studied three aspects of the impact of IOS on industrial markets: value added to the marketed good, buyer adoption costs for the IOS, and more competitive supplier costs. Nault and Dexter provided case studies of specific EDI applications to illustrate the discussion. They concluded by offering specific guidelines for senior managers making IOS decisions.

2.5.6 International Applications of EDI

Clarke et al. (1991), after an excellent review of the basics of EDI, discussed the international impacts of EDI: its role in international trade, effect on trading blocs and barriers, and the issue of standardization. They also analyzed the role of EDI in the corporate value chain and government operations. They concluded their discussion

with a detailed research agenda based on case studies.

Two recent studies (Hellberg and Sannes 1991; Heaver 1992) focused on the impact of EDI on international customs administration and logistics procedures. Hellberg and Sannes described how three Norwegian freight forwarders used the TVINN, the Norwegian information system for customs clearance, and how it reduced customs clearance times and handling costs. Heaver commented on developments in international logistics, such as supply chain management, and the differences in customs administration among European and North American countries, which complicate international logistics operations. Heaver concluded that the search for efficiency and the move to reduce trade barriers will stimulate the redesign of customs procedures and the application of EDI to international customs administration.

Janssens and Cuyvers (1991) described international EDI as a way to synchronize the flow of goods and customs documents and data. Too often, under traditional paper-based procedures, goods arrive for customs clearance before the necessary documents, causing costly delays and confusion. Janssens and Cuyvers explained the evolution of EDI standards and document formats, value-added networks, benefits and problems, and recommended steps for implementation.

On a related topic, Steinbart and Nath (1992) conducted an empirical study via mail survey of American companies to determine which ones operate and maintain global computer networks. The purpose was to gather information on the nature of political and other restraints on the international flow of data, effectiveness of global data management strategies, degree of top management support and understanding, and degree of success in operating global networks. While manufacturing companies were more likely than non-manufacturing companies to have global networks, the non-manufacturing companies were more likely to use their networks to exchange data with customers and suppliers, or as interorganizational systems, and to regard their networks as successful. Seventy percent of respondents encountered some kind of political restraint on transferring data across international borders. The most common restraint was the requirement to use foreign telephone networks, which led to problems in quality and reliability of transmissions.

2.6 INFORMATION TECHNOLOGY IMPLEMENTATION MODELS

Cooper and Zmud (1990) proposed an information technology (IT) research framework which provided a means for categorizing research into IT implementation. They defined "IT implementation" as "an organizational effort

directed toward diffusing appropriate information technology within a user community." The stages of the IT implementation model were as follows: Initiation, Adoption, Adaptation, Acceptance, Routinization, and Infusion. In addition, they defined five major contextual factors which affected the processes and products associated with each of the implementation stages: User, Organization, Task, Technology, and Environment. The researchers suggested that "future research should explore the impact of multiple contextual factors on multiple implementation stages."

Monczka and Carter (1987, 1988) described four stages in the evolution of electronic purchasing linkages between a firm and its suppliers: development of the computer-to-computer linkages to the initial suppliers and the elimination of certain basic purchasing documents; addition of more suppliers and electronic documents; connection of the EDI applications to the manufacturing planning and control system and initiatives to cut the order-cycle time; and, linking the EDI applications to the receiving and accounting systems, thus "closing the loop."

2.7 SUMMARY

This review of previous research has shown that a firm's logistics processes and use of EDI can individually

contribute to its strategic strengths and help to improve performance and, possibly, to achieve sustained competitive advantage. Several research frameworks, including a typology of logistics organizations and an information technology implementation model, were described. The purpose of this review was to develop an appropriate foundation for the present study, which links the stage of logistics organization and degree of EDI implementation in a business unit to its performance and achievement of competitive advantage.

CHAPTER III

RESEARCH MODEL

3.1 INTRODUCTION

The purpose of this chapter is to describe the proposed research model, its variables and how they were measured, the research objectives, and the research hypotheses.

The research model proposes that the stage of logistics organization and degree of EDI implementation in a business unit positively affect its relative logistics performance measures, achievement of competitive advantage, and overall performance measures, and that this relationship is enhanced by certain management techniques and other information technologies.

3.2 DEFINITION OF THE MODEL

3.2.1 Independent Variables

The independent variables (IV) were designed to measure the degree of EDI implementation and the stage of logistics organization in a business unit (see Table 3.1).

In order to understand how the first independent variable, IV1, is measured, it is necessary to describe the EDI Implementation Model (Figure 3.1) developed for this research project. The elements of a modified Cooper and

TABLE 3.1

INDEPENDENT VARIABLES (IV)

Degree of EDI Implementation	
IV1	Stage of EDI implementation/scale of 0 to 8 (categorical)
IV2	Length of involvement with EDI in years*
IV3	Percentage of business transactions supported by EDI*
IV4C	Percentage of EDI-linked customers*
IV4S	Percentage of EDI-linked suppliers*
IV5	Functional range of types of EDI transactions/scale of 0 to 7*
IV6	Use of international EDI/(yes/no;categorical)
Stage of Logistics Organization	
IV7	Stage of Logistics Organization/scale of 1 to 3 (categorical)

* Indicates a continuous variable.

FIGURE 3.1

EDI IMPLEMENTATION MODEL

Stage		Activity
0.		No plans to implement EDI.
1.	Initiation	Firm studies EDI possibilities.
2.	Adoption	Decision is made to invest in EDI.
3.	Adaptation	Prototype and pilot systems are tested; users are trained, procedures are revised; system is ready for use.
4.	Acceptance	EDI is used regularly and certain paper documents are eliminated.
5.	Routinization	EDI use is viewed as a normal activity.
6.	Expansion	Additional kinds of paper documents are eliminated; more trading partners are added.
7.	Infusion	EDI is linked to manufacturing planning and control systems; increased organizational effectiveness is obtained.
8.	Enhancement	EDI system is linked to receiving and accounting to achieve full internal MIS integration; invoices are transmitted electronically and paid via electronic funds transfer.

Zmud (1990) model were merged with the elements of a modified Monczka and Carter (1987, 1988) model, both described in Section 2.6. Two stages, Expansion and Enhancement, derived from the Monczka and Carter model, were added to the modified Cooper and Zmud model, in order to describe the EDI implementation process more fully. This EDI Implementation Model was used to evaluate a firm's progress towards fully integrating EDI applications into its business processes. The variable, IV1, is categorical and it represents the stage of the business unit's EDI implementation efforts. The current stage of implementation, as described by the model, is used to assign an integer value of 0 through 8 to IV1. A value of 0 indicates that no EDI implementation is planned, while values of 1 through 8 correspond exactly to the model stages.

Variables IV2 through IV5, as additional measures of the degree of EDI implementation, were adapted from Carter and Fredenhall's (1990) study of EDI (see Section 2.5.2). Their study concentrated on the use of EDI for purchasing; the four dimensions they used to measure a firm's degree of EDI implementation were expanded to include EDI relationships with both suppliers and customers.

IV2, the length in years of involvement with EDI, was adapted directly from the Carter and Fredenhall (1990)

study. IV3, the percentage of business transactions supported by EDI, is an updated version of Carter and Fredenhall's measure of the percentage of annual purchases transmitted using EDI and measured in dollars. IV4C and IV4S, the percentage of EDI-linked customers and suppliers, respectively, is an expanded version of Carter and Fredenhall's measure of the percentage of the firm's supply base involved in EDI. IV5 is a continuous variable which indicates whether EDI (and international EDI) is used for the major functions of purchasing, distribution, sales/marketing, finance, manufacturing, or others. This variable is an outgrowth of Carter and Fredenhall's measure of the number of different purchasing forms transmitted using EDI. IV5 can assume values from 0 through 7, indicating how many different major functions of the business unit utilize EDI. The use or non-use of international EDI is indicated by the categorical variable IV6.

The stage of logistics organization, derived from the logistics typology (Byrne and Markham 1991) described in Section 2.2.4, is represented by the categorical variable IV7, with integer values ranging from 1 to 3, corresponding to the three stages of logistics organization derived from the logistics typology. A value of "1" indicates a business unit with the least sophisticated logistics

organization, while "3" represents the most sophisticated.

3.2.2 Dependent Variables

The dependent variables (DV) of the research model were developed from measures of logistics performance, competitive advantage, and overall performance (see Table 3.2). The logistics performance measures were adapted from a list of 38 logistics performance measures compiled and empirically tested by Bowersox et al. (1989, 1992) in studies of how firms measure logistics performance. The criterion for selecting each logistics measure for this study was that it was reported to be used by approximately 75 percent of the manufacturing, wholesaling, or retailing firms surveyed in the Bowersox study. Several performance measures did not meet this criterion (order processing costs, cycle time, and units per labor dollar) but were selected because they are especially pertinent to users of EDI. Since it was unlikely that all business units in the study population used each one of the twenty performance measures selected, the overall logistics performance measure LPU was added to the model. The last four performance measures (sales volume, market share, return on investment, profitability) were added to assess the overall impact of EDI usage.

In addition to the individual performance measures,

TABLE 3.2

DEPENDENT VARIABLES (DV)

Variable Name	Description
Logistics Performance Measures *	
LPA	Inventory carrying costs
LPB	Obsolete inventory
LPC	Logistics cost per unit
LPD	Logistics cost as % of sales
LPE	Inbound freight costs
LPF	Outbound freight costs
LPG	Warehouse costs
LPH	Direct labor costs
LPI	Administrative costs
LPJ	Order processing costs
LPK	Units shipped per employee
LPL	Units per labor dollar
LPM	Fill rate
LPN	Stockouts
LPO	Shipping errors
LPP	On-time delivery
LPQ	Backorders
LPR	Cycle time
LPS	Number of customer returns
LPT	Dollar amount of damage
LPU	Overall logistics performance
Composite Logistics Measures	
LOGMEAN	Overall logistics performance
COSTS	Costs
INVEN	Measures related to inventory performance
CUSTSER	Measures related to customer service
LABOR	Measures related to labor
ERRORS	Measures related to errors

TABLE 3.2 (CONTINUED)

Variable Name	Description
Overall Performance Measures *	
	LPV
Sales Volume	
LPW	Market Share
LPX	Return on investment
LPY	Profitability
OVMEAN	Composite of LPV through LPY

* The business unit's performance was evaluated using a discrete scale of 1 to 5, indicating whether the business unit's performance was (1) significantly worse than, (2) somewhat worse than, (3) roughly comparable to, (4) somewhat better than, or (5) significantly better than the industry average. A response of "NA" indicates that the performance measure was not used or that no information was available.

seven composite measures were developed a posteriori (see Section 5.2.3) to represent performance in broader functional categories. For each of these composite measures, related individual performance measures were grouped in logical categories and the mean of the category calculated in order to create the new composite measure. The seven composite measures are overall logistics performance (LOGMEAN), overall performance (OVMEAN), cost-related measures (COSTS), measures related to inventory performance (INVEN), measures related to customer service (CUSTSER), measures related to the use of labor (LABOR), and measures related to shipping errors and damage (ERRORS). Table 3.3 lists the specific individual performance measures used to build each composite measure.

The measures of competitive advantage (DVCA1/2/3) are categorical variables representing yes/no responses indicating whether or not the business unit has achieved competitive advantage, and whether or not the source of competitive advantage is the use of EDI or logistics competence. These measures are summarized in Table 3.4.

TABLE 3.3

COMPOSITE DEPENDENT VARIABLES

Variable Name	Individual Performance Measures
LOGMEAN	LPA through LPT
OVMEAN	LPV through LPY
COSTS	LPA, LPC, LPD, LPE, LPF, LPG, LPH, LPI, LPJ
INVEN	LPA, LPB, LPG, LPM, LPN, LPQ
CUSTSER	LPM, LPN, LPO, LPP, LPQ, LPR, LPS, LPT
LABOR	LPH, LPK, LPL
ERRORS	LPO, LPS, LPT

TABLE 3.4

Measures of Competitive Advantage (DVCA)

Variable Name	Description
DVCA1	Achievement of Competitive Advantage (yes/no)
DVCA2	Competitive Advantage Resulting from EDI (yes/no)
DVCA3	Competitive Advantage Resulting from Logistics Competence (yes/no)

3.2.3 Intervening Variables

The intervening variables (NV) were identified through the literature review (see Table 3.5) as the organizational factors most likely to affect the impact of EDI implementation on relative logistics performance. The following management techniques or technologies were evaluated as part of this research model:

1) Use of Just-In-Time (JIT) management techniques (NV1).

2) Use of Total Quality Management (TQM) techniques (NV2).

3) Use of bar code technology (NV3).

4) Use of EDI to support business process reengineering (NV4).

5) Use of partnerships with domestic (NV5) and international (NV6) suppliers.

TABLE 3.5

INTERVENING VARIABLES (NV)

Variable Name	Description
NV1	Use of Just-In-Time (JIT)
NV2	Use of Total Quality Management (TQM)
NV3	Use of Bar Code Technology
NV4	Use of EDI to support business process reengineering
NV5	Use of domestic supply partnerships
NV6	Use of international supply partnerships

Note: The intervening variables were evaluated using a discrete scale of 1 to 5, indicating the value of the NV to the business unit's overall logistics operations: (1) very unimportant, (2) somewhat unimportant, (3) of undecided value, (4) somewhat important, or (5) very important. A rating of "NA" indicates that the performance measure was not used or that no information was available.

3.2.4 Model Description

Having described the individual elements of the model, it is now appropriate to describe the model as a whole (see Figure 3.2). The independent variables of the model represent a business unit's degree of EDI implementation and stage of logistics organization, and it is proposed that these independent variables have a positive impact on the dependent variables, which represent logistics performance, overall performance, and achievement of competitive advantage. It is also proposed that certain business practices and techniques of the business unit, such as the use of Just-In-Time and Total Quality Management techniques, serve as intervening variables in the relationship between the independent and dependent variables, and that these intervening variables also have a positive impact on the dependent variables.

