

**DESIGN OF DISTRIBUTION NETWORK SYSTEMS: A STUDY FOR
PRIVATE SECTOR PERSPECTIVE**

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**DESIGN OF DISTRIBUTION NETWORK SYSTEMS: A STUDY FOR
PRIVATE SECTOR PERSPECTIVE**

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
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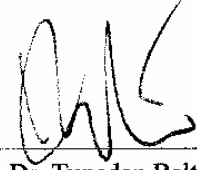
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OKTAY ÇOBAN

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
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Approval of the Graduate School of Social Sciences



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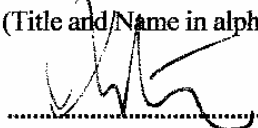
This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Art of Logistics Management.



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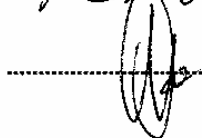
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ABSTRACT

DESIGN OF DISTRIBUTION NETWORK SYSTEMS: A STUDY FOR PRIVATE
SECTOR PERSPECTIVE

Çoban, Oktay

MLM, Department of Logistics Management

Supervisor: Assoc. Prof. Dr. Frank Bates

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The main purpose of this thesis is to determine the most cost-effective configuration of the Company X's current distribution network and its logistics practices so as to minimize the company's annual costs of supplying its demand, while maintaining an acceptable service level. More specifically, this purpose includes determination of the optimum (cost-effective) number of distribution centers; determination of the potential savings in distribution costs; identification of the minimum service level for current distribution network; determination of the relative importance of each distribution center from an outbound distribution perspective.

Keywords: Supply Chain, Logistics, Distribution, Warehouse.

ÖZET

DAĞITIM AĞI SİSTEMLERİNİN DİZAYNI: ÖZEL SEKTÖR PERSPEKTİFLİ BİR ÇALIŞMA

Çoban, Oktay

Lojistik Yönetimi Yüksek Lisans, Lojistik
Yönetimi Bölümü

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Bu çalışmanın amacı, Şirket X'in hali hazırda mevcut bulunan dağıtım ağının, yıllık talebin karşılanması sırasında meydana gelen arz maliyetlerinin en aza indirilmesi ve bu yıllık talebin kabul edilebilir bir servis karşılama oranı ile düzenlenerek en uygun maliyet odaklı bir biçimde yeniden gözden geçirilmesini sağlamaktır. Bu amaç özellikle, maliyetleri minimum seviyede tutabilmek için en uygun sayıda depo miktarının belirlenmesi; dağıtım maliyetlerindeki potansiyel tasarrufların belirlenmesi; mevcut dağıtım ağı için minimum servis karşılama oranının tayini; ve şirketin hali hazırda bulunan her bir deposunun bir dışsal dağıtım perspektifine dayalı olarak göreceli (nispi) öneminin belirlenmesi şeklinde tanımlanabilir.

Anahtar Kelimeler: Tedarik Zinciri, Lojistik, Dağıtım, Depolama.

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LIST OF ABBREVIATIONS

This list covers a complete list of the abbreviations used in this thesis.

All abbreviations are arranged in alphabetical order except the first one.

3PL	Third-Party Logistics Service Provider
DC	Distribution Center
EFTA	European Free Trade Association
ERP	Enterprise Resource Planning
EU	European Union
FTL	Full Truckload
GSCF	Global Supply Chain Froum
IS	Information System
LTL	Less than Truckload
MERCOSUR	El Mercado Común de Sur
MRP	Material Requirement Planning
NAFTA	North American Free Trade Agreement
PDCA	Plan, Do, Check, Act
R&D	Research and Development
SCM	Supply Chain Management
VAS	Value Added Services
WERC	Warehouse and Research Council

INTRODUCTION

1 Introduction

In this first chapter, an overview of the thesis is provided, in order for the reader to become acquainted with the subject. The thesis' background and a short discussion around the problem will be followed by a presentation of the thesis' purpose.

1.1 Background of Thesis

The world economy is, and has been for some time, in a radical shift. We are moving away from a world where national economies are isolated from each other by barriers that hinder cross-border trading and investments; by distance, time zones, and language; and by national differences in government regulation, culture, and business systems. The globalization of markets is merging national markets into one huge global marketplace, where companies have great opportunities to earn money. However, the emergence of globalization has made the business world tougher. Competition between companies is fiercer than ever and staying profitable is not as obvious as in earlier days. The main drivers of globalization are the changes in customer preferences, technological improvements and the decline in barriers to the free flow of goods, services and capital (Hill, 2000). So, reduced prices, superior product quality, excellent customer service, expanded variety, and exceptional value are examples of the ever- increasing demands being placed on businesses by their customers. How will companies satisfy the increasing number of customer requirements? Many believe that the answer lies in supply chain management. Supply chain management (SCM) has become an important topic of discussion among

managers and academicians alike. One definition for SCM is “the integration of key business processes from end user through original suppliers that provides products, services and information that add value for customers and other stakeholders” (Lambert and Cooper, 2000). Improved SCM can enhance customer service while maintaining low costs. Having recognized these benefits of SCM, many successful firms are implementing SCM principles to create and sustain their competitive advantage.

What should companies do to maximize the benefits offered by SCM? One answer lies in choosing the appropriate supply chain strategy. The appropriate supply chain strategy should match the corporate strategy in order to “fit” within the company. In addition, the supply chain strategy should complement the logistics and manufacturing strategies in order to achieve superior performance. A dissonance among these strategies could lead to building conflicting capabilities. As a result, companies will not realize the complete benefits of SCM.