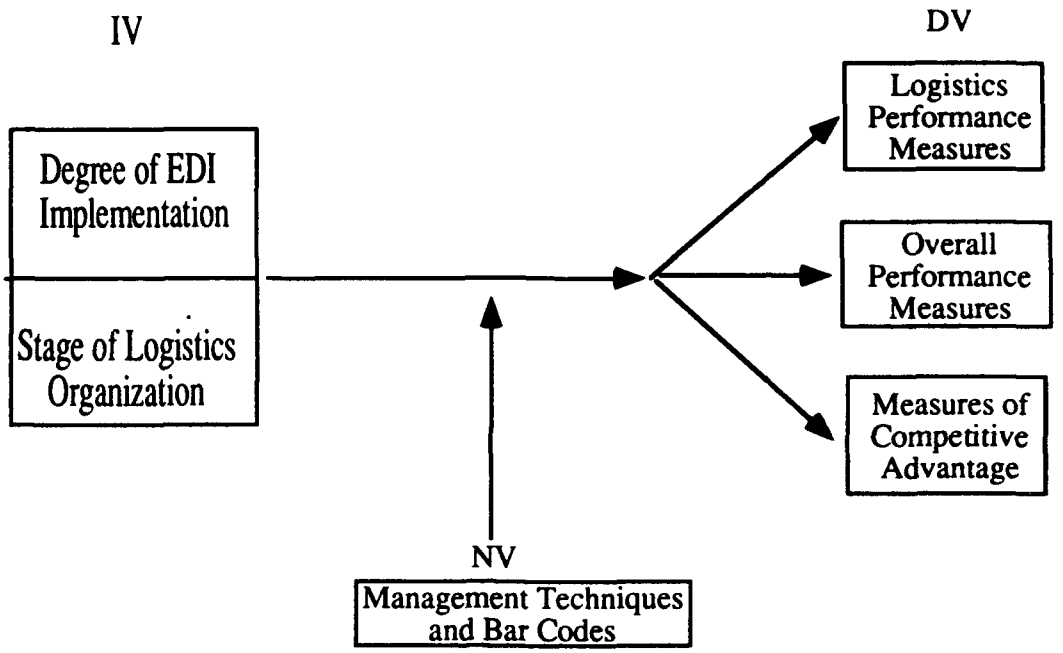
3.3 Research Objectives

The specific objectives of studying this model are as follows:

1. To identify those specific performance measures for which EDI use or nonuse appears to make a significant difference in relative performance.

FIGURE 3.2

MODEL DESCRIPTION



2. To identify those specific dependent variables which are significantly related to the proposed independent variables.
3. In regard to these specific dependent variables:
    a. To identify those individual independent variables which have the greatest impact on the dependent variables.
    b. To identify the effect of the intervening variables on the relationship between the independent variables and the dependent variables.
4. To develop some conclusions regarding the relationship between the independent, dependent, and intervening variables.

3.4 RESEARCH HYPOTHESES

3.4.1 Hypothesis 1

The first hypothesis compares the performance of business units that use EDI to support business transactions with customers and suppliers against the performance of business units that have not implemented EDI for regular operations. The concept of "performance" is represented by the series of selected logistics and overall performance measures listed in Table 3.2. Each performance measure will be evaluated individually.

H_{o1}: In comparison to nonusers, EDI users will rate their performance on selected measures (Table 3.2, LPA through LPY, and composite performance variables) as equal to or relatively worse than the industry average.

Rejection of the null hypothesis indicates that EDI users rated their performance on selected measures as relatively better than did nonusers. Failure to reject the null hypothesis indicates that EDI users did not rate their performance on selected measures as relatively better than did nonusers.

3.4.2 Hypothesis 2

The second hypothesis compares a business unit's stage of logistics organization (IV7) and its degree of EDI implementation, evaluated across several dimensions (IV1 through IV6) with its performance across a broad array of relative logistics and overall performance measures (Table 3.2). Each performance measure (dependent variable) will be evaluated individually with the independent variables (IV1 through IV7).

H_{o2}: The stage of logistics organization and degree of EDI implementation in a business unit are not correlated or are negatively correlated with its relative logistics or overall performance.

Rejection of the null hypothesis indicates that the stage of logistics organization and degree of EDI implementation in a business unit are positively correlated with its

relative logistics or overall performance. Failure to reject the null hypothesis indicates that the stage of logistics organization and degree of EDI implementation in a business unit are not positively correlated with its relative logistics or overall performance.

3.4.3 Hypothesis 3

The third hypothesis compares a business unit's stage of logistics organization (IV7) and its degree of EDI implementation, evaluated across several dimensions (IV1 through IV6) with its perceived achievement of competitive advantage. Three different perspectives on the achievement of competitive advantage (Table 3.4) will be evaluated individually with the independent variables (IV1 through IV7).

H_{o3}: The stage of logistics organization and degree of EDI implementation in a business unit are not correlated or are negatively correlated with its achievement of competitive advantage.

Rejection of the null hypothesis indicates that the stage of logistics organization and degree of EDI implementation in a business unit are positively correlated with its achievement of competitive advantage. Failure to reject the null hypothesis indicates that the stage of logistics organization and degree of EDI implementation in a business unit are not positively correlated with its achievement of

competitive advantage.

3.4.4 Hypothesis 4

The fourth hypothesis compares a business unit's stage of logistics organization (IV7), its degree of EDI implementation, evaluated across several dimensions (IV1 through IV6), and its involvement with certain management techniques and information technologies (Table 3.5, Intervening Variables) with its performance across a broad array of relative logistics and overall performance measures (Table 3.2). Each performance measure (dependent variable) will be evaluated individually with the combined independent variables (IV1 through IV7) and intervening variables (NV1 through NV6).

> H_{o4}: Certain management techniques and information technologies (Table 3.5, Intervening Variables) incorporated with the stage of logistics organization and degree of EDI implementation in a business unit are not correlated or are negatively correlated with its relative logistics or overall performance.

Rejection of the null hypothesis indicates that the combination of certain management techniques and information technologies with the stage of logistics organization and degree of EDI implementation in a business unit are positively correlated with its relative logistics or overall performance. Failure to reject the null hypothesis indicates that the combination of certain

management techniques and information technologies with the stage of logistics organization and degree of EDI implementation in a business unit are not positively correlated with its relative logistics or overall performance.

3.4.5 Hypothesis 5

The fifth hypothesis compares a business unit's stage of logistics organization (IV7), its degree of EDI implementation, evaluated across several dimensions (IV1 through IV6), and its involvement with certain management techniques and information technologies (Table 3.5, Intervening Variables) with its perceived achievement of competitive advantage. Three different perspectives on the achievement of competitive advantage (Table 3.4) will be evaluated individually with the combined independent variables (IV1 through IV7) and intervening variables (NV1 through NV6).

> H_{o5}: Certain management techniques and information technologies incorporated with the stage of logistics organization and degree of EDI implementation in a business unit are not correlated or are negatively correlated with its achievement of competitive advantage.

Rejection of the null hypothesis indicates that the combination of certain management techniques and

information technologies with the stage of logistics organization and degree of EDI implementation in a business unit are positively correlated with its achievement of competitive advantage. Failure to reject the null hypothesis indicates that the combination of certain management techniques and information technologies with the stage of logistics organization and degree of EDI implementation in a business unit are not positively correlated with its achievement of competitive advantage.

3.5 SUMMARY

This chapter has defined the variables used in this study and how they are measured, and explained how these variables are combined to create a research model. The research objectives hypotheses were listed and discussed. The next chapter will describe the empirical process of operationalizing the model and testing the hypotheses.

CHAPTER IV

METHODOLOGY

4.1 INTRODUCTION

The purpose of this chapter is to describe the methodology used in this empirical study. By means of a self-administered mail survey, data were collected on relevant characteristics from logistics and EDI managers employed by manufacturers, merchandisers, and distributors located in the United States. This chapter explains the development of the survey instrument, selection of the study population and sample size, preparation and mailing of the questionnaire packages, and organization of the data for analysis.

4.2 SURVEY INSTRUMENT

A draft survey instrument was prepared as a result of the literature review and research model development. To establish content validity, the survey instrument was reviewed by six academic and business experts in logistics and EDI. The experts were asked to comment on the clarity of the terminology and instructions, the appropriateness of the questions and possible responses, and any apparent omissions. Content validity is defined as the extent to which the appropriate topic elements are included and

assessed (Carmines and Zeller 1979).

As a result of the experts' comments, several questions were rewritten to improve their meaning and format, and to ensure that the most appropriate terminology was used. Two major problems noted were: the questionnaire was too long and some questions required both logistics and EDI functional experts to answer. Rather than limit the scope of the research questions, it was decided to split the original questionnaire into two separate survey instruments. One questionnaire (Appendix A), sent to logistics managers, contained the questions primarily related to logistics management. The second questionnaire (Appendix B), with questions primarily related to EDI implementation, was included in the package to the logistics manager, who was requested to direct this second questionnaire to the EDI manager of the same business unit. Both questionnaires included the same set of questions on competitive advantage. Since the unit of analysis was the business unit, a complete observation required that both a logistics and an EDI questionnaire be returned from the same business unit. If the business unit did not use EDI, then the logistics questionnaire alone would represent a complete observation, for the purpose of testing Hypothesis 1 only.

4.3 STUDY POPULATION AND SAMPLE

The primary study population was drawn from the membership roster (current as of March 3, 1993) of the Council of Logistics Management (CLM). This not-for-profit organization, headquartered in Oak Brook, Illinois, was organized to support the exchange of information and to sponsor research projects and training and career opportunities for logistics professionals (Membership Roster 1992).

The primary sampling frame of the study was composed of CLM members who were employed by a manufacturing, merchandising, or distribution firm, in a capacity related to logistics, and whose level of responsibility was listed as "Corporate Officer" or "Director." This identifying information was given by CLM members on their membership applications. The initial list provided by the CLM included 1551 names; this list was edited to ensure that each business unit was represented on the list only once. If there were multiple CLM members in the same business unit, the individual whose job title most closely resembled "Director of Logistics" was selected. The final mailing list contained 1065 names of logistics directors (or those individuals in a related capacity) employed by firms located in the United States.

Development of the sample size for the primary

sampling frame is explained below.

Referring to Hypothesis 1, sample size for the primary sampling frame was determined by referring to Kraemer and Thiemann (1987), Table 4.3 and the Master Table for a one-tailed test, alpha = 5 percent, delta (effect size) = .50, and power of 80 percent. These parameters indicate a sample size of 127, assuming that 70 percent of respondents use EDI, and 30 percent do not.

In reference to the sample size for the regression functions (Hypotheses 2 through 5), a rule-of-thumb to determine the number of responses needed is 15 cases per predictor (Stevens 1986) or 6 to 10 cases per predictor (Neter et al 1989). In this case, building a regression function with 7 independent variables and 1 intervening variable would require approximately 120 matched responses from logistics and EDI managers, if 15 cases per predictor is deemed necessary. Assuming that 70 percent of the respondents use EDI, the target number for total responses is 172. Exact power calculations of the kind demonstrated by Cohen (1988) are not possible since the population variance is unknown and any estimate would be no more than a guess.

To estimate the total number of questionnaire packages to be mailed, the formula given by Henry (1990) was used. Assuming a response rate of 23 percent, a desired response

of 172 completed logistics questionnaires, and estimating the proportion of ineligibles on the list at 5 percent, at least 956 questionnaires must be mailed. The response rate of 23 percent was taken from the report on a 1987 survey of Council of Logistics Management members dealing with a broad range of logistics practices (Bowersox et al. 1989). It was assumed that the sample size (172) determined for Hypotheses 2 through 5 would also provide an adequate number of responses for the first hypothesis. Given the uncertainty of response to self-administered mail questionnaires, it was decided to use all 1065 names available from the CLM sampling frame and to mail that number of questionnaire packages.

4.4 DATA COLLECTION PROCEDURES

4.4.1 Mailing and Follow-up Procedures

Each pair of logistics and EDI questionnaires was mailed together in a personalized envelope with two personalized cover letters on Department of Business Analysis and Research letterhead, directed to one of the CLM members listed on the mailing list described above. While more costly and time-consuming, it was believed that personalized envelopes and letters would significantly increase the response rate (Alreck and Settle 1985). The first cover letter (Appendix C) asked the addressee to

complete and return the logistics questionnaire and to forward the second cover letter (Appendix D) and EDI questionnaire to the business unit's EDI manager, if the business unit used EDI. The logistics manager was asked to complete the logistics questionnaire regardless of whether or not the business unit used EDI, since replies were needed from nonusers in order to test Hypothesis 1. Self-addressed business reply envelopes were provided for each questionnaire. Questionnaires were numbered on the last page and cross-referenced to the mailing list, which was maintained in zip code order. All 1065 questionnaire packages were sent via bulk mail on April 8, 1993 through the University Mail Service.

Follow-up postcards were sent via first-class mail on April 30, 1993 to the 965 original addressees who had not responded as of that date. Selected telephone follow-up was performed over the next eight weeks to obtain either the logistics questionnaire or the EDI questionnaire needed to complete a pair and to obtain enough logistics questionnaires to achieve the required sample size. In twenty-five cases, the individual contacted by telephone requested another copy of either the logistics or EDI questionnaire or both, so another copy or copies was sent via first-class mail or facsimile transmission.

4.4.2 Recording the Data

A PC database management file in AlphaFOUR (1991) was created to record and manage the data from the returned questionnaires. Responses were also tracked manually using a hard copy "code book" as recommended by mail survey experts (Alreck and Settle 1985).

Data collection was completed on June 29, 1993 with 100 usable questionnaire pairs and 171 usable logistics questionnaires returned. This data collection effort represented a 16.1 percent response rate for the logistics questionnaires. Since it was not known how many of the business units on the mailing list used EDI, it was not possible to determine a response rate for the EDI questionnaires. However, 100 usable EDI questionnaires were returned and matched with a logistics questionnaire from the same business unit.

The data was transferred to WYLBUR (mainframe) in various ASCII file formats as needed to perform statistical tests using SAS (SAS Institute Inc. 1989).

4.5 SUMMARY

This chapter has described how the research instrument was developed, how the study sample size was determined, and how data was collected and organized for analysis. The next chapter will describe the specific statistical

techniques used to test the hypotheses and the results of the data collection and hypotheses testing.

CHAPTER V

DATA ANALYSIS AND RESULTS

5.1 INTRODUCTION

The purpose of this chapter is to explain the initial data analyses performed before hypothesis testing began, provide relevant descriptive data regarding the questionnaire responses, and describe the statistical procedures used for hypotheses testing and the results. T-tests were used to evaluate the difference in perceived performance between business units that used EDI and ones that did not. Multiple regression and logistic regression were used to determine relationships between the dependent variables: relative measures of logistics performance, overall performance, and competitive advantage, and the independent variables: stage of logistics organization and degree of EDI implementation. The impact on these relationships of certain intervening variables, selected management practices and bar code technology, was also measured.

Key results for each hypothesis are listed in tables within the chapter; complete results for each hypothesis tested are listed in the appendices as noted in the text. A discussion of nonresponse bias and the data collected on the use of international EDI is also included.

"LQ" refers to questions from the logistics management questionnaire and "EQ" refers to questions from the EDI questionnaire.

5.2 PRELIMINARY ANALYSES

5.2.1 Response Rate

As explained in Section 4.3, the appropriate sample size needed to test Hypothesis 1 was determined to be 127, if the percentage of EDI users was 70 percent. However, 171 usable logistics questionnaires were returned, with the percentage of EDI users equal to 87.72 percent (150/171). Recalculating the sample size using Kraemer and Thiemann's (1987) method and the actual proportion of EDI users gave an approximate power of 62.5 percent.

The target number for returned pairs of matched EDI and logistics questionnaires was 120. However, an extensive follow-up effort by telephone yielded only 100 matched pairs. This was judged to be acceptable since the recommended number of observations per predictor ranged from 6 to 10 to 15, and 100 matched pairs is adequate if the middle recommendation (10 observations for each of 8 predictor variables) was used.

5.2.2 Tests for Normality

The SAS (SAS Institute Inc. 1989) "UNIVARIATE" procedure was used to test the univariate normality of all the variables in both data sets (n = 171 and n = 100). The Kolomogorov D statistic was used to test the null hypothesis that the data values were a random sample from a normal distribution. In no instance in either data set was the null hypothesis rejected.

5.2.3 Development of Composite Dependent Variables

The initial development and testing of the multiple regression equations using the individual performance measures (LPA through LPY, Table 3.2) produced somewhat disappointing results; only five of the twenty-five performance measures yielded a significant relationship as indicated by the p-value of the regression model. It was then decided to combine the individual performance measures in logical categories to create a set of composite performance measures (dependent variables) a posteriori. These composite dependent variables were created in order to provide a broader focus for the dependent variables than was possible if just the individual measures were used. The individual measures used to build the composite dependent variables (LOGMEAN, OVMEAN, COSTS, INVEN, CUSTSER, LABOR, and ERRORS) are listed in Table 3.3. A

description of each composite dependent variable is found in Section 3.2.2.

5.2.4 Reliability Assessment

While there are four basic methods for assessing the reliability of empirical measurements (retest, alternative form, split-halves, and internal consistency (Carmines and Zeller 1979)), only the latter is feasible for the mail survey methodology used in this study. Cronbach's coefficient alpha is a frequently used measure of internal consistency of rating scales with values ranging from 0 to 1. Coefficient alpha is used to give a measure of the reliability of a scale, and generally, reliabilities for scales in use should not fall below .80 (Carmines and Zeller 1979). For the set of performance measures (LPA through LPY) on the logistics management questionnaire, the standardized coefficient alpha calculated for 119 observations was .904469, and for 60 observations (questionnaire pairs) it was calculated to be .903965 (any observations with missing values were deleted). For the intervening variables NV1 through NV5, the standardized coefficient alpha for 171 observations was .781793 and for 91 observations it was .821487. These were judged to be acceptable levels of reliability for the scales used to measure the dependent and intervening variables.

5.2.5 Analysis of Nonresponse Bias

Since 1065 questionnaires were mailed and 171 usable logistics questionnaires were returned, the response rate was determined to be 16.1 percent. Since the number of EDI users in the study population was not known, it was not possible to calculate an exact response rate for the EDI questionnaires (100 usable ones were returned and matched with the logistics questionnaire from the same business unit).

In order to assess the impact of nonresponse on the study's conclusions, a "wave analysis" (Henry 1990) was performed on both the returned logistics and EDI questionnaires. Respondents were divided into two groups: those who responded as a result of the initial mailing or follow-up postcard ("wave 1"), and those who responded only after a personal telephone call or handwritten note ("wave 2"). It was assumed that those in the second group most nearly resemble nonrespondents.

The first series of t-tests to compare the means of the two groups was performed on 100 returned survey pairs (91 usable observations). All the independent and dependent variables were analyzed, as well as the intervening variables and the composite dependent variables. Only NV3 showed a p value of less than .05 (.0238), although LOGSTAGE may be questionable (p = .0674).

Appendix E summarizes the results of these tests. These tests indicate that there are no relevant differences between the responses from the two groups or waves.

The second series of t-tests was run on the data from the 171 returned logistics questionnaires. All of the intervening and dependent variables were tested, as well as LOGSTAGE and the composite dependent variables. Appendix F summarizes the results of these tests. Only the dependent variable LPA showed a p value of less than .05, thus indicating the means of the two groups or waves are likely different for that variable only. However, LPA was not a key variable in any of the analyses, except as it contributed to the composite dependent variables. Therefore, it was assumed on the basis of these t-tests that nonresponse bias was not a significant factor in this study.

5.3 HYPOTHESIS 1

5.3.1 Data Analysis Plan

The data set used to test Hypothesis 1 consisted of 171 returned logistics questionnaires. Descriptive data regarding the respondents' use of EDI, participation in international trade, primary mission of the business unit, and stage of logistics organization is shown in Table 5.4.

TABLE 5.1

DESCRIPTIVE DATA: LOGISTICS QUESTIONNAIRES

n = 171	n / %		
	Yes	No	Total
Use EDI	150/87.7%	21/12.3%	171/100%
Trade Internationally	134/78.4%	37/21.6%	171/100%

Primary Mission of Business Unit	n / %
Manufacturing	102/59.6%
Wholesaling	15/8.8%
Retailing	18/10.5%
Distribution	36/21.1%
Total	171/100%

Stage of Logistics Organization	
I	2/1.2%
II	76/44.4%
III	93/54.4%
Total	171/100%

The respondents were categorized as EDI users or nonusers based upon the existence of a returned EDI survey, written information from the respondent, listing of the business unit in the EDI Yellow Pages (1992), or a telephone call if necessary. In order to test Hypothesis 1, data from question LQ15, parts a through y, was analyzed. This question asked respondents to compare their business unit's performance with the average industry performance on 25 logistics and overall performance measures (Table 3.2, variables LPA through LPY). The value of the variable was determined by the respondent's choice of an integer from from 1 (significantly worse than the average industry performance) to 5 (significantly better than the average industry performance). The mean responses for each individual and composite performance measure were determined, and two-sample t-tests were performed to determine if the means for EDI users were statistically greater than the means for the nonusers.

5.3.2 Results

T-Tests were performed on the 25 logistics and overall performance measures from LQ15a through LQ15y, as well as the seven composite performance measures (Table 3.2), and the intervening variables NV1 through NV5 (Table 3.5), in

order to compare the means for EDI users and nonusers. Appendix G summarizes the results of these tests. Table 5.2 summarizes the tests on the measures that indicate that the means were greater for EDI users at the .025 significance level for a one-sided test. Therefore, the null hypothesis was rejected only for the performance measures listed in Table 5.2.

These tests indicated that EDI users experienced better performance in functions relating to inventory management, cycle time, and customer service, than did nonusers. Also, EDI users believed that the use of bar codes, the use of EDI to support business process reengineering, and the development of domestic supply partnerships were more important to their business operations than did nonusers.

5.4 HYPOTHESIS 2

5.4.1 Data Analysis Plan

The data set used to test Hypotheses 2 through 5 consisted of 100 paired logistics and EDI questionnaires, therefore representing responses from 100 business units. Since nine of the responding business units were in the very early stages of EDI implementation, they could not provide the complete data set needed for the independent variables. These incomplete observations reduced the

TABLE 5.2

HYPOTHESIS 1: SIGNIFICANT T-TESTS

* H_{o1}: $\mu_1 - \mu_2 <= 0$

Variable	Description	Variances (p) Unequal	Equal	Prob> F'
Logistics Performance Measures				
LPM	Fill rate	.0071	.0009	.2861
LPN	Stockouts	.0122	.0039	.5356
LPP	On-time delivery	.0006	.0000	.3563
LPQ	Backorders	.0325	.0174	.6126
LPR	Cycle time	.0056	.0014	.6592
Composite Logistics Measures				
LOGMEAN	Overall logistics perf.	.0815	.0346	.1651
INVEN	Inventory perf.	.0317	.0231	.8973
CUSTSER	Customer service	.0054	.0004	.1485
Intervening Variables				
NV3	Use of bar codes	.0282	.0073	.1869
NV4	Business process reengineering	.0001	.0000	.5631
NV5	Domestic supply partnerships	.0047	.0012	.5667

* μ_1 refers to EDI users, μ_2 refers to nonusers.

number of usable observations to 91. Table 5.3 summarizes the descriptive data relating to these respondents' participation in international trade, primary mission of the business unit, and stage of logistics organization.

The independent variables measuring the degree of EDI implementation were developed using data from questions EQ1 through EQ9 (see Table 5.4). Appendix H summarizes the responses to these questions. The response EQ1a identified all EDI users. For variable IV1 (Figure 3.1), the responses to question EQ9 rated the stage of EDI implementation on a scale of 0 to 8 (responses a through i). The responses to questions EQ4 through EQ7 provided specific values for variables IV2 through IV4S. IV5 was a continuous variable developed from the responses to question EQ8. For each business function (purchasing, distribution, order entry, etc.) in which EDI was used on a regular basis, one point was given. The total number of points determined the value of IV5, which had a possible range of integer values from 0 to 7.

Questions EQ4 through EQ8 requested specific information regarding both domestic and international EDI usage; this information was recorded separately and the domestic statistics were used in the data analyses unless explicitly stated otherwise. IV6 was determined by the responses to question EQ2, used to identify the users of

TABLE 5.3

DESCRIPTIVE DATA: QUESTIONNAIRE PAIRS

n = 91	n / %		
	Yes	No	Total
Trade Internationally	76/83.5%	15/16.5%	91/100%
Primary Mission of Business Unit	n / %		
Manufacturing	55/60.4%		
Wholesaling	6/6.6%		
Retailing	10/11.0%		
Distribution	20/22.0%		
Total	91/100%		
Stage of Logistics Organization			
I	0/0.0%		
II	36/39.6%		
III	55/60.4%		
Total	91/100%		

TABLE 5.4

HYPOTHESIS 2: INDEPENDENT VARIABLES

Variable	Description
IV1/EQ9	Categorical, stage of EDI implementation [from Figure 3.1, integer scale of 0 to 8, grouped into four categories as follows: IV1A1 = 1, 2, 3 (initiation through adoption) IV1A2 = 4, 5, 6 (acceptance through expansion) IV1A3 = 7,8 (infusion and enhancement)] (unstated) = 0, no plans to implement EDI
IV2/EQ4	Length of involvement with EDI in years (integer)*
IV3/EQ5	Percentage of business transactions supported by EDI*
IV4C/EQ6	Percentage of customer base supported by EDI*
IV4S/EQ7	Percentage of supplier base supported by EDI*
IV5/EQ8	Range of document formats used* (integer total of different business functions where EDI is used)
IV7/ LQ6 to LQ13	Categorical, stage of logistics organization [integer scale of 1 to 3, grouped into two categories as follows: IV72 = stage 2 logistics organization (unstated) = stage 3 logistics organization]

*Indicates a continuous variable.

international EDI.

The stage of logistics organization, IV7 (see Section 2.2.4), was determined by the responses to questions LQ6 through LQ13. Responses a, b, or c for questions LQ6 through LQ13 indicated a logistics organization of stage I, II, or III, respectively, and each were assigned that same number of points. The mean of the points received for these questions was calculated and rounded off to an integer; this score placed the respondent in that particular stage of logistics development. The stage of development determined the value of IV7: 1, 2, or 3. All of the responding business units in this data set were calculated to have a stage II or stage III logistics organization.

The dependent variables for Hypothesis 2, listed in Table 3.2, were derived from the responses to question LQ15, parts a through y. Appendix I gives basic descriptive statistics for the responses to the questions used to formulate the relative logistics and overall performance measures.

To test Hypotheses 2, a multiple regression function was developed using variables IV1 through IV5 and IV7 as the predictors. A series of regressions was then performed, using one dependent variable at a time. IV6 was not used as a predictor since an insufficient number of

international EDI users responded to the EDI questionnaire (see Section 5.8).

5.4.2 Results

A series of multiple linear regressions were developed using the independent variables shown in Table 5.4. The number of categories for IV1 was reduced from 9 to 4, as indicated in Table 5.4, because the distribution of responses across the original 9 categories resulted in some very sparse cells, as shown in Appendix H.

There were 91 observations, although some regressions used fewer observations because of missing data for the dependent variable. Variables IV1 and IV7 were coded as categorical variables using indicator variables, and all of the data were standardized.

The entire set of independent variables listed in Table 5.4 was regressed against each individual logistics and overall performance measure (LQ15a through LQ15y, referred to as LPA through LPY) and the composite performance measures shown in Table 3.2. Appendix J lists the results for all models tested.

Table 5.5 shows the results for the models with p values of .05 or less. The null hypotheses was rejected for these models indicating a significant relationship for these models; the null hypothesis was not rejected for the

TABLE 5.5

HYPOTHESIS 2: SIGNIFICANT MODELS

Dependent Variable*	p	R^2	Adjusted R^2
LPK (units shipped per employee)	.0442	.2126	.1099
LPL (units per labor dollar)	.0145	.2478	.1497
LPP (on-time delivery)	.0188	.2165	.1261
LPR (cycle time)	.0281	.2072	.1146
LPU (overall logistics performance)	.0336	.1998	.1074
LOGMEAN	.0089	.2294	.1438
COSTS	.0416	.1871	.0968
CUSTSER	.0334	.1957	.1052
LABOR	.0164	.2227	.1318

* Each model was developed using one dependent variable and the following independent variables: IV1A1, IV1A2, IV1A3, IV2, IV3, IV4C, IV4S, IV5, IV72 (as listed in Table 5.4).

remainder of the models.

The variance inflation factor (VIF) was used to check each independent variable for possible multiple collinearity. In these models, collinearity was not judged to be a problem since all the VIF values were below 8.4, while the critical value is generally judged to be 10 (Hair et al. 1992).

An additional series of regression analyses on these significant models was performed by testing all possible combinations of independent variables for each model. A reduced version of each model was selected by choosing the combination of independent variables with the highest adjusted R^2, as shown in Table 5.6. The same set of analyses was performed using the smallest Cp criterion; the results were unchanged. All of the reduced models, also as shown in Table 5.6, were significant at the .05 level.