Strategic alignment between the corporate and supply chain strategies is essential for the success of a company. A survey conducted by Ernst and Young LLP and Stevens Institute of Technology revealed that only 13% of the respondents believed that their supply chain practices were fully aligned with their business unit strategy. Only 47% said that they were "somewhat" aligned with their business unit strategy (Tamas, 2000). There are many reasons as to why a company might fail. One important reason according Chopra and Meindl (2001) is: “A company may fail either because of a lack of strategic fit or because its processes and resources do not provide the capabilities to support the desired strategic fit.”

What exactly is meant by strategic fit? Chopra and Meindl (2001) give the following definition:

“Strategic fit means that both the competitive and supply chain strategies have the same goal. It refers to consistency between the customer priorities that competitive strategy is designed to satisfy and the supply chain capabilities that the supply chain strategy aims to build.”

The above definition of strategic fit can be expanded to include the manufacturing and logistics strategies. The logistics and manufacturing strategies should be aligned with the supply chain strategy in order to build the necessary capabilities to address customer priorities. Thus, a lack of strategic fit can mean that a company wastes time and valuable resources developing capabilities that will not satisfy current customers nor win new customers.

Before choosing what type of supply chain strategy to pursue, a firm must first evaluate the type of supply chain(s) in which it participates. One paradigm that has evolved over the years consists of two types of supply chains: the lean and the agile. Naylor, Naim and Berry (1999) define agility as “using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile market place” (pg. 108). They define leanness as “developing a value stream to eliminate all waste, including time, and to ensure a level schedule” (pg. 108).

Manufacturing strategy has been defined as the pattern of decisions that, over time,

enables a business unit to achieve a desired manufacturing structure, infrastructure and set of specific capabilities. Typical manufacturing competitive priorities or strategies are low cost, delivery, flexibility and quality (Hayes and Wheelwright, 1984).

Unlike manufacturing strategy, logistics strategy literature has varying views on what constitutes the typical logistics strategies. Bowersox and Daugherty (1987) proposed a framework for logistics strategy classification. The three strategies they articulated were the process, market, and channel strategies. McGinnis and Kohn (1990) performed a factor analysis of logistics strategy where they identified four strategies: (1) intensive logistics strategy; (2) integrated logistics strategy; (3) low integration strategy; (4) low effectiveness logistics strategy.

1.1.1 Drivers of Globalization

As mentioned earlier, customer preferences have changed in many ways. Customers nowadays expect goods to be available at all times, in the right quality and to the right price. Furthermore, technology is continuously improving. It is particularly the dramatic developments in recent years in communication, information processing and transportation technologies that have pushed the world towards globalization. One of the most notable trends in the global economy in recent years has been the movement towards regional economic integration. Free trade zones, such as EU, EFTA, NAFTA and MERCOSUR have decreased the number of trade barriers between nations, which has further strengthened globalization (Hill, 2000).

Production has also become global. Firms source goods and services from locations

anywhere around the world in order to take advantage of national differences in the cost and quality of factors of production (labor, energy, land and capital). The aim of this is to lower the overall cost structure allowing the firms to compete more effectively. In order for firms to become more efficient the concept of Supply Chain Management has developed.

Supply Chain Management consists, according to Bowersox, et al., of firms collaborating to leverage strategic positioning and to improve operating efficiency. As late as the early 1990's the average time that a company needed to process and deliver goods to a customer from warehouse inventory ranged from 15 to 30 days. Today, however, as customers are more demanding, firms must be able to manufacture to exact specifications and rapidly deliver to customers anywhere around the globe. Customer order and delivery of goods can be made in hours. Service failures that often occurred in the past are no longer acceptable. Instead, perfect orders i.e. delivering the correct assortment and quantity of products to the right location on time, damage free with correct invoice is what customers expect (Bowersox, et. al., 2002).

1.1.2 Cope with the Challenges

In order to cope with these challenges in the new business environment it is essential that companies have, among many other things, a well-functioning material management, i.e., an efficient physical supply of materials throughout the supply chain. An efficient materials flow is crucial in order for firms to meet customer expectations and thereby deliver the products at the right time, in the right quality and quantity, at the right price and at the right place.

To achieve a well functioning materials flow companies must put much emphasis on the different warehouse operations and inventory management, including the stratification of articles, product flow patterns and the layout of the storage. Today control and communication in materials flow demands computerized systems. Information systems refer not only to computerized solutions but also to all communication and data processing connected to the materials flow. Thereby, the overall control of the entire materials flow can be viewed as one process, in order to see how the different parts are integrated and influence each other.

Logistics and Supply Chain Management have during the last centuries grown in popularity because of the firms' needs to become more customer-oriented and cost effective. Much research has been done in these areas and they will most certainly continue to be investigated in the future. Distribution and its relation to the warehouse, are areas within logistics that must be studied in-depth for the firms and so, there is a need for further research. This is the reason why this study will be conducted.

1.2 Purpose

The main purpose of this research is to determine the most advantageous (cost-effective) configuration of the Company X's current distribution network and its logistics practices so as to minimize the company's annual costs of supplying its demand, while maintaining an acceptable service level. More specifically, this purpose includes:

- Determination of the optimum (cost-effective) number of distribution centers.

- Determination of the potential savings in distribution costs.
- Identification of the minimum service level for current distribution network.
- Determination of the relative importance of each distribution center from an outbound distribution perspective.

Some specific activities associated with the preliminary objectives include:

- Conducting research to determine competitive market requirements.
- Collecting and analyzing Company X's data to determine shipping patterns and transit time requirements.
- Reviewing Company X's logistics processes and systems for improvement potential.
- Researching third party logistics providers for fit and value added potential.
- Preparing reports, presentations and recommendations to management.