These regression models demonstrate that the relationships between the dependent variables related to labor, cycle time, costs, customer service, and overall logistics performance, and the entire set of independent variables produced significant models. Therefore, the null hypothesis was rejected for the nine models associated with those dependent variables listed in Tables 5.5 and 5.6, indicating a positive correlation with the following

TABLE 5.6

HYPOTHESIS 2: REDUCED MODELS

DV/p	# IVs	R^2/Adjusted R^2	IVs Selected
LPK/.0043	5	.2052/.1507	IV3, -IV1A1/A2/A3, -IV72
LPL/.0016	5	.2292/.1764	IV3, -IV1A1/A2/A3, -IV72
LPP/.0015	4	.1889/.1498	IV4C, IV4S, -IV5, -IV72
LPR/.0051	6	.2020/.1421	IV3, IV4C, -IV1A1/A2/A3, -IV72
LPU/.0032	5	.1925/.1432	IV4S, -IV1A1/A2/A3, -IV72
LOGMEAN/.0012	6	.2255/.1702	IV3, IV4C, -IV1A1/A2/A3, -IV72
COSTS/.0006	2	.1546/.1354	IV3, -IV72
CUSTSER/.0032	5	.1880/.1397	IV4C, -IV1A1/A2/A3, -IV72
LABOR/.0010	5	.2198/.1716	IV3, -IV1A1/A2/A3, -IV72

Note: LPK = units shipped per employee
LPL = units per labor dollar
LPP = on-time delivery
LPR = cycle time
LPU = overall logistics performance

independent variables: IV3 (percentage of business transactions supported by EDI), IV4C (percentage of customer base supported by EDI), IV4S (percentage of supplier base supported by EDI), and IV7 (stage of logistics organization).

5.4.3 Discussion

In each of the nine models, the independent variable representing the stage of logistics organization (IV7) was shown to be significant in determining a reduced model with the highest adjusted R^2. The indicator variable IV72, signifying a stage II logistics organization, had a negative parameter estimate. This indicates that the regression line for an observation for a stage II logistics organization has a lower intercept than a regression line for an observation for a stage III logistics organization, which was the unstated indicator variable (see Table 5.4), represented by the intercept only. This set of parallel lines, portraying the two levels of logistics organization in this data set, shows that the performance of the lower level logistics organization (stage II) was ranked below the performance of the stage III organization.

IV1, the independent variable representing the stage of EDI implementation, was significant in 7 of the 9 models (all except LPP and COSTS). However, in every case, the

parameter estimates associated with the three indicator variables representing IV1 were negative. Since the unstated indicator variable (intercept) represented stage zero (no EDI implementation planned for the majority of the customer/supplier base), the more advanced categories of the model (IV1A1/A2/A3) are associated with regression lines with lower intercepts, therefore indicating lower performance levels. This may indicate a problem with the measurement of the construct itself (see Figure 3.1), or it may indicate that integration of EDI throughout the functions of a business unit is an evolutionary process and does not result immediately in improved performance and utilization of resources.

IV4C, percentage of EDI-linked customers, was significant for the models associated with the dependent variables LPP, LPR, LOGMEAN and CUSTSER. IV4S, percentage of supplier base supported by EDI, was significant for the models associated with the dependent variables LPP and LPU. Furthermore, IV3 (percentage of business transactions supported by EDI) was significant for the models associated with the dependent variables LPK, LPL, LPR, LOGMEAN, COSTS, and LABOR. The independent variable representing the functional range of EDI usage (IV5) appears only once and with a negative parameter estimate (in the model associated with the dependent variable LPP, on-time delivery). This

may also indicate a problem between the functional integration of EDI and performance.

Interestingly, the independent variables associated with percentage of business transactions supported by EDI (IV3), stage of EDI implementation (IV1), and stage of logistics organization (IV7) appear clustered together 5 times. Also, IV4C (percentage of customer base supported by EDI) appears clustered with IV1 and IV7 in three instances (cycle time (LPR), LOGMEAN, AND CUSTSER).

5.5 HYPOTHESIS 3

5.5.1 Data Analysis Plan

The set of independent variables developed for Hypothesis 2 were also used to develop a series of logistic regression functions to test Hypothesis 3. The measures of competitive advantage, dichotomous response variables for Hypothesis 3, were derived from the categorical responses to questions LQ17, LQ19, LQ20, EQ11, EQ13, and EQ14. The same series of questions regarding the achievement of competitive advantage and its source (Table 3.4) appeared on both questionnaires. Table 5.7 summarizes the questions and the categorical responses to these questions. Each response variable was tested individually in the logistic regression equation.

For questions LQ17 and EQ11, the response for the

TABLE 5.7

HYPOTHESIS 3: RESPONSE DISTRIBUTION

Questions

LQ17/EQ11: Does your business unit's management generally perceive that it has achieved a competitive advantage?

Response	LQ17 Frequency/Percent	EQ11 Frequency/Percent
Yes	60/65.9	59/64.8
No	18/19.8	14/15.4
Not Sure	13/14.3	18/19.8

LQ19/EQ13: Your business unit generally regards EDI relationships with customers and suppliers as a source of competitive advantage (C.A.) or as a source of competitive necessity (C.N.)?

Response	LQ19 Frequency/Percent	EQ13 Frequency/Percent
Source of C.A.	36/39.6	27/29.7
Source of C.N.	46/50.5	54/59.3
Neither of above	6/6.6	6/6.6
Both of above	3/3.3	4/4.4

LQ20/EQ14: Your business unit generally regards logistics competence as a source of competitive advantage (C.A.) or as a source of competitive necessity (C.N.)?

Response	LQ20 Frequency/Percent	EQ14 Frequency/Percent
Source of C.A.	54/59.3	35/38.5
Source of C.N.	28/30.8	47/51.6
Neither of above	8/8.8	6/6.6
Both of above	1/1.1	3/3.3

purposes of analysis was considered "yes" if the response to the question was selection "a" or "yes"; otherwise, the response was considered to be "no", thus grouping together the possible responses of "no" and "not sure". For questions LQ19 and EQ13, and LQ20 and EQ14, the response was "yes" for the purposes of analysis only if the first option, "a source of competitive advantage", was selected. Otherwise, the response was judged to be "no", thus grouping together the other alternatives. An extra category ("both a and b") had to be added to these four questions during postcoding since a number of respondents marked both "a" and "b" for the same question. Table 5.8 summarizes this revised grouping of responses.

A chi square analysis (Ferguson and Takane 1989) based on the frequency of the "yes" and "no" responses shown in Table 5.8 was performed to determine if the observed frequency of responses differed statistically from the expected. Comparing the calculated chi square statistic to the critical value at alpha equal to .05 and one degree of freedom, the null hypothesis of no true difference in opinion was rejected for three questions: LQ17, EQ11, and EQ13. It appears, therefore, that a majority of both logistics and EDI managers believe that their business units have achieved a competitive advantage, although EDI managers do not attribute this achievement to EDI.

TABLE 5.8

HYPOTHESIS 3: RESPONSE ANALYSIS

Questions

LQ17/EQ11: Does your business unit's management generally perceive that it has achieved a competitive advantage?

Response	LQ17 Frequency/Percent	EQ11 Frequency/Percent
Yes	60/65.9	59/64.8
No/Not Sure	31/34.1	32/35.2
Chi Square*	9.242	8.010

LQ19/EQ13: Your business unit generally regards EDI relationships with customers and suppliers as a source of competitive advantage (C.A.) or as a source of competitive necessity (C.N.)?

Response	LQ19 Frequency/Percent	EQ13 Frequency/Percent
Source of C.A.		
Yes	39/41.5	31/32.6
No	55/58.5	64/67.4
Chi Square*	2.9121	12.143

LQ20/EQ14: Your business unit generally regards logistics competence as a source of competitive advantage (C.A.) or as a source of competitive necessity (C.N.)?

Response	LQ20 Frequency/Percent	EQ14 Frequency/Percent
Source of C.A.		
Yes	55/59.8	38/41.3
No	37/40.2	56/59.6
Chi Square*	3.5714	3.6594

* Calculated statistic; critical value for alpha = .05 and 1 degree of freedom = 3.84.

5.5.2 Results

A series of logistic regressions were developed using the independent variables listed in Table 5.4 and the dichotomous response variables as described above. Table 5.9 summarizes the results of the logistic regressions. None of the models tested was significant at the .05 level. Therefore, there was a failure to reject each null hypotheses for Hypothesis 3. However, several of the independent variables (IV1, IV7, and IV4S) were found to be individually significant, which may indicate some relationship between those variables and the achievement of competitive advantage. While the sign of the parameter estimate for IV4S was negative, the majority of the actual standardized data values for IV4S were negative as well. Since the model itself lacks significance, specific conclusions regarding the behavior of a particular variable are not justified. However, the presence of a negative parameter estimate for IV4S may indicate the need for additional investigation.

5.6 HYPOTHESIS 4

5.6.1 Data Analysis Plan

The intervening variables NV1 through NV6 (Table 3.5) were developed from question LQ14, parts a through f. In each part, the respondent rated on a scale of 1 to 5

TABLE 5.9

HYPOTHESIS 3: LOGISTIC REGRESSION RESULTS

Question	-2 LOG L	SCORE	Significant IV/ p-value)
LQ17	.1279	.2052	IV72 (.0322)
LQ19	.5277	.5621	(intercept only)
LQ20	.1634	.2015	(intercept only)
EQ11	.0907	.1483	IV1A1 (.0431)
EQ13	.3602	.3660	(intercept only)
EQ14	.0607	.0737	-IV4S (.0024)

the importance of each intervening variable (use of JIT, TQM, supply partnerships, etc.) to the business unit's logistics operations.

In order to test the hypothesis, a multiple regression function was constructed as described for Hypothesis 2. The intervening variables were entered into the complete model as additional predictors to observe their impact on the performance of the series of regression models developed from using one dependent variable at a time. This relationship was hypothesized to be positive. Appendix K gives basic descriptive statistics for the intervening variables, NV1 through NV5. NV6 (LQ14f), "partnerships with foreign suppliers", was not used in this analysis since it would be appropriate only for a data set in which all the members traded internationally (see Section 5.8).

5.6.2 Results

The series of regression analyses described above were performed. The significance of the new models was determined, as shown in Table 5.10. Again, the VIF values were checked for possible collinearity problems but none were noted. At the .05 level of significance, the null hypothesis was initially rejected for the models associated with the dependent variables LPP (on-time delivery),

TABLE 5.10

HYPOTHESIS 4: MODELS TESTED

Dependent variable*	p	R^2	adjusted R^2
LPK (units shipped per employee)	.0934	.2636	.1025
LPL (units per labor dollar)	.0533	.2857	.1294
LPP (on-time delivery)	.0155	.2968	.1620
LPR (cycle time)	.0188	.2943	.1570
LPU (overall logistics performance)	.0489	.2605	.1187
LOGMEAN	.0099	.3001	.1712
COSTS	.0738	.2381	.0978
CUSTSER	.0048	.3227	.1963
LABOR	.0372	.2726	.1311

* Each model was developed using one dependent variable, and the following independent variables: IV1A1, IV1A2, IV1A3, IV2, IV3, IV4C, IV4S, IV5, IV72 (as listed in Table 5.4), and the entire set of intervening variables NV1 through NV5 (Table 3.5).

LPR (cycle time), LPU (overall logistics performance, LOGMEAN, CUSTSER, AND LABOR.

An additional series of regression analyses was performed on all of the models listed in Table 5.10 to find the combination of variables with the highest adjusted R^2 and to determine the significance of the model, as shown in Table 5.11. As that table demonstrates, all of the reduced models were significant at the .05 level. Therefore, the null hypothesis was rejected for each of the models listed in Tables 5.10 and 5.11.

The addition of the intervening variables to the significant models also produced interesting results. NV1, JIT techniques, was significant for LPP, LPU, LOGMEAN, COSTS, CUSTSER, and LABOR. NV2, TQM, was significant for LPK, LPP, LPR, LOGMEAN, CUSTSER, and LABOR. NV3, UPC/bar codes, was significant for LPP and LPR. NV4, using EDI to support business process reengineering, was significant for LPL, LPP, LPR, LPU, LOGMEAN, and CUSTSER. However, in all but the first instance (LPL), the sign of the parameter estimate was negative. This may indicate that trying to integrate EDI throughout an organization may not immediately result in improved performance.

NV5, partnerships with U.S. suppliers, was significant for LPK, LPL, CUSTSER, and LABOR. However, in every model

TABLE 5.11

HYPOTHESIS 4: REDUCED MODELS

DV/p	# IVs	R^2/Adjusted R^2	IVs and NVs Selected
LPK/.0047	7	.2431/.1685	IV3, -IV1A1/A2/A3, -IV72, NV2, -NV5
LPL/.0031	7	.2534/.1798	IV3, -IV1A1/A2/A3, -IV72, NV4, -NV5
LPP/.0014	9	.2816/.1987	-IV3, IV4C, IV4S, -IV5, -IV72, NV1, NV2, NV3, -NV4
LPR/.0017	9	.2814/.1974	IV3, IV4C, -IV1A1/A2/A3, -IV72, NV2, NV3, -NV4
LPU/.0008	6	.2419/.1858	-IV1A1/A2/A3, -IV72, NV1,-NV4
LOGMEAN/ .0001	6	.2772/.2256	IV3, IV4C, -IV72, NV1, NV2, -NV4
COSTS/ .0001	3	.2093/.1820	IV3, -IV72, NV1
CUSTSER/ .0001	6	.2932/.2421	IV4C, -IV72, NV1, NV2, -NV4, NV5
LABOR/ .0021	8	.2593/.1834	IV3, -IV1A1/A2/A3, -IV72, NV1, NV2, -NV5

except the one associated with CUSTSER, the parameter estimate of NV5 is negative. This circumstance might raise questions concerning the impact of supplier partnerships on performance. Overall, these results indicate that certain management initiatives such as JIT, TQM, and use of bar codes can be used in combination with EDI in order to improve customer service and the utilization of labor, time, and other resources.

5.7 HYPOTHESIS 5

5.7.1 Data Analysis Plan

This hypothesis was tested by using the predictor variables, both independent and intervening, developed for Hypothesis 4. The response variables were the same ones developed for Hypothesis 3. These variables were used to construct a logistic regression function in which the dichotomous response variables were tested individually as described for Hypothesis 3.

5.7.2 Results

Table 5.12 summarizes the results of these tests. Only one model appeared to be possibly significant (EQ11), although the indicators of model significance were mixed. Therefore, the null hypotheses was not rejected for any of these models. Two independent variables (IV4S and IV7) and

TABLE 5.12

HYPOTHESIS 5: LOGISTIC REGRESSION RESULTS

Question	-2 LOG L	SCORE	Significant IV (p-value)
LQ17	.0660	.1808	IV72 (.0262) -NV5 (.0339)
LQ19	.5159	.5806	-NV4 (.0336)
LQ20	.1485	.2687	(intercept only)
EQ11	.0383	.0761	(intercept only)
EQ13	.6349	.6445	(intercept only)
EQ14	.1751	.2247	-IV4S (.0022)

two intervening variables (NV4 and NV5) were found to be individually significant. The parameter estimate for IV4S was shown to be negative, as occurred in the testing of Hypothesis 3. The parameter estimates for NV4 and NV5 were also negative, as shown in the testing of Hypothesis 4. These negative parameter estimates indicate that additional investigation of the variables IV4S (percentage of supplier base supported by EDI), NV4 (use of EDI to support business process reengineering), and NV5 (use of domestic supply partnerships) may be warranted.