RESEARCH DESIGN AND METHODOLOGY

2 Research Design and Methodology

In order to carry out a study, an optimal research method has to be decided upon. The choice of method is dependent on the purpose of the study, the problem definition, and the frame of reference and time constraints. It is therefore not what is theoretically interesting, but what is possible within the limitations of a given method that will determine the outcome of the research. By describing the theory of methodology used, we wish to clarify how the research problems and the information needs have been approached.

2.1 Introduction

This chapter deals with the planned research design and data collection methods used. The methodology approach and the analysis approach will be presented, followed by a discussion concerning both secondary and primary data collection. Finally, we will discuss the thesis' method problems and errors.

2.2 Research Design

Research design or methodology refers to the procedural framework within which the research is conducted. It describes an approach to a problem that can be put into practice in a research program or process, which could be formally defined as an operational framework within which the facts are placed, so that their meaning may be seen more clearly.

Firstly, the research design is a plan and structure for selecting the sources and types of information used to answer the research questions. Secondly, it is a framework for

specifying the relationships among the research's variables. Thirdly, the research design guides the data collection and the analysis phases of the research work (Cooper and Schindler, 1998). In other words, the method is a tool used to retrieve new knowledge.

A good design will make sure that the information gathered is consistent with the study objectives, and that the data are collected by accurate and economical procedures. Research objectives are dependent upon the stages of the decision-making process which information is needed. There are different types of research methodologies, e.g. exploratory, explanatory, conclusive and performance-monitoring research (Kinnear and Taylor, 1991).

Every empirical research has an implicit, if not explicit, research design. In most elementary sense, the design is the logical sequence that connects the empirical data to a study's initial research questions and, ultimately, to its conclusions.

2.3 Methodology Approach

As stated above (Kinnear and Taylor, 1991), a research can be divided into different types of research designs: exploratory, explanatory, conclusive; which can be both descriptive or causal, and a performance monitoring research. However, in this thesis mainly the descriptive, explanatory and exploratory research will be used and explained since the others are not applicable on this research. Another method to categorize different types of research is to identify the project as a quantitative or qualitative study, which will be mentioned in later section of this chapter.

This kind of study can also be explained by the induction and deduction process where induction occurs when fact is observed, and to draw conclusions from them and make hypothesis. Deduction is the process where the hypothesis is tested if it can explain the fact or not. However, these two concepts will not be mentioned in this thesis since the method approaches and data collection methods are instead explained by the above-mentioned approaches, i.e. explorative, descriptive, and explanatory research approaches (Kinnear and Taylor, 1991).

2.3.1 The Value of Information

The value of information for a company might be measured in the time required to make a decision or in increased profits to the company. Before selecting a research approach, it is necessary to estimate the value of information, i.e. the value of obtaining answers to the research questions. This estimation will help determine how much time should be spent on the research. The value of the research information may also be judged in terms of “the difference between the result of decisions made with the information and the result that would be made without it” (Aaker and Day, 1986).

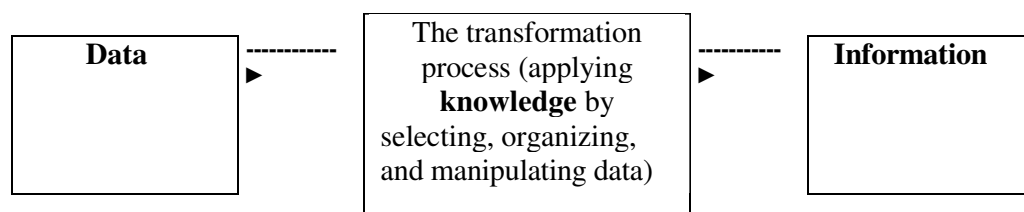


Figure 1: The Process of Transforming Data into Information.

Source: Stair & Reynolds, 2001, p. 7

Therefore, when the valuation of the present information is done a decision of which research approach to select is made. It is also crucial that when the valuation is done some method questions have to be asked. How can the information be found and gathered? How should the mapping procedure be done in order to describe the present situation? Which employees should be contacted for further information and how many? Should this be done through quantitative research, such as questionnaires or through qualitative ones by carrying out interviews?

2.3.2 The Explorative Research Approach

The explorative research method is the most appropriate when knowledge of the subject is relatively small. This is a form of pre-examination where necessary knowledge is acquired in order to precise the task and the problem definition, and to enter more deeply into the subject. This research design is characterized by flexibility in order to be sensitive to the unexpected and to discover insights not previously recognized. When using an explorative design the objective of the research is to broaden the field of alternatives identified with the hope of including the “best” alternative, in the set of alternatives to be evaluated. Useful techniques are observations; direct and indirect, case studies, studies of secondary data and interviews with experts on the subject (Kinnear and Taylor, 1991).

2.3.3 The Descriptive Research Approach

When it is desirable to provide information for the evaluation of alternative research approaches, the descriptive research approach within the conclusive research is often used. The descriptive research method requires more basic knowledge of the subject than the explorative one. A descriptive study is characterized by a clearly defined

problem to be explored, specified objects of exploration, a detailed need of information and a detailed and well-structured research design. Facts and state of things are surveyed and the properties of a number of objectives are described. The aim of a descriptive research is to describe how things are, for example, by mapping or observations without explaining why and that must not only be viewed as a fact gathering expedition. It covers an array of research interests and requires skilful planning if they are to be used effectively in decision-making. Data collection methods are surveys, studies of primary and secondary data and simulations (Kinnear and Taylor, 1991).

The descriptive method is highly suitable for the empirical study in this research since the main research question is to find the best way of determining the optimum design for the Company X's distribution network and its logistics practices so as to minimize the company's annual costs of supplying its demand, while maintaining an acceptable service level. The study is descriptive in the way that distribution network is observed and all the warehouses are mapped, listed and then sorted in different ways. The problem studied is clearly defined and the facts on the subject have been surveyed, such as studies of both primary and secondary data. The theoretical platform provides a descriptive background and the sources of data in this type of research include interviews and secondary data.

2.3.4 Explanatory Research Approach

In an explanatory research method, the aim is to search further for connections between cause and effect. An explanatory study can be done with different focus as the following: "in-depth" by focusing on specific research unities, "in breadth" by

focusing on different connections or “over time” by focusing on the development and changes over time. The difference between descriptive and explanatory is quite small. Almost all descriptive research contain explanatory parts as well. The main difference between the two is that an explanatory research usually is concentrated on relatively few variables while the descriptive research covers a broader perspective (Lekvall and Whalbin, 1987).

In this study, the explanatory research approach will partly be used in order to find the cause of current distribution practices and see the connection between the different departments of the company and their functions. Therefore, the explanatory research design aims to explain these connections and how different factors are connected to each other and what impacts they have on each other. In order to get an understanding interviews have been made, both structured and unstructured ones to get a deeper understanding for the cause and problem of the symptom. The symptom in this case is the distribution network.

2.4 Data and Information Collection

The human perception and mind are all but objective and each individual can see things from a certain perspective. In fact, the interpretation is inseparable from subjective perceptions. Therefore, it is important to systematically reflect the nature of the problem from different perspectives. By doing so, the interpretation can reach a higher level of quality, which will give the empirical study a higher value (Alvesson and Sköldberg, 1994). Therefore, the situation has been viewed from many different perspectives, by using different data collection methods, to be able to interpret the empirical situation in the best possible way.

There are several methods to use in a data and information collection process. The first grouping of this thesis is whether secondary or primary sources of data are used. Secondary data for this thesis is for example studies made by others for their own purposes. The authors of the thesis, especially to answer the research questions of this study, collect primary data. Primary and secondary have both strengths and weaknesses but normally complement each other in a good way (Aaker and Day, 1986).

2.4.1 Secondary Data Collection

Secondary data can be divided into two categories: internal and external data. Internal secondary data is available within the company studied, e.g. annual reports. External secondary data is provided by sources outside the organization, such as reports and books. However, internal data should always be valued above external data. The advantages of secondary data are that they save cost and time. Secondary data can also serve as comparative data which primary data can be evaluated and interpreted against. Two major disadvantages of secondary data exist is that this data may not fit the project since it was not acquired for this purpose and the accuracy may not be as good as that of primary data (Kinnear and Taylor, 1991).

2.4.1.1 Internal Data

Internal secondary data originates within the organization studied and is a part of the normal operations, such as sales and cost data, research and development, etc. However, many organizations do not collect and maintain sales and cost data in sufficient detail to be used for many research projects. Additionally, internal data can be proprietary and not accessible to all. The advantages of internal secondary data

are their low cost and availability (Kinnear and Taylor, 1991). In this thesis information such as annual reports, documented article information have been obtained from the company.

2.4.1.2 External Data

External secondary data is obtained from two main sources: syndicated sources and library sources. Syndicated sources are services that collect standardized data to serve the needs of an array of clients but are fortunately often expensive and sometimes not available for the public. Library sources are e.g. government documents, periodicals, books, and research reports (Kinnear and Taylor, 1991). The library is a rich storage base for secondary data but nowadays-computerized databases make literature search much faster and easier to use.

2.4.2 Primary Data Collection

Data collected by those conducting a study for a predetermined purpose is primary data. It is advantageous due to its high degree of reliability and control over errors (Patel and Davidson, 1991). Primary data can be collected in a number of different ways, for example through interviews, observations and case studies.

Another way to label a research project is to identify it as quantitative or qualitative. Depending on which one of the two methods that is used different types of primary data is obtained. The qualitative type of investigation proceeds from the researcher's subjective perspective and the quantitative approach proceed from the researcher's ideas about which categories and dimensions should be in focus (Patel and Davidson, 1991).

In a quantitative research, the collected data is coded in order to be analyzed quantitatively. This type of research is designed to explain what is happening and the frequency of occurrence and includes large-scale surveys, experiments and time-series analysis. Quantitative methods are more formal and structured but it does not mean that this approach is objective since the numbers and techniques used are not always interpreted at the optimal level of objectivity. Instead, objectivity can be subordinated predetermined perceptions of the researcher (Patel and Davidson, 1991).

In studies where data cannot be analyzed efficiently in a quantitative way, qualitative research is appropriate. The analysis and interpretation of the data is more subjective in a qualitative research (Lekvall and Whalbin, 1993). The qualitative approach allows a wide range of interpretations and perceptions of what seems to be more or less characteristic in the research, since the method is based on more of an understanding of the situation. The important thing is to increase the understanding of the research problem and be able to describe the whole in which this problem exists (Holme and Solvang, 1997).

In this research, both qualitative and quantitative data have been used. These techniques were used in order to receive as much useful information as possible. The strong sides of each approach are used to complement each other. By using both a quantitative and a qualitative research approach, a more accurate shape of the whole picture illustrating the nature and complexity of distribution network of a company will be obtained. In this thesis, both quantitative as well as qualitative research is essential in order to get correct information, since the employees who are managing,

the flow of the material is an important information source.

Quantitative researches as numeric data in form of information about different article numbers will be handled. Qualitative researches will be made through interviews and meetings with different knowledgeable employees within the logistical area of the organization.