5.8 USE OF INTERNATIONAL EDI

The original data set used for multiple linear regression consisted of 100 completed survey pairs. Incomplete replies reduced that data set to 91 pairs. In order to perform regression analyses of international EDI users, similar to that done for domestic EDI users, a subset of the original 100 survey pairs had to be selected to determine those respondents who traded internationally and used international EDI. Unfortunately, only 10 respondents met these criteria. This small number of observations prevented any multiple regression analyses using all the independent variables used for the domestic EDI users plus the addition of IV6, use of international EDI. Since the question regarding the use of international

EDI (EQ2) appeared only on the EDI questionnaire, that information is available only for those business units that responded to both questionnaires. Appendix L summarizes the responses of the international EDI users.

5.9 SUMMARY

This chapter described the preliminary analyses of the survey data, including the response rate and the development of the composite dependent variables. Descriptive data, specific statistical procedures used, models developed, and the testing results were given for each hypothesis, and the analysis of nonresponse bias and the use of international EDI were discussed.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

6.1 INTRODUCTION

This chapter provides a summary of the experimental outcomes, discusses the limitations and contributions of the present study, and suggests possible topics for future research.

6.2 CONCLUSIONS

6.2.1 Overall Logistics Performance

In this study there were two measures of overall logistics performance: LPU and LOGMEAN. LPU was one of the individual performance measures and LOGMEAN was the mean of of the individual measures LPA through LPT. In comparison to nonusers, EDI users indicated a better than average industry performance if measured by the composite variable LOGMEAN. Both LPU and LOGMEAN were dependent variables in significant multiple regression models. Both of these measures of overall logistics performance had strong associations with IV7, stage of logistics organization. However, LPU was also strongly related to IV4S, the percentage of supplier base supported by EDI, while LOGMEAN was strongly related to IV3, the percentage of business transactions supported by EDI, and to IV4C, the

percentage of customer base supported by EDI.

6.2.2 Inventory Management and Customer Service Measures

EDI users rated their average relative performance higher than nonusers for the following measures: fill rate (LPM), stockouts (LPN), on-time delivery (LPP), backorders (LPQ), and cycle time (LPR). Means for the composite performance measures INVEN and CUSTSER were higher for EDI users than for nonusers. This seems to indicate that the benefits of EDI are most visible not in the area of cost savings but in the areas of improved customer service, cycle time, and inventory management.

The individual measures LPP and LPR, both related to the inventory performance cycle, were elements of significant models relating those dependent variables to the stage of logistics organization. LPP was also associated with the percentages of customer and supplier bases supported by EDI. LPR was also associated with the percentages of business transactions and customer base supported by EDI. The composite measure of customer service, CUSTSER, was also part of a significant model that included percentage of customer base supported by EDI, and stage of logistics organization.

6.2.3 Labor Measures

The individual performance measures LPK (units shipped per employee) and LPL (units per labor dollar) were also dependent variables in significant models. These variables were most strongly associated with the same set of independent variables: percentage of business transactions supported by EDI, degree of EDI implementation, and stage of logistics organization. Not surprisingly, the composite measure LABOR, which includes the two labor-related measures just mentioned plus LPH (direct labor costs), was also the dependent variable in a significant model with the same independent variables listed above.

6.2.4 Costs

EDI users did not indicate above average industry performance on any cost-related measures. However, cost-related measures did appear in two significant models: LPL (units per labor dollar) and the composite measure COSTS (see Table 3.3 for a list of the individual dependent measures included in COSTS). The significant independent variables associated with LPL are listed in Section 6.2.3. COSTS was associated with a unique set of independent variables: percentage of business transactions supported by EDI, and stage of logistics organization.

6.2.5 EDI Implementation and Logistics Organization

In this study six constructs were used to measure the degree of EDI implementation in a business unit, and one construct was used to measure the stage of logistics organization. IV6, the use of international EDI, could not be included in the analysis because only ten respondents used international EDI.

The stage of EDI implementation (IV1), based on the EDI Implementation Model (Figure 3.1), was found to be a significant independent variable in all but two of the significant models (Table 5.6). The negative parameter estimates associated with the indicator variables representing IV1 could raise questions concerning the relationship between performance and the extent to which EDI is integrated throughout a business unit. However, since all of the adjusted R_2 values for the regression models involved are below .18, any conclusions concerning the negative signs of the parameter estimates are open to debate and further study.

The stage of logistics organization (IV7) was significant in all of the significant models. This indicates that this contruct was strongly associated with a number of logistics performance measures related to labor usage, customer service, inventory management, and overall logistics performance, and warrants additional

investigation. This also seems to indicate that the stage of logistics organization can be a key factor in a business unit's logistics performance.

Less frequently associated with the above listed performance measures, but still significant, were percentage of business transactions supported by EDI (IV3), percentage of customer base supported by EDI (IV4C), and percentage of supplier base supported by EDI (IV4S).

IV2, the length of involvement with EDI in years, did not appear in any significant models. The mean value for IV2 for the 91 observations used in the regression analyses was 4.93, with a standard deviation of 3.49. This may indicate that while a learning curve (i.e., time) is relevant for EDI users as they develop their systems, the PC-based, rapidly changing EDI technology levels the playing field between new users and experienced ones.

IV5, the functional range of EDI usage, appeared in only one significant model, and was associated with a negative parameter estimate. Since both variables (IV1 and IV5) representing the degree to which EDI is integrated throughout a business unit occurred with negative parameter estimates in the significant models, additional research is needed to explore the relationship between performance and the extent of EDI integration.

6.2.6 Intervening Variables

EDI users considered the following business practices (intervening variables) as more important to their overall logistics operations than did nonusers: use of bar code technology (NV3), use of EDI to support business process reengineering (NV4), and use of domestic supply partnerships (NV5). These three intervening variables are very logical activities for business units seeking to expand and enhance their implementation of EDI. Surprisingly, use of Just-In-Time (JIT) techniques (NV1), was not rated more important by EDI users. In actual practice, EDI is often used in conjunction with JIT, but businesses can employ JIT techniques without implementing EDI. This finding may indicate that JIT is equally important to EDI users and nonusers alike.

The addition of the intervening variables to the regression models demonstrated some anticipated relationships. JIT techniques (NV1) was a significant intervening variable for models with the dependent variables on-time delivery (LPP), overall logistics performance (LPU), LOGMEAN, COSTS, CUSTSER, and LABOR. The finding that JIT generally enhances EDI utilization confirms previous research and anecdotal information. NV2, Total Quality Management (TQM), was significant for LPK (units shipped per employee), LPP, LPR (cycle time),

LOGMEAN, CUSTSER, and LABOR. Again, the finding that TQM is generally compatible with EDI confirms previous anecdotal reports. NV3, UPC/bar codes, was significant for LPK, LPP, and LPR. This is a logical finding and confirms previous anecdotal information regarding the use of bar codes to improve shipping and receiving processing times. NV4, using EDI to support business process reengineering, was significant for LPL (units per labor dollar), LPP, LPR, LPU (overall logistics performance), LOGMEAN, and CUSTSER. NV5, partnerships with U.S. suppliers, was significant for LPK, LPL, CUSTSER, and LABOR. However, since NV4 and NV5 appeared with negative parameter estimates in all but two models (LPL and CUSTSER), the relationship between performance and these two intervening variables (use of EDI to support business process reengineering and use of partnerships with U.S. suppliers) is open to question, especially since EDI users had rated NV4 and NV5 as more important to their overall logistics operations than did nonusers. These results call for additional investigation.

6.2.7 Competitive Advantage

The series of logistic regressions developed to test the relationships between the independent and intervening variables and the dichotomous dependent variable indicating achievement of competitive advantage and sources of

competitive advantage did not produce significant results. However, several independent variables, stage of EDI implementation and stage of logistics organization, were found to be individually significant for the logistics regression developed to test Hypothesis 3. This may indicate that while these variables do contribute to the achievement of competitive advantage, they represent only a small proportion of the critical business factors necessary to achieve a sustained competitive advantage.

A chi square analysis of the responses used to build the logistic regressions showed that while both EDI and logistics managers believed their business units' management acknowledged the achievement of competitive advantage, EDI managers definitely did not attribute that competitive advantage to EDI.

The intervening variables NV4 (use of EDI to support business process reengineering) and NV5 (use of domestic supply partnerships) were found to be individually significant for the models developed using LQ19 and LQ17 respectively, although the associated parameter estimates were negative. This circumstance is additional justification for further investigation of these two intervening variables.

6.2.8 Use of International EDI

The lack of sufficient responses to test the use of international EDI (IV6) as a predictor in the multiple regression models was unfortunate but not unexpected. An extensive search of academic and practioner literature on international EDI failed to discover any list or database of international EDI users. Even the publishers of the EDI Yellow Pages (1992) do not maintain a list of international EDI users. Conversations with many academic and business EDI experts indicated that the number of international EDI users, while growing, is still very small. The result of this study, that only 10 percent of the respondents to both questionnaires use international EDI, was not surprising.

6.3 LIMITATIONS

In terms of limitations, the basic validation of the model was accomplished by surveying members of the Council of Logistics Management, whose logistics-related knowledge, interest, and job experience is probably superior to that of the average manufacturer or merchandiser. The majority of the respondents to both the logistics and EDI questionnaires represented manufacturers that traded internationally and were characterized as having a stage III, or most sophisticated, logistics organization. Since Byrne and Markham's (1991) initial application of their

logistics typology yielded a much lower percentage of stage III logistics organizations, it is likely that the respondents to this present study work for more progressive companies and are more highly motivated themselves. Certainly, the findings of this study were dependent upon the goodwill of the respondents and their willingness to complete the questionnaires honestly. Also, the responses of the EDI managers were limited by company policy; some companies refused to release any information at all concerning their use of EDI. Furthermore, it was necessary to accept a fairly low response rate, since that is usually the fate of mail surveys conducted without some form of organizational sponsorship.

Finally, this research project narrowly defined the universe of variables that could possibly contribute to logistics performance and competitive advantage. The predictor variables studied were limited to the stage of logistics organization and six measures of EDI implementation. Similarly, these predictors undoubtedly also have effects on a business unit's performance beyond the current focus on logistics functions.

6.4 CONTRIBUTIONS TO KNOWLEDGE

This research project has determined that:

1. EDI usage improves certain relative logistics

performance measures: fill rate, stockouts, on-time delivery, backorders, cycle time, and composite measures relating to overall logistics performance, inventory management, and customer service.

2. EDI users place more importance on the use of bar code technology, use of EDI to support business process reengineering, and use of domestic supply partnerships than do nonusers.

3. A business unit's degree of EDI implementation and its stage of logistics organization have the strongest impact on measures of labor usage, cycle time, costs, customer service, and overall logistics performance.

4. A business unit's stage of EDI implementation as measured by the percentage of business transactions supported by EDI, and percentages of customer base and supplier base supported by EDI are the most significant measures of the business unit's overall progress in implementing EDI.

5. Just-In-Time techniques, Total Quality Management, and bar codes are used in conjunction with EDI to enhance logistics performance in the areas noted above.

6. While both logistics managers and EDI managers may state that their management believes their business units have achieved a competitive advantage, EDI managers definitely do not attribute that competitive advantage to

EDI.

7. The use of international EDI is still very limited, even among users of domestic EDI and among those business units that trade internationally.

6.5 RECOMMENDATIONS FOR FUTURE RESEARCH

The present study examined a broad array of EDI and logistics management issues across a wide variety of industries. It would be beneficial to narrow the scope by examining one specific industry where EDI is widely used; perhaps automobile manufacturing, pharmaceuticals, or retail food chains. Since testing of Hypothesis 1 revealed that EDI users rated their relative performance on fill rate, stockouts, on-time delivery, backorders, and cycle-time as higher than nonusers, future studies should focus on these inventory management and customer service measures.

The present study relied on self-administered mail questionnaires and the perceptions of the logistics and EDI managers who responded. The next research step should seek out specific operational data from business units. For example, specific inventory management and delivery data could be obtained from a selected group of automobile parts suppliers over a given period of time. This data could be analyzed to determine if the actual performance of EDI

users can be related to actual measures of EDI implementation and logistics organization.

However, this kind of empirical data is very difficult, if not impossible, to obtain, without the sponsorship of an industry association specifically interested in EDI. The alternative would be a large scale simulation of an EDI manufacturing or distribution environment, if enough realistic data can be gathered to set the parameters of the simulation.

Additional research should be performed to refine the EDI Implementation Model (Figure 3.1) developed for this project. If a greater number of observations could be obtained, the full range of the model could be examined, instead of the reduced version (4 stages instead of 9 distinct stages) used here. Also, the implications of the negative parameter estimates associated with the indicator variables representing IV1 should be studied. Since IV5, another measure of the range of EDI implementation within a business unit, also was associated with a negative parameter estimate, it would be worthwhile to look at two aspects of this problem. First, how should the various dimensions of EDI implementation within a business unit be measured and described? Second, what is the relationship beween the range of EDI implementation described and performance? Is it negative, as the present study has

indicated?

Additional research using the logistics typology (Byrne and Markham 1991) would also be useful. One approach could involve classifying a group of business units according to the logistics typology and then re-classifying those same units several years later. How would time affect the development of a business unit's logistics organization? What other major factors influence this evolution?

Another interesting area of inquiry, perhaps by the end of this decade, will be the use of international EDI and how it facilitates the movement of goods internationally and the processing of international customs documentation. Does international EDI affect international logistics performance in the same way that domestic EDI affects domestic logistics performance? How does the development of a business unit's logistics organization relate to its use of international EDI and practice of international logistics? If supply chain management revolves around the exchange of information for inventory, as Ellram and Cooper (1990) stated, then EDI will become increasingly essential in the complex environment of international logistics. More timely and accurate information will assist global logistics managers to improve customer service and inventory management.

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APPENDIX A

LOGISTICS MANAGEMENT QUESTIONNAIRE

Texas A&M University

Graduate School of Business/Department of Business Analysis & Research

LOGISTICS MANAGEMENT QUESTIONNAIRE

General Information: The objective of this research project is to measure the impact of Electronic Data Interchange (EDI) and selected logistics management practices on a firm's competitive position in its industry. Results of this project should assist a firm to benchmark its performance given its stage of logistics organization and EDI implementation. This questionnaire will request information on your business unit's logistics organization and performance measures, and sources of competitive advantage.