2.4.2.1 Direct observation - Quantitative research

Observational methods allow the recording of behavior when it occurs, thus eliminating those errors associated with the recall of behavior. It is often less costly and more accurate than asking the respondent to recall the same behavior at another point of time. By making a visit to the research “site”, there is an opportunity for direct observation. The observation can be either formal or informal with data collection activities. Formal ones can involve observations of meetings, sidewalk activities, storage or factory work, photographing, etc. Less formally, direct observations might be made throughout a field visit, including short interviews at the same time. Observational evidence is often useful in providing additional information about the topic being studied (Yin, 1994).

Advantages with direct observation (Yin, 1994):

- Reality, covers events in real time
- Contextual-covers context of event
- Less costly

Disadvantages with direct observation (Yin, 1994):

- Time-consuming
- Selectivity-unless broad coverage

- Reflexivity-event may proceed differently because it is being observed.
- Cost-hours needed by human observers.

2.4.2.2 Interviews- Qualitative Research

The whole point of doing qualitative interviews is to raise the value of the information and to create a foundation for deeper and more extensive knowledge about the subject studied. While an observation can accurately record what people do and how it is done, it cannot be used to determine the motivations, attitudes, and knowledge that underlie the behavior. Therefore, it is good to have interviews as a complement (Kinnear and Taylor, 1991). There are two types of face-to-face interviews: unstructured and structured interviews (Sekaran, 2000).

In an unstructured interview, the interviewer does not enter the interview setting with a planned sequence of questions that will be asked of the respondent. The objective with this kind of interview is to cause some preliminary issues to surface so that the researcher can decide which variables need further in-depth investigation.

When it comes to structured interviews, it is known at the outset what information is needed. The interviewer often has predetermined questions to ask the respondent either personally or through telephone or mail. In this interview, focus can be put on those subjects discussed during the unstructured interviews.

The advantages of interviews are that (Sekaran, 2000):

- the interviewer can ask attendant questions depending on the answers received.

- the interviewer can clarify the questions, clear doubts and add new questions.
- the situation can make the respondent more comfortable, leading to more honest answers.
- the interviewer can use visual aid to clarify points.
- they are targeted and focused on the topic of the study.
- this method makes it easier for the interviewer to build a relationship when body language can be interpreted (Eriksson and Wiedersheim-Paul, 1991).
- the interviewer can perceive what has not been said (Yin, 1994).
- the respondent and give more in depth answers (Holme and Solvang, 1991).

The disadvantages of interviews are that:

- the interviewer, so called interviewer bias due to poorly asked questions, can affect answers (Yin, 1994).
- The respondent may be concerned about confidentiality of information given. Therefore, sensitive questions may be difficult to ask due to the non-anonymity of the respondent (Sekaran, 2000).
- accessibility may be limited (Eriksson and Wiedersheim-Paul, 1991).
- inaccuracies due to poor recall may occur (Yin, 1994).
- there are few adequately qualified interviewers and those that are qualified are highly paid (Kinnear and Taylor, 1991).
- this method is relatively expensive and time consuming (Holme and Solvang, 1991).
- the respondents can terminate the interview at any time (Sekaran, 2000).

In this research, both structured and unstructured interviews were made. The booked interviews were structured in the sense that we had specific questions as guidelines, which were followed, but they were also unstructured in the sense that these questions were not handed out to the respondents in advanced. They had instead only been informed of the subject of the interview. Thereby, the interviews were open and welcomed for open qualitative questions and not too locked up and controlled.

2.5 Research Evaluation and Errors

When conducting a study, the researcher must be critical since there are many pitfalls that might decrease the credibility of the research. Errors can result in serious misinformation being communicated to managers. However, to be aware of these weaknesses and to consider them when drawing conclusions from the findings may counterbalance them to some extent. We will therefore conclude this chapter with an evaluation of this thesis' research.

2.5.1 Evaluation

A critical awareness of different types of research errors and that they may be evident is important from the beginning of the research process. It is as important to choose the direction and approach, as it is to evaluate the validity and the reliability of the study. A research design is supposed to represent a logical set of statements and one can judge the quality of any given design, according to certain logical tests. However, this part of the thesis will focus on the credibility of the study and define whether it can be trusted to give an objective picture through pointing out the validity and reliability of the study (Yin, 1994).

2.5.1.1 Validity

According to Kinnear and Taylor, the validity of a measure refers to the extent to which the measurement process is free from both systematic and random error. Systematic error refers to an error that causes a constant bias in the measurements, while random error involves influences that bias measurements but are not systematic (Kinnear and Taylor, 1991). According to Lekvall and Whalbin, validity is defined as the research method's ability to measure what it is intended to measure. Therefore, the main question that validity deals with is: Are we measuring what we think we are measuring? (Lekvall and Whalbin, 1993)

Validity can be divided into three parts; construct validity, and internal and external validity. To meet the test of construct validity, the investigator should be sure of first selecting the right specific types of changes that are to be studied, and second to demonstrate that the selected measures of these changes do indeed reflect the specific types of change that have been selected. Internal validity deals with the study itself and the direct connection between the theoretical framework and the empirical. External validity concerns the study with all its contents in a broader perspective, which implies if it is possible to generalize from the study, or not. When the study does not have internal validity, the external validity can be excluded as well (Yin, 1994).

This study includes both internal and external validity. The validation process in this thesis consists mainly of the opinions expressed by the tutor at the Izmir University of Economics, and partly of the opinions expressed by the tutor of Company X and comparisons with other similar research projects. Our validation process has also

mainly been focused on the external validity since this research not only fills an essential value but will also be read by others. Furthermore, the validity in this research has been established by clearly defining the subject with the aim of ascertaining that no irrelevant questions have been asked. Multiple sources of information have been used; several people within the company as well as experts on the subject have been interviewed in order to gain a deeper understanding of the subject. Other sources of information are homepages, annual reports, literature and articles.

2.5.1.2 Reliability

According to Lekvall and Whalbin, an interview that is based on a qualitative approach involves an inherent factor of uncertainty concerning reliability of data collected. Reliability concerns whether things are measured in a proper way, without random errors (Lekvall and Whalbin, 1993). The reliability is concerned with consistency, accuracy, and predictability of the research findings. The more clearly a problem analysis is formulated, the smaller is the risk of random errors and greater the probability of a high reliability. This means that the measurement must be performed several times in the same way without very different results in order for the reliability to be high (Eriksson and Wiedersheim-Paul, 1991). Reliability is a necessary but not sufficient condition for validity.

In order to increase the reliability of this study, only well-known researchers, authors and institutions has been used in the construction of the theoretical framework. The reliability of the primary data, e.g., the interviews is difficult to measure. It is heavily dependent on the credibility of the person interviewed,

position, expertise, situation, expectation and own perception on the subject. Therefore, the interviews are conducted in a non-leading manner by designed questions, with the aim to keep the interviews as open as possible. To increase the reliability of this study further the respondents interviewed have been given the information regarding the subject of the study before the interview to give them possibility to prepare themselves. The questions in the interview guides were used as guidelines, which made it possible for the respondents to discuss other relevant issues. The fact that the interviews were recorded also improves reliability since it reduces interpretation errors. As many persons as possible, relevant for this research, have been interviewed.

The empirical framework has also been sent to the respondents in order to give them possibility to correct mistakes and explain things that they thought to be unclear. We were both well read on the company and the theoretical background when conducting the interviews, which further increased the reliability.

2.5.2 Research Errors

According to Patel and Davidson, there are three criteria for reliability that are important: respondent errors, measurement errors and interviewer effect (Patel and Davidson, 1991).

2.5.2.1 Respondent Errors

Respondent errors arise when the research is erroneous because the respondent cannot or will not give correct answers. As the topics discussed are relatively complex, it demands good knowledge from the respondents. It may therefore be hard

for us to see what is correct or faulty but we have done our best in order to be objective and read the answers in the right way.

2.5.2.2 Interviewer Effect

Interviewer effect arises when the interviewer in some way affects the respondents' answers. This risk is of course larger as the authors of the thesis are unaccustomed to interview situations. In evaluating the quality of the data identified, the researcher must be sensitive to the origin of the data and the research design.

It is hard to avoid not controlling an interview. The answers you are going to get all depend on how you as an interviewer asks the questions. When using open questions a more relaxed conversation form is hold and the respondent is able to talk freely without thinking too deeply on possible consequences. By doing this, the interviewer can act more as a support. In this study, we as interviewers tried to act more as a support in order to get as freely answered questions as possible.

2.5.2.3 Measurement Errors

Measurement errors arise when the tools of measurement are wrong, for example poorly formulated questions. As we have made sure that, an objective party read the interview guides before the interviews took place we feel that these errors have been minimized.

Since the article data has been gathered through visual observations there, might be the case of missing articles when doing the observation and can therefore not be taken into account. Since the matching with the company's computer system and the

articles found on the storage area was made after three days some articles might have left the area during that time. Therefore, the balance of articles given in the company data might not agree with the data gathered during the observation. The human interference in gathering data and calculations of it could also lead to some measurement errors.

2.6 Summary of Methodology Chapter

In this chapter, we have described what the methodology literature says about different methods to use when writing a research. Some problems that might appear during a thesis study are also mentioned and what research errors that must be taken under consideration. This thesis is mainly a descriptive and partly an exploratory and explanatory research with both quantitative and qualitative data. Primary data such as visual observation and personal interviews have been used as well as secondary data such as theory, which is gathered in the next chapter, articles and internal information gained from the company.

In the empirical part, Chapter 4 that follows the theoretical chapter, data obtained in the research is both presented in text, figures and tables in order to clarify the meaning and understanding of the results.

THEORETICAL FRAMEWORK

3 Theoretical Framework

This chapter consists of description of the theories that are most vital for understanding the thesis' subject. First, a broader view of process thinking, supply chain management, manufacturing strategy, and logistics strategy will be given and then be followed by theories more focused on logistical goals, and information and its components.

3.1 Introduction

Logistics mainly deals with the materials flow and the activities and systems connected to it. In order to deliver the products when they are needed and at a low cost, it is required that the flow of materials is controlled efficiently. The opinion on logistics has gradually turned from only being an instrument for cost reduction to also include the issue of tied up capital and income related issues such as delivery service (Lumsden, 2002).

Another important issue to consider is that the material flow cannot be viewed isolated from the information flow. Today, control and communication in materials flow demands computerized information systems. Information systems refer not only to computerized solutions but also to all communication and data processing connected to the material flow. Thereby, the overall control of the entire materials flow can be viewed as a process in order to see how the different parts within it are integrated and have influence on each other (Ljunberg and Larsson, 2001).

Holding inventory is a major use of capital and it is therefore of major importance to focus on inventory management. The objectives of inventory management are to increase corporate profitability, to predict the impact of corporate policies on inventory levels, and to minimize the total cost of logistics activities. The amount of products in stock is dependent on how much has been ordered. Therefore, the order quantity has to be optimized, which can be done by the economic order quantity model, i.e. the Wilson equation. One thing goes hand-in-hand with the other but major focus will be put on the latter (Stock and Lambert, 2001).