"Business unit" refers to a component (of a company) with a distinct set of products, customers, and competitors.

General Instructions:

1. ***Please complete this questionnaire whether or not your business unit uses EDI.***
2. ***Your responses to this questionnaire will remain strictly confidential. Neither you nor your firm will be identified with the results of this study.***
3. ***Please circle the letter which best indicates your response to each question or fill in the blanks provided. Provide your best estimate if necessary.***
4. ***Please return this questionnaire in the business reply envelope by April 27, 1993. Your timely response will be greatly appreciated.***

2 Logistics Management Questionnaire

Background Information

1. **Please briefly describe your primary responsibilities within your business unit:**

_____
_____
_____
_____

2. **Your business unit is primarily involved in:**
   a. **Manufacturing**
   b. **Wholesaling**
   c. **Retailing**
   d. **Distribution Services**
   e. **Other (specify)** _____

3. **Your business unit's four-digit SIC code is** _ _ _ _.

4. **Your business unit's gross volume of sales in dollars for the latest fiscal year available:**
   $_____**(to the nearest thousand)**

5. **Your business unit regularly conducts (international) business transactions with customers or suppliers not located in the United States?**
   a. **Yes**
   b. **No**

Logistics Productivity Measurement and Improvement Programs

Please select the option that most closely describes your response.

6. **Your business unit's primary approach to logistics performance measurement is:**
   a. **Cost as a percentage of sales or historical cost basis.**
   b. **Actual cost vs. budget.**
   c. **Actual cost vs. standard, engineered costs or productivity vs. goal.**

7. **Your business unit's primary approach to logistics productivity improvement programs is:**
   a. **No specific programs or *ad hoc* reaction to current situation.**
   b. **Programs developed as a reaction to budget variance or need for cost reduction.**
   c. **Ongoing series of programs based on standards specifically designed to improve logistics productivity.**

8. **Your business unit's primary approach to long-range planning is:**
   a. **Fragmented or not accomplished.**
   b. **Divided among logistics functions that do their own planning.**
   c. **Integrated through all logistics functions.**

9. **Your business unit's approach to operations planning is:**
   a. **A day at a time or for each transaction.**
   b. **A month at a time or for each budget period.**
   c. **A year at a time or for rolling horizons.**

Thanks for your assistance -- please continue to the top of the next page.

10. Your business unit's approach to service goal setting is to:
   a. Handle each transaction independently.
   b. Treat customers alike, according to internally set goals.
   c. Provide differentiated service in order to meet or exceed customer requirements.

11. Your business unit's approach to workforce management is best described as:
   a. Traditional management-labor relationship.
   b. Limited employee involvement in decision-making.
   c. Empowerment, shared goals and rewards for employees.

12. Your business unit's approach to information management is best described as:
   a. Transaction processing with no data analysis capabilities.
   b. Financial period reporting with limited data analysis capabilities.
   c. Reporting of operational data to support planning; flexible analysis capabilities and data sharing.

13. Your business unit's approach to relationships with supplier and third-party service providers is best described as:
   a. Traditional "business as usual", *ad hoc* problem-solving when needed.
   b. A managed process based upon costs, multiple sources, and competitive bidding.
   c. A managed process based upon partnerships, mutual results, and joint improvement.

14. Please rate the importance of the following items as they apply to your business unit's overall logistics operations. In your opinion, the following items are:

1 = very unimportant
2 = somewhat unimportant
3 = of undecided value
4 = somewhat important
5 = very important

TO YOUR BUSINESS UNIT'S LOGISTICS OPERATIONS?

Circle one alternative in each category.
NA = not applicable or information not available.

Items	Very Unimportant				Very Important	
a. Just-In-Time (JIT) techniques	1	2	3	4	5	NA
b. Total Quality Management (TQM)	1	2	3	4	5	NA
c. Universal Product Codes/Bar Codes	1	2	3	4	5	NA
d. Using EDI to support business process reengineering	1	2	3	4	5	NA
e. Partnerships with U.S. (domestic) suppliers	1	2	3	4	5	NA
f. Partnerships with offshore (foreign) suppliers	1	2	3	4	5	NA

Thanks for your assistance -- please continue to the top of the next page.

15. For each performance measurement estimate, compare the performance of your business unit with your industry's average performance. Your business unit's performance is:

1 = significantly worse than
2 = somewhat worse than
3 = roughly comparable to
4 = somewhat better than
5 = significantly better than

THE AVERAGE INDUSTRY PERFORMANCE?

Circle one alternative in each category:
NA = not applicable or information not available.

Category	Significantly Worse				Significantly Better	
a. Inventory carrying costs	1	2	3	4	5	NA
b. Obsolete inventory	1	2	3	4	5	NA
c. Logistics cost per unit	1	2	3	4	5	NA
d. Logistics cost as % of sales	1	2	3	4	5	NA
e. Inbound freight costs	1	2	3	4	5	NA
f. Outbound freight costs	1	2	3	4	5	NA
g. Warehouse costs	1	2	3	4	5	NA
h. Direct labor costs	1	2	3	4	5	NA
i. Administrative costs	1	2	3	4	5	NA
j. Order processing costs	1	2	3	4	5	NA
k. Units shipped per employee	1	2	3	4	5	NA
l. Units per labor dollar	1	2	3	4	5	NA
m. Fill rate	1	2	3	4	5	NA
n. Stockouts	1	2	3	4	5	NA
o. Shipping errors	1	2	3	4	5	NA
p. On-time delivery	1	2	3	4	5	NA
q. Backorders	1	2	3	4	5	NA
r. Cycle time	1	2	3	4	5	NA
s. Number of customer returns	1	2	3	4	5	NA
t. Dollar amount of damage	1	2	3	4	5	NA
u. Overall logistics performance	1	2	3	4	5	NA
v. Sales Volume	1	2	3	4	5	NA
w. Market Share	1	2	3	4	5	NA
x. Return on investment	1	2	3	4	5	NA
y. Profitability	1	2	3	4	5	NA

Thanks for your assistance -- please continue to the top of the next page.

Competitive Advantage

Competitive advantage refers to a firm's ability to sustain above average performance in relation to its competitors over the long run.

16. Your business unit's strategy specifically requires it to compete on the basis of:
    a. Cost.
    b. Product or service differentiation.
    c. Focus (concentration on a narrow segment within an industry).
    d. Other (specify) _____.
    e. No stated strategy for competition is followed.

17. Does your business unit's management generally perceive that it has achieved a competitive advantage?
    a. Yes
    b. No
    c. Not sure.

18. Please rate your performance on the following possible sources of competitive advantage in relation to your competitors. Your business unit's performance is:

    1 = significantly worse than
    2 = somewhat worse than
    3 = roughly comparable to THE AVERAGE INDUSTRY PERFORMANCE?
    4 = somewhat better than
    5 = significantly better than

Circle one alternative in each category.
NA = not applicable or information not available.

Sources	Significantly Worse				Significantly Better	
a. Product innovation/design	1	2	3	4	5	NA
b. Technological leadership	1	2	3	4	5	NA
c. Superior product quality	1	2	3	4	5	NA
d. Superior customer service	1	2	3	4	5	NA
e. Brand identification	1	2	3	4	5	NA
f. Cost	1	2	3	4	5	NA
g. Logistics competence	1	2	3	4	5	NA
h. Use of information technology	1	2	3	4	5	NA
i. Market share	1	2	3	4	5	NA
j. Profitability	1	2	3	4	5	NA
k. Patent or other government protection	1	2	3	4	5	NA

Thanks for your assistance -- please continue to the top of the next page.

19. Your business unit generally regards EDI relationships with customers and suppliers as:
    a. A source of competitive advantage.
    b. A source of competitive necessity.
    c. Neither a nor b.

20. Your business unit generally regards logistics competence as:
    a. A source of competitive advantage.
    b. A source of competitive necessity.
    c. Neither a nor b.

****

Please fill in the blanks below or attach a copy of your business card. Remember, your reponses will remain strictly confidential: this information will be used to analyze response patterns. However, if you do not wish to identify yourself or your business, then accept our thanks for your assistance and simply return the completed survey.

Name:_____
Job Title:_____
Name of Business Unit:_____
Name of (Parent) Company:_____
Address:_____
City:_____
State and Zip Code:_____
Telephone: (Area Code/Local Number)_____

Send me an Executive Summary of survey results: Yes No

Thank you very much for participating in our research project.

Please return questionnaire in business reply envelope
provided by April 27, 1993 to:

Karen Currie
Department of Business Analysis and Research
Texas A&M University
College Station, TX 77843-4217
(409) 845-7670 or (409) 696-0380 / FAX: (409) 845-5653

The following sources were instrumental in preparing this questionnaire:

Bowersox, D. J. et als, Leading Edge Logistics: Competitive Positioning for the 1990's, Council of Logistics Management, Oak Brook, IL, 1989.

Byrne, P. M. and W. J. Markham, Improving Quality and Productivity in the Logistics Process: Achieving Customer Satisfaction Breakthroughs, Council of Logistics Management, Oak Brook, IL, 1991.

APPENDIX B

EDI QUESTIONNAIRE

Texas A&M University

Graduate School of Business/Department of Business Analysis & Research

EDI QUESTIONNAIRE

General Information: The objective of this research project is to measure the impact of Electronic Data Interchange (EDI) and selected logistics management practices on a firm's competitive position in its industry. Results of this project should assist a firm to benchmark its performance given its stage of logistics organization and EDI implementation. This questionnaire requests information on your business unit's EDI applications and sources of competitive advantage.

"Electronic Data Interchange (EDI)" refers to the computer-to-computer exchange of inter-company business documents and information in machine-processable standard form.

"Business unit" refers to a component (of a company) with a distinct set of products, customers, and competitors.

General Instructions:

1. ***Please complete this questionnaire only if your business unit uses EDI.***
2. *Your responses to this questionnaire will remain strictly confidential. Neither you nor your firm will be identified with the results of this study.*
3. *Please circle the letter which best indicates your response to each question or fill in the blanks provided. Provide your best estimate if necessary.*
4. *Please return this questionnaire in the business reply envelope by **April 30, 1993.** Your timely response will be greatly appreciated.*

2 EDI Questionnaire

Electronic Data Interchange (EDI) Usage

1. Does your business unit use EDI to support business with domestic customers and/or suppliers?
   a. Yes.
   b. Not now, but we did previously.
   c. We have plans to implement in 19___ (specify year).

If you selected "c", please go to question #9.

2. Does your business unit use international EDI to support business with (foreign) customers and/or suppliers not located in the United States?
   a. Yes.
   b. Not now, but we did previously.
   c. We have plans to implement in 19___ (specify year).
   d. No; no current plans to implement.

3. Please give details if you selected "b" for questions #1 or #2.

_____

_____

_____

For each of the following questions, please indicate the extent of your domestic EDI relationships with suppliers and customers as well as your international EDI relationships with foreign suppliers or customers not located in the United States. If you do not use international EDI, skip that portion of each question.

4. The exact year your business unit began to use EDI?
   Domestic: _____.
   International: _____.

5. The estimated percentage of your total business transactions supported by EDI?
   Domestic: _____.
   International: _____.

6. The estimated percentage of your customer base supported by EDI?
   Domestic: _____.
   International: _____.

Thanks for your assistance -- please continue to the top of the next page.

7. The estimated percentage of your supplier base supported by EDI?
   Domestic: _____.
   International: _____.

8. Check the functions for which your business unit uses EDI on a regular basis. Check as many as appropriate.

Domestic	International	Functions
_____	_____	a. Purchasing.
_____	_____	b. Distribution.
_____	_____	c. Order Entry.
_____	_____	d. Sales/Marketing.
_____	_____	e. Finance.
_____	_____	f. Manufacturing.
_____	_____	g. Other (please specify) _____.

EDI Implementation Stages

9. Circle the alternative which best describes your business unit's current overall status in applying EDI with the majority of your supplier/customer base:

   a. No plans to implement.

   b. *Initiation* -- Firm is studying EDI possibilities.

   c. *Adoption* -- Firm has made decision to invest in EDI.

   d. *Adaptation* -- Prototype and pilot systems are tested; users are trained, operating procedures are revised; EDI application is ready for use.

   e. *Acceptance* -- EDI is used regularly and certain paper documents are eliminated.

   f. *Routinization* -- EDI use is viewed as a normal business activity.

   g. *Expansion* -- Additional paper documents are eliminated; more trading partners are added.

   h. *Infusion* -- EDI is linked to manufacturing planning and control systems; increased organizational effectiveness is obtained; EDI is transparent to the end user.

   i. *Enhancement* -- EDI system is linked to receiving and accounting systems to achieve full internal integration with management information systems (MIS); invoices are transmitted electronically.

Thanks for your assistance -- please continue to the top of the next page.

4

EDI Questionnaire

Competitive Advantage

Competitive advantage refers to a firm's ability to sustain above average performance in relation to its competitors over the long run.

10. Your business unit's strategy specifically requires it to compete on the basis of:
    a. Cost.
    b. Product or service differentiation.
    c. Focus (concentration on a narrow segment within an industry).
    d. Other (specify) _____.
    e. No stated strategy for competition is followed.

11. Does your business unit's management generally perceive that it has achieved a competitive advantage?
    a. Yes
    b. No
    c. Not sure.

12. Please rate your performance on the following possible sources of competitive advantage in relation to your competitors. Your business unit's performance is:

    1 = significantly worse than
    2 = somewhat worse than
    3 = roughly comparable to THE AVERAGE INDUSTRY PERFORMANCE?
    4 = somewhat better than
    5 = significantly better than

    Circle one alternative in each category; NA = not applicable or information not available.

Sources	Significantly Worse				Significantly Better	
a. Product innovation/design	1	2	3	4	5	NA
b. Technological leadership	1	2	3	4	5	NA
c. Superior product quality	1	2	3	4	5	NA
d. Superior customer service	1	2	3	4	5	NA
e. Brand identification	1	2	3	4	5	NA
f. Cost	1	2	3	4	5	NA
g. Logistics competence	1	2	3	4	5	NA
h. Use of information technology	1	2	3	4	5	NA
i. Market share	1	2	3	4	5	NA
j. Profitability	1	2	3	4	5	NA
k. Patent or other government protection	1	2	3	4	5	NA

13. Your business unit generally regards EDI relationships with customers and suppliers as:
    a. A source of competitive advantage.
    b. A source of competitive necessity.
    c. Neither a nor b.

Thanks for your assistance -- please continue to the top of the next page.

14. Your business unit generally regards logistics competence as:
   a. A source of competitive advantage.
   b. A source of competitive necessity.
   c. Neither a nor b.

Background Information

15. Please briefly describe your primary responsibilities within your business unit:

____
____
____
____

16. Your business unit's four-digit Standard Industrial Classification (SIC) code is _ _ _ _ .

****

Please fill in the blanks below or attach a copy of your business card. Remember, your reponses will remain strictly confidential; this information will be used to analyze response patterns. However, if you do not wish to identify yourself or your business, then accept our thanks for your assistance and simply return the completed survey.

Name:____________________________
Job Title:__________________________
Name of Business Unit:__________________
Name of (Parent) Company:________________
Address:___________________________
City:_____________________________
State and Zip Code:____________________
Telephone: (Area Code/Local Number)____________

Send me an Executive Summary of survey results: Yes No

Thank you very much for participating in our research project.

Please return questionnaire in business reply envelope provided by April 30, 1993 to:

Karen Currie
Department of Business Analysis and Research
Texas A&M University
College Station, TX 77843-4217
(409) 845-7670 or (409) 696-0380 / FAX: (409) 845-5653

APPENDIX C

COVER LETTER TO LOGISTICS MANAGERS

TEXAS A&M UNIVERSITY
COLLEGE OF BUSINESS ADMINISTRATION AND GRADUATE SCHOOL OF BUSINESS
COLLEGE STATION, TEXAS 77843-4217

Department of BUSINESS ANALYSIS & RESEARCH
•Management Information Systems
•Management Science
•Production & Operations Management

Telephone: (409) 845-1616
FAX: (409) 845-5653

April 6, 1993

(Name of Logistics Manager)
(Job Title)
(Business Unit)
(Mailing Address)

Dear Mr or Ms (Name),

Please share with us your knowledge of logistics and a few minutes of your time. We are studying the relationship between a firm's logistics organization and performance and its use of electronic data interchange (EDI). You were selected to participate in this study because of your membership in the Council of Logistics Management and your logistics-related job experience. As fellow members of the Council of Logistics Management, we respectfully request your assistance in accomplishing this research.

We ask your assistance in two ways. Please complete the enclosed "Logistics Management Questionnaire" yourself and return it to us in the enclosed business reply envelope. Then, if your business unit uses EDI, we ask you to forward the "EDI Questionnaire" and cover letter enclosed in the second business reply envelope to the individual who manages the EDI operations for your business unit.

Any information you provide will be kept strictly confidential; no individual responses will ever be identified in published reports.

Your participation, whether or not your business unit uses EDI, is very important. The information obtained from this study will help us to determine how firms like yours can become more competitive in today's demanding business environment. Results of this project should assist a firm to benchmark its performance given its stage of logistics organization and EDI implementation. At your request, we will send you an Executive Summary of the research when it is completed.

This research project is being conducted under the auspices of the Department of Business Analysis and Research in the Graduate School of Business at Texas A&M University. Please take a few minutes to complete our questionnaire and return it within two weeks, whether or not your business unit uses EDI. Your participation will be very much appreciated. If you have any hesitation about completing the survey or any questions, please call us and discuss your concerns. Your participation is extremely critical to the success of this study.

We wish to thank you for your valuable time and assistance.

Very sincerely yours,

KAREN W. CURRIE
Ph.D. Student

FRANK P. BUFFA
Professor and Department Head

APPENDIX D

COVER LETTER TO EDI MANAGERS

TEXAS A&M UNIVERSITY
COLLEGE OF BUSINESS ADMINISTRATION AND GRADUATE SCHOOL OF BUSINESS
COLLEGE STATION, TEXAS 77843-4217

Department of BUSINESS ANALYSIS & RESEARCH
•Management Information Systems
•Management Science
•Production & Operations Management

Telephone: (409) 845-1616
FAX: (409) 845-5653

April 6, 1993

EDI Manager
(Name of Business Unit)
(Mailing Address)

Dear Sir or Madam,

Please share with us your knowledge of Electronic Data Interchange (EDI) and a few minutes of your time. We are studying the relationship between a firm's logistics organization and performance and its use of EDI. At our request, this questionnaire was forwarded to you by another individual in your business unit who has completed a companion questionnaire on logistics management and performance.

We respectfully request your assistance in completing the enclosed questionnaire and returning it in the envelope provided. Any information you provide will be kept strictly confidential; no individual responses will ever be identified in published reports.

Your participation is very important. The information obtained from this study will help us to determine how firms like yours can become more competitive in today's demanding business environment. Results of this project should assist a firm to benchmark its performance given its stage of logistics organization and EDI implementation. Your response is especially critical because it will be used to complete the information obtained through the companion survey on logistics management. Both sets of responses are necessary to complete our research objectives. At your request, we will send you an Executive Summary of the research when it is completed.

This research project is being conducted under the auspices of the Department of Business Analysis and Research in the Graduate School of Business at Texas A&M University. Please take a few minutes to complete our questionnaire and return it within two weeks. Your participation will be very much appreciated. If you have any hesitation about completing the survey or any questions, please call us and discuss your concerns. Your participation is extremely critical to the success of this study.

We wish to thank you for your valuable time and assistance.

Very sincerely yours,

KAREN W. CURRIE
Ph.D. Student

FRANK P. BUFFA
Professor and Department Head

APPENDIX E

WAVE ANALYSIS: SURVEY PAIRS

Variable	Wave	N	Mean	Std Dev	Variances Unequal	(p) Equal	Prob> F'
Logistics Performance Measures							
LPA	1	80	3.3875	0.8190			
	2	7	3.5714	0.5345	.4292	.5623	.2808
LPB	1	80	3.3375	0.9671			
	2	7	3.7143	1.1127	.4152	.3312	.5130
LPC	1	77	3.6364	0.7238			
	2	6	4.0000	0.6325	.2278	.2360	.8421
LPD	1	79	3.7215	0.8614			
	2	6	3.6667	1.0328	.9036	.8824	.4404
LPE	1	77	3.6494	0.8234			
	2	8	3.1250	0.6409	.0595	.0850	.5012
LPF	1	82	3.8171	0.9044			
	2	8	3.8750	0.8345	.8568	.8623	.9031
LPG	1	82	3.4756	0.8495			
	2	8	3.2500	1.0351	.5670	.4835	.3688
LPH	1	78	3.4615	0.7506			
	2	7	3.0000	1.1547	.3367	.1409	.0753
LPI	1	81	3.3951	0.8467			
	2	7	3.0000	1.0000	.3455	.2459	.4540
LPJ	1	79	3.5316	0.8139			
	2	7	3.2857	0.9512	.5293	.4515	.4779
LPK	1	73	3.6027	0.7948			
	2	6	3.5000	0.5477	.6844	.7576	.4215

Variable	Wave	N	Mean	Std Dev	Variances Unequal	(p) Equal	Prob> F'
LPL	1	73	3.5890	0.7608			
	2	6	3.3333	0.8165	.4880	.4334	.6826
LPM	1	78	3.8718	0.7789			
	2	7	3.7143	0.7559	.6143	.6089	1.0000
LPN	1	76	3.6579	0.8092			
	2	7	3.4286	0.7868	.4849	.4742	1.0000
LPO	1	79	3.7595	0.8802			
	2	8	3.5000	0.9258	.4689	.4311	.7353
LPP	1	80	4.0625	0.7850			
	2	8	4.0000	0.7559	.8294	.8300	1.0000
LPQ	1	71	3.5493	0.7890			
	2	7	3.4286	0.9759	.7606	.7062	.3624
LPR	1	80	3.5625	0.8545			
	2	7	3.4286	0.9759	.7358	.6950	.5302
LPS	1	77	3.3247	0.8020			
	2	8	3.0000	0.9258	.3670	.2856	.4935
LPT	1	76	3.7105	0.7969			
	2	8	3.7500	0.7071	.8854	.8933	.7998
LPU	1	81	3.8519	0.5940			
	2	7	3.7143	0.4880	.5034	.5536	.6596
Composite Logistics Measures							
LOG-MEAN	1	83	3.6107	0.4542			
	2	8	3.4444	0.3031	.1888	.3145	.2587
COSTS	1	83	3.5665	0.5024			
	2	8	3.3810	0.5549	.3887	.3252	.6027

Variable	Wave	N	Mean	Std Dev	Variances Unequal	(p) Equal	Prob> F'
IN-VEN	1	83	3.5384	0.5765			
	2	8	3.4583	0.3421	.5693	.7012	.1462
CUST-SER	1	82	3.6947	0.5602			
	2	8	3.5000	0.2988	.1368	.3366	.0834
LA-BOR	1	80	3.5604	0.6443			
	2	7	3.1429	0.8997	.2715	.1151	.1658
ERR-ORS	1	81	3.5988	0.6470			
	2	8	3.4167	0.4272	.3008	.4391	.2466
Overall Performance Measures							
LPV	1	80	3.7250	0.7791			
	2	5	4.2000	1.0954	.3912	.1998	.2121
LPW	1	80	3.8250	0.8969			
	2	7	4.1429	0.6901	.2887	.3642	.5284
LPX	1	76	3.5132	0.8405			
	2	8	4.0000	0.9258	.1904	.1264	.6124
LPY	1	77	3.4675	0.9677			
	2	8	3.8750	0.9910	.2980	.2612	.8097
OV-MEAN	1	81	3.6409	0.7192			
	2	8	4.0521	0.7967	.1972	.1300	.5957
Intervening Variables							
NV1	1	83	3.6386	1.0544			
	2	8	3.3750	1.1877	.5617	.5057	.5519
NV2	1	83	3.9398	1.2817			
	2	8	3.3750	1.5980	.3609	.2471	.3216

Variable	Wave	N	Mean	Std Dev	Variances Unequal	(p) Equal	Prob> F'
NV3	1	83	3.8916	1.3068			
	2	8	2.8750	1.4577	.0934	.0403	.5769
NV4	1	83	3.9518	1.1142			
	2	8	3.0000	1.7728	.1769	.0319	.0415
NV5	1	83	4.0241	1.0238			
	2	8	3.1250	1.4577	.1284	.0249	.1225
NV6	1	83	3.1446	1.3980			
	2	8	3.0000	1.0690	.7308	.7770	.4670
Independent Variables							
IV1	1	83	4.7831	2.0780			
	2	8	4.8750	1.4577	.8738	.9033	.3245
IV2	1	83	4.8193	3.3135			
	2	8	6.1250	5.1391	.5022	.3152	.0546
IV3	1	83	0.2630	0.2555			
	2	8	0.3013	0.3022	.7381	.6916	.4347
IV4C	1	83	0.2235	0.2961			
	2	8	0.2525	0.3645	.8328	.7959	.3467
IV4S	1	83	0.1418	0.2410			
	2	8	0.1775	0.2029	.6517	.6867	.6706
IV5	1	83	2.8193	1.3981			
	2	8	3.0000	1.4142	.7382	.7280	.8428
IV7	1	83	2.5783	.4968			
	2	8	2.8750	.3536	.0550	.1034	.3455

APPENDIX F

WAVE ANALYSIS: LOGISTICS SURVEYS

Vari-able	Wave	N	Mean	Std Dev	Variances Unequal	(p) Equal	Prob> F'
Logistics Performance Measures							
LPA	1	150	3.4200	0.8919			
	2	13	2.8462	0.5547	.0034	.0240	.0668
LPB	1	147	3.3061	0.9408			
	2	14	3.3571	1.1507	.8744	.8495	.2504
LPC	1	145	3.6207	0.7912			
	2	14	3.6429	0.8419	.9259	.9208	.6736
LPD	1	147	3.7211	0.9125			
	2	14	3.5714	1.0894	.6260	.5651	.3083
LPE	1	147	3.5510	0.8291			
	2	14	3.7857	0.9750	.3975	.3205	.3483
LPF	1	154	3.7403	0.8541			
	2	14	4.0000	1.0377	.3781	.2863	.2642
LPG	1	151	3.5430	0.8385			
	2	14	3.7857	0.6993	.2396	.2959	.4688
LPH	1	150	3.4667	0.8487			
	2	13	3.3077	0.6304	.4104	.5109	.2455
LPI	1	152	3.3947	0.8701			
	2	14	3.0714	0.9972	.2594	.1906	.4212
LPJ	1	146	3.4384	0.8049			
	2	14	3.5714	0.7559	.5405	.5535	.8532
LPK	1	143	3.6434	0.7997			
	2	11	3.1818	0.6030	.0333	.0632	.3253

Variable	Wave	N	Mean	Std Dev	Variances Unequal	(p) Equal	Prob> F'
LPL	1	141	3.6170	0.8251			
	2	12	3.4167	0.7930	.4173	.4194	.9604
LPM	1	146	3.7260	0.8984			
	2	14	3.7857	0.8018	.7957	.8111	.6739
LPN	1	146	3.6507	0.8835			
	2	14	3.6429	0.9288	.9763	.9749	.7185
LPO	1	150	3.7667	0.8855			
	2	14	3.7143	0.9139	.8398	.8331	.7875
LPP	1	154	3.9351	0.8219			
	2	14	4.0000	0.9608	.8099	.7805	.3632
LPQ	1	134	3.4851	0.8472			
	2	14	3.5714	1.0894	.7776	.7248	.1569
LPR	1	148	3.4662	0.9141			
	2	14	3.4286	0.7559	.8634	.8816	.4467
LPS	1	148	3.3649	0.8177			
	2	12	2.9167	0.6686	.0459	.0665	.4670
LPT	1	143	3.6713	0.8288			
	2	14	3.6429	1.0818	.9250	.9053	.1322
LPU	1	151	3.8212	0.6541			
	2	14	3.5714	0.7559	.2506	.1792	.3966
Composite Logistics Measures							
LOG-MEAN	1	157	3.5767	0.4698			
	2	14	3.5529	0.6027	.8874	.8593	.1562
COSTS	1	157	3.5392	0.5331			
	2	14	3.5397	0.5909	.9976	.9973	.5271
IN-VEN	1	155	3.5175	0.5867			
	2	14	3.5167	0.5938	.9959	.9958	.8616