3.2 A Process Oriented Approach

It takes a lot of effort and hard work to change a traditional function oriented organization into a process oriented. According to the author Anders Ljungberg, the function oriented organization has over the years given both the employees and the leaders stability in terms of clear functions. However, this feeling of security and traditional thinking might lead to sub-optimization, internal hierarchic disputes, lack of customer focus, bureaucracy, slow decision-making, and difficulties to adapt the organization to external changes. By describing the organization in terms of processes, it will facilitate the understanding of how different parts of the organization are integrated and cooperate in order to create value to the customers, external or internal. Changes and developments into a process-oriented organization must be carefully planned. However, several components of a function-oriented organization are similar or even identical to those in a process-oriented organization. Therefore, the well- functioning parts of the old organization must be taken care of instead of just being rejected and replaced. One of the most difficult issues within the development process is the changing of attitudes of the employees and not only the

changes of the organization (Ljungberg and Larsson, 2001).

3.2.1 Effective Processes

First, when the process is identified, it is possible to start to make it more efficient and to improve it. In order to know if the process is effective, and if all activities add value to the product or the customer, it is necessary to know the use of resources, such as economical costs, time, personnel, and system resources. The development work of improving processes is similar to the one of improving the quality, follows the five steps below (Ljungberg and Larsson, 2001).

- **Plan:** : Identification and mapping (Determine the processes and illustrate them.) Analysis and reconstruction (How well does the process work? Can they be improved?)
- **Do:** Implementation of new or changed processes (How to make the new processes work in practice?)
- **Check:** Measurement of the processes (Were the processes improved? What will be the next step?)
- **Act:** Continuous improvements of the processes (What can be even more improved? Do the processes need to be adjusted to new expectations and conditions?)

The last step in the development work is one of the most important since there are always things to improve within an organization. Therefore, the employees themselves, i.e. the process owners, should accomplish the continuous improvement work (Ljungberg and Larsson, 2001).

3.2.2 Flexible Processes

A flexible process can be described as a type of process that easily can be adjusted to changes in external and internal condition, i.e. that the process can adjust rapidly without high additional costs or resources (Ljungberg and Larsson, 2001).

3.2.3 Identification of Processes

In order to identify and map a process one must know what a process is. One basic definition of a process is “*a sequence of events or changes*”. The purpose of the process itself is to satisfy an internal and external customer need. The identification of the need will activate a number of activities that will cooperate in order to satisfy the need, e.g. an ordered product to a delivered one and a satisfied customer (Ljungberg and Larsson, 2001).

When processes are mapped and visible, it is easier for each employee to see where their own work fits into the whole organization, and thereby gives them a fully understanding of how the processes within the company look like. However, it is important to understand that process mapping does not signify improvements of the processes since the mapping is only one-step in the development of the organization's processes (Ljungberg and Larsson, 2001).

3.2.4 The Components of the Process

The process includes five key words: *object in/input*, *activity*, *resources*, *information*, and *object out/output*. The input is what starts a process, such as an order, i.e. customer need. An *activity* is what adds value to the *object in* or the input, such as planning of production and production of the products. *Resources* are needed

in order to complete the activity, such as human resources, material handling equipment, storage area, etc. *Information* supports and controls the process. The *object out* is the result of the transformation, for example a finished product, and can sometimes activate the next object in (Ljungberg and Larsson, 2001).

3.3 Supply Chain Management (SCM)

Researchers and managers have debated for approximately the last 15 years about the definition of supply chain management. Some believe that SCM is just integrated logistics properly implemented. Others view SCM as the integration of more functions than just logistics (e.g. manufacturing with marketing and R&D, etc.). Cooper, et al. (1997) point out the need for “the integration of business operations in the supply chain that goes beyond logistics.” Discussion with members of the Global Supply Chain Forum (GSCF) resulted in the following definition of SCM:

“Supply Chain Management is the integration of key business processes from end user through original suppliers that provides products, services and information that add value for customers and other stakeholders” Lambert and Cooper (2000).

The eight key processes identified are shown in Table 1. Each process is customer-focused and aims to achieve superior product flows through the efficient use of information along the supply chain.

Process	Description of Process
Customer relationship management	In the customer relationship management process, key customers are identified and worked with closely to establish product and service agreements that specify the levels of expected performance. Also, customer service teams work with customers to further identify and eliminate sources of demand variability.
Customer service management	A single source of customer information is provided in this process. A key point of contact for administering the product/service agreement is established.
Demand management	Point-of-sale and “key” customer data is used to reduce uncertainty and provide efficient flows throughout the supply chain.
Order fulfillment	Integration of the firm’s manufacturing, distribution and transportation plans is performed in this process in order to guarantee timely and accurately filled orders.
Manufacturing flow management	Ideally, orders are processed on a just-in-time (JIT) basis where required delivery dates drive production priorities. Furthermore, manufacturing processes must be flexible enough to respond quickly to market changes.
Procurement	Long-term strategic alliances with a small core group of suppliers are utilized in conjunction with rapid communication mechanisms (e.g. EDI, Internet, etc.).
Product development and commercialization	Customer Relationship Management is coordinated with this process to identify customer-articulated and –unarticulated needs. Procurement is involved in this process as well to select materials and suppliers. Coordination with Manufacturing Flow Management is needed to develop production technology and integrate into the best supply chain flow for the product/market combination.
Returns	The Returns process enables identification of productivity improvement opportunities.

Table 1: Eight Supply Chain Processes Proposed by Lambert and Cooper (2000).

Taking a slightly different perspective, Ballou, et al. (2000) identifies three dimensions of supply chain management. They are intra- functional coordination, inter-functional coordination and inter-organizational coordination. Intra- functional coordination refers to the administration of the activities and processes *within* the logistics function of a firm. Inter-functional coordination refers to the coordination of activities *among* the functional areas of the firm while inter-organizational coordination refers to the coordination of supply chain activities that take place *between* legally separate firms within the product- flow channel. Hence, the following definition for supply chain management was proposed:

“The supply chain refers to all those activities associated with the transformation and flow of goods and services, including their attendant information flows, from the sources of raw materials to end users. Management refers to the integration of all these activities, both internal and external to the firm.”

Also emphasizing the importance of functional coordination and strategic congruence, Mentzer, DeWitt, Keebler, Min, Nix, Smith and Zacharia (2001) define supply chain management as:

“The systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole.”

Other definitions of supply chain management are offered in Table 2.

Authors	Definition
Tan et al. (1998)	SCM encompasses materials/supply management from the supply of basic raw materials to final product (and possible recycling and re-use). SCM focuses on how firms utilize their suppliers' processes, technology and capability to enhance competitive advantage. It is a management philosophy that extends traditional intra-enterprise activities by bringing trading partners together with the common goal of optimization and efficiency.
Berry et al. (1994)	SCM aims at building trust, exchanging information on market needs, developing new products, and reducing the supplier base to a particular OEM so as to release management resources for developing meaningful, long term relationships.
Jones and Riley (1985)	An integrative approach to dealing with the planning and control of the materials flow from suppliers to end-users.
Saunders (1995)	External Chain is the total chain of exchange from original source of raw material, through the various firms involved in extracting and processing raw materials, manufacturing, assembling, distributing and retailing to ultimate end customers.
Elram (1991)	A network of firms interacting to deliver product or service to the end customer, linking flows from raw material supply to final delivery.
Christopher (1992)	Network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer.
Lee and Billington (1992)	Networks of manufacturing and distribution sites that procure raw materials, transform them into intermediate and finished products, and distribute the finished products to customers.
Kopczak (1997)	The set of entities, including suppliers, logistics services providers, manufacturers, distributors and resellers, through which materials, products and information flow.
Lee and Ng (1997)	A network of entities that starts with the suppliers' supplier and ends with the customers' custom production and delivery of goods and services.

Table 2: Definitions of Supply Chain Management. Reproduced from Croom, Simon, Pietro Romano and Mihalis Giannakis, "Supply Chain Management: An Analytical Framework for Critical Literature Review," *European Journal of Purchasing and Supply Management*, Vol. 6, 2000, pp. 67-83.

Though these definitions differ slightly in wording, all communicate the importance of integration, communication and coordination between functions and organizations that will create value for the customer.

Other researchers have attempted to develop math models to address coordination in the supply chain. Many of these models attempt to minimize inventory in the supply chain. However, these analyses are dyadic in nature, examining the interaction of only two supply chain members, a buyer and a supplier. Thus, the entire supply chain as given by the previous definitions is not modeled using these analytical methods. In addition, inventory is not the only consideration or motivation for supply chain coordination. Thomas and Griffin (1996) reviewed the literature that uses math models to address supply chain coordination issues.

Several authors have proposed frameworks for the design and control of supply chains (Davis 1993; Beamon and Ware 1998; Bowman 1997; Sengupta and Turnbull 1996). However, much of this work is geared toward the manager and does not give theoretical insights as to how supply chain management relates to functional strategies. One of the goals of this study is to examine the relationship among the type of supply chain a firm participates in and two of the firm's functional strategies, namely their manufacturing and logistics strategies.

One of the seminal papers on supply chain management provides a framework for determining what type of supply chain is appropriate for a particular product. Fisher (1997) recommends first examining a product's demand nature in order to determine what type of supply chain to use. Products fall into one of two categories according

to Fisher, primarily functional or primarily innovative products. Functional products have stable demand, low profit margins and long life cycles. Innovative products have unpredictable demand, short life cycles and higher profit margins. Functional products require an efficient supply chain that minimizes cost while innovative products require a responsive supply chain that maximizes speed and flexibility. Any other combination of product type and supply chain type will result in inferior performance.

Akin to the efficient and responsive supply chains are the two supply chain archetypes that have evolved in the literature, the lean and the agile supply chain. Naylor et al. (1999) define agility as “using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile market place” (pg. 108). They define leanness as “developing a value stream to eliminate all waste, including time, and to ensure a level schedule” (pg. 108). Both types may be employed simultaneously in the supply chain. Though both archetypes use market knowledge and are concerned with waste elimination and lead-time compression, the two do have several differences. Smooth demand and level scheduling are essential to the lean supply chain whereas robustness and rapid reconfiguration capabilities are essential in the agile supply chain. Metrics also have differing importance levels in the lean and agile supply chains. Both paradigms share lead-time and quality as key metrics. However, service is a key metric for the agile supply chain while costs are a key metric for the lean supply chain (Naylor, et. al., 1999).

Christopher and Towill (2000) go so far as to outline the market qualifiers and winners for the agile and lean supply chains. Market qualifiers are those

characteristics that enable a company to be considered by potential customers. Market winners are those characteristics that lead a customer to choose to purchase from a particular company.

Quality, cost and short lead-time are the market qualifiers for the agile supply chain whereas service is the market winner. Cost, however, is the market winner for the lean supply chain and quality, service, and lead-time are market qualifiers. Christopher and Towill (2000) also outline the distinguishing attributes for the lean and agile supply chains. They are summarized in Table 3:

Distinguishing Attributes	Lean Supply	Agile Supply
Typical products	Commodities	Fashion goods
Marketplace demand	Predictable	Volatile
Product variety	Low	High
Product life cycle	Long	Short
Customer drivers	Cost	Availability
Profit margin	Low	High
Dominant costs	Physical costs	Marketability costs
Stockout penalties	Long term contractual	Immediate and volatile
Purchasing policy	Buy goods	Assign capacity
Information enrichment	Highly desirable	Obligatory
Forecasting mechanism