Variable	Wave	N	Mean	Std Dev	Variances Unequal	(p) Equal	Prob> F'
CUST-SER	1	156	3.6402	0.6169			
	2	14	3.6161	0.7050	.9032	.8901	.4289
LA-BOR	1	153	3.5697	0.7140			
	2	13	3.3590	0.5521	.2166	.3012	.3173
ERR-ORS	1	152	3.6020	0.6465			
	2	14	3.5000	0.7596	.6338	.5787	.3497
Overall Performance Measures							
LPV	1	149	3.8792	0.7703			
	2	12	3.6667	0.9847	.4794	.3695	.1894
LPW	1	151	3.9669	0.8280			
	2	14	3.7857	0.9750	.5112	.4416	.3438
LPX	1	149	3.6107	0.8907			
	2	13	3.3077	0.8549	.2415	.2398	.9447
LPY	1	151	3.6093	0.9864			
	2	13	3.5385	1.0500	.8181	.8051	.6752
OV-MEAN	1	154	3.7570	0.7344			
	2	14	3.6607	0.8804	.6971	.6447	.2967
Intervening Variables							
NV1	1	157	3.6561	1.0784			
	2	14	3.2143	1.0509	.1527	.1430	.9926
NV2	1	157	3.9809	1.1847			
	2	14	3.5714	1.4525	.3222	.2257	.2431
NV3	1	157	3.6943	1.3571			
	2	14	3.5714	1.2225	.7259	.7442	.7051

Variable	Wave	N	Mean	Std Dev	Variances Unequal	(p) Equal	Prob> F'
NV4	1	157	3.5605	1.2626			
	2	14	4.0000	0.9608	.1292	.2063	.2637
NV5	1	157	3.9172	1.0498			
	2	14	4.0000	1.0377	.7788	.7775	1.0000
NV6	1	157	3.1274	1.5095			
	2	14	3.1429	1.2315	.9653	.9704	.4116
Independent Variables							
IV7	1	157	2.5350	.5254			
	2	14	2.5000	.5189	.8121	.8112	1.0000

APPENDIX G

HYPOTHESIS 1: T-TESTS

Variable	EDI Use	N	Mean	Std Dev	Variances Unequal	(p) Equal	Prob> F'
Logistics Performance Measures							
LPA	N	19	3.1053	0.8753			
	Y	144	3.4097	0.8803	.1678	.1582	1.0000
LPB	N	19	3.2632	1.1471			
	Y	142	3.3169	0.9330	.8467	.8190	.1882
LPC	N	20	3.4500	0.9445			
	Y	139	3.6475	0.7696	.3810	.2992	.1843
LPD	N	20	3.6000	1.0463			
	Y	141	3.7234	0.9111	.6209	.5787	.3614
LPE	N	19	3.3684	0.9551			
	Y	142	3.5986	0.8257	.3726	.2644	.3464
LPF	N	20	3.8000	0.9515			
	Y	148	3.7568	0.8621	.8487	.8355	.5009
LPG	N	19	3.8421	0.6882			
	Y	146	3.5274	0.8403	.0799	.1197	.3294
LPH	N	20	3.4000	1.0463			
	Y	143	3.4615	0.8029	.8027	.7580	.0856
LPI	N	20	3.4000	0.9403			
	Y	146	3.3630	0.8779	.8694	.8611	.6230
LPJ	N	19	3.4211	0.7685			
	Y	141	3.4539	0.8060	.8635	.8671	.8628
LPK	N	19	3.5789	0.7685			
	Y	135	3.6148	0.8010	.8513	.8546	.8897
LPL	N	19	3.5263	0.9643			
	Y	134	3.6119	0.8033	.7155	.6723	.2453

Variable	EDI Use	N	Mean	Std Dev	Variances Unequal	(p) Equal	Prob> F'
LPM*	N	19	3.1053	0.9941			
	Y	141	3.8156	0.8418	.0071	.0009	.2861
LPN*	N	19	3.1053	0.9366			
	Y	141	3.7234	0.8545	.0122	.0039	.5356
LPO	N	20	3.4500	1.0990			
	Y	144	3.8056	0.8469	.1781	.0924	.0905
LPP*	N	21	3.2381	0.8891			
	Y	147	4.0408	0.7753	.0006	.0000	.3563
LPQ*	N	19	3.0526	0.9113			
	Y	129	3.5581	0.8469	.0325	.0174	.6126
LPR*	N	18	2.8333	0.9235			
	Y	144	3.5417	0.8680	.0056	.0014	.6592
LPS	N	19	3.2632	0.8057			
	Y	141	3.3404	0.8179	.6988	.6991	1.0000
LPT	N	19	3.6842	0.8852			
	Y	138	3.6667	0.8486	.9358	.9331	.7411
LPU	N	19	3.6842	1.0029			
	Y	146	3.8151	0.6103	.5848	.4210	.0011
Composite Logistics Measures							
LOG-MEAN*	N	21	3.3680	0.5683			
	Y	150	3.6037	0.4611	.0815	.0346	.1651
COSTS	N	21	3.4610	0.6118			
	Y	150	3.5502	0.5261	.5307	.4768	.3112
IN-VEN*	N	20	3.2392	0.5818			
	Y	149	3.5548	0.5778	.0317	.0231	.8973

Variable	EDI Use	N	Mean	Std Dev	Variances Unequal	(p) Equal	Prob> F'
CUST-SER*	N	21	3.1952	0.7245			
	Y	149	3.7006	0.5827	.0054	.0004	.1485
LA-BOR	N	20	3.4833	0.8270			
	Y	146	3.5628	0.6876	.6852	.6372	.2285
ERR-ORS	N	20	3.4500	0.7744			
	Y	146	3.6130	0.6373	.3773	.2978	.2041
Overall Performance Measures							
LPV	N	21	3.9048	0.7684			
	Y	140	3.8571	0.7918	.7940	.7968	.9281
LPW	N	21	4.0952	0.7684			
	Y	144	3.9306	0.8500	.3734	.4027	.6210
LPX	N	21	3.6667	1.0646			
	Y	141	3.5745	0.8638	.7082	.6589	.1675
LPY	N	21	3.6667	1.1106			
	Y	143	3.5944	0.9731	.7798	.7555	.3738
OV-MEAN	N	21	3.8333	0.8036			
	Y	147	3.7370	0.7385	.6082	.5808	.5519
Intervening Variables							
NV1	N	21	3.6667	0.9661			
	Y	150	3.6133	1.0978	.8176	.8329	.5187
NV2	N	21	3.7619	1.2209			
	Y	149	4.0000	1.1683	.4081	.3858	.7272
NV3*	N	21	2.9524	1.5645			
	Y	150	3.7867	1.2828	.0282	.0073	.1869

Variable	EDI Use	N	Mean	Std Dev	Variances Unequal	(p) Equal	Prob> F'
NV4*	N	20	2.2500	0.9665			
	Y	149	3.8255	1.0888	.0001	.0000	.5631
NV5*	N	21	3.2381	1.0911			
	Y	150	4.0200	1.0065	.0047	.0012	.5667
NV6	N	19	3.1053	1.3701			
	Y	143	3.3287	1.3204	.5093	.4912	.7629

*Indicates rejection of H_{o1} at the .025 level of significance.

APPENDIX H

INDEPENDENT VARIABLES: DESCRIPTIVE STATISTICS

N = 91

Categorical Variables

Variable/ Question	Response Levels	Frequency	Percent
IV1/EQ9	0	3	3.3
	1	4	4.4
	2	4	4.4
	3	10	11.0
	4	21	23.1
	5	9	9.9
	6	26	28.6
	7	3	3.3
	8	11	12.1
IV7/LQ6 - LQ13	2	36	39.6
	3	55	60.4

Continuous Variables

	Mean	Std Dev
IV2/EQ4	4.9341	3.4922
IV3/EQ5	0.2664	0.2583
IV4C/EQ6	0.2260	0.3004
IV4S/EQ7	0.1449	0.2371
IV5/EQ8	2.8352	1.3926

APPENDIX I

DEPENDENT VARIABLES: DESCRIPTIVE STATISTICS

Variable	N	Mean	Std Dev
LPA	87	3.4023	0.7991
LPB	87	3.3678	0.9778
LPC	83	3.6627	0.7204
LPD	85	3.7176	0.8676
LPE	85	3.6000	0.8194
LPF	90	3.8222	0.8941
LPG	90	3.4556	0.8632
LPH	85	3.4235	0.7925
LPI	88	3.3636	0.8601
LPJ	86	3.5116	0.8224
LPK	79	3.5949	0.7766
LPL	79	3.5696	0.7626
LPM	85	3.8588	0.7739
LPN	83	3.6385	0.8051
LPO	87	3.7356	0.8821
LPP	88	4.0568	0.7784
LPQ	78	3.5385	0.8008
LPR	87	3.5517	0.8594
LPS	85	3.2941	0.8139

Variable	N	Mean	Std Dev
LPT	84	3.7143	0.7850
LPU	88	3.8409	0.5850
Composite Logistics Measures			
LOGMEAN	91	3.5961	0.4442
COSTS	91	3.5502	0.5066
INVEN	91	3.5313	0.5589
CUSTSER	90	3.6774	0.5438
LABOR	87	3.5268	0.6714
ERRORS	89	3.5824	0.6307
Overall Performance Measures			
LPV	85	3.7529	0.8004
LPW	87	3.8506	0.8830
LPX	84	3.5595	0.8552
LPY	85	3.5059	0.9713
OVMEAN	89	3.6779	0.7313

APPENDIX J

HYPOTHESIS 2: MULTIPLE REGRESSION RESULTS

Dependent Variable #	p	R^2	Adjusted R^2
LPA	.2626	.1299	.0282
LPB	.7807	.0671	-.0420
LPC	.3273	.1260	.0183
LPD	.3468	.1202	.0147
LPE	.2595	.1336	.0296
LPF	.1502	.1472	.0513
LPG	.0884	.1655	.0716
LPH	.3209	.1239	.0188
LPI	.0718	.1761	.0811
LPJ	.2867	.1276	.0243
LPK*	.0442	.2126	.1099
LPL*	.0145	.2478	.1497
LPM	.7763	.0693	-.0424
LPN	.6974	.0805	-.0328
LPO	.4888	.0998	-.0054
LPP*	.0188	.2165	.1261
LPQ	.8948	.0577	-.0671
LPR*	.0281	.2072	.1146

Dependent Variable	p	R^2	Adjusted R^2
LPS	.1620	.1529	.0513
LPT	.1202	.1661	.0647
LPU*	.0336	.1998	.1074
Composite Logistics Measures			
LOGMEAN*	.0089	.2294	.1438
COSTS*	.0416	.1871	.0968
INVEN	.1244	.1522	.0581
CUSTSER*	.0334	.1957	.1052
LABOR*	.0164	.2227	.1318
ERRORS	.1946	.1391	.0410

Dependent Variable	p	R^2	Adjusted R^2
Overall Performance Measures			
LPV	.5059	.1002	-.0078
LPW	.8872	.0526	-.0581
LPX	.2637	.1344	.0292
LPY	.3340	.1220	.0167
OVMEAN	.3002	.1212	.0211

Each model was developed using one dependent variable and the following independent variables: IV1A1, IV1A2, IV1A3, IV2, IV3, IV4C, IV4S, IV5, IV72 (as listed in Table 5.4).

* Indicates rejection of H_{o2} at the .05 level of significance.

APPENDIX K

INTERVENING VARIABLES: DESCRIPTIVE STATISTICS

Variable	N	Mean	Std Dev
NV1	91	3.6154	1.0622
NV2	90	3.9333	1.2524
NV3	91	3.8022	1.3435
NV4	90	3.9111	1.1381
NV5	91	3.9451	1.0890
NV6	88	3.2386	1.2594

APPENDIX L

INTERNATIONAL EDI USERS: DESCRIPTIVE STATISTICS

N = 10 (EQ2/IV6 = Yes)

Categorical Variables

Variable/ Question	Response Levels	Frequency	Percent
IV1/EQ9	3	2	20.0
	4	1	10.0
	6	3	30.0
	8	4	40.0
IV7/LQ6 - LQ13	2	6	60.0
	3	4	40.0

Continuous Variables

	Mean	Std Dev
IV2/EQ4	3.8000	5.2662
IV3/EQ5	0.2620	0.3328
IV4C/EQ6	0.1720	0.3179
IV4S/EQ7	0.2160	0.3910
IV5/EQ8	2.4000	1.8379

Dependent Variable	N	Mean	Std Dev
LPA	10	3.6000	0.6992
LPB	10	3.5000	1.0801
LPC	10	4.1000	0.7379
LPD	10	3.9000	0.8756
LPE	10	3.6000	0.6992
LPF	10	3.9000	0.8756
LPG	10	3.5000	0.8498
LPH	10	3.3000	1.2517
LPI	10	3.2000	1.1353
LPJ	10	3.3000	0.9487
LPK	8	3.3750	0.7440
LPL	8	3.2500	0.8864
LPM	10	3.9000	0.8756
LPN	9	3.7778	0.9718
LPO	9	3.5556	0.5270
LPP	9	3.7778	0.8333
LPQ	9	3.6667	0.7071
LPR	9	3.5556	0.8819
LPS	9	3.6667	0.7071
LPT	9	3.6667	0.8660
LPU	10	3.7000	0.4830

Dependent Variable	N	Mean	Std Dev
Composite Logistics Measures			
LOGMEAN	10	3.5942	0.4856
COSTS	10	3.6000	0.6246
INVEN	10	3.6417	0.5358
CUSTSER	10	3.6554	0.4872
LABOR	10	3.3333	0.8749
ERRORS	10	3.6000	0.4661
Overall Performance Measures			
LPV	9	3.7778	0.8333
LPW	10	4.0000	0.9428
LPX	8	3.7500	1.0351
LPY	8	3.8750	0.9910
OVMEAN	10	3.9000	0.8991
Intervening Variables	**N**	**Mean**	**Std Dev**
NV1	10	3.6000	0.9661
NV2	10	4.4000	0.6992
NV3	10	4.0000	1.3333
NV4	10	4.2000	1.0328
NV5	10	4.5000	0.7071
NV6	10	4.3000	0.9487

VITA

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Major Karen W. Currie is a supply officer in the United States Air Force who was commissioned in 1979. She has been assigned to Randolph Air Force Base, TX; Wright-Patterson Air Force Base, OH; Comiso Air Station, Sicily; and Lindsey Air Station, Germany, where she served for three years as the commander of the 7100th Supply Squadron. Major Currie is presently a Ph.D. candidate in the Department of Business Analysis and Research at Texas A&M University under the sponsorship of the Air Force Institute of Technology. Her major area of concentration is Operations Management, with a degree in Business Analysis. The anticipated completion date is December 1993.

Major Currie previously earned an MS in Logistics Management from the Air Force Institute of Technology in 1984; an MA in Diplomacy from the University of Kentucky, Lexington, KY, in 1977; and a BA in English from Duquesne University, Pittsburgh, PA in 1976. After graduation from Texas A&M, Major Currie will serve on the graduate faculty of the School of Acquisition and Logistics, Air Force Institute of Technology, Wright-Patterson Air Force Base, OH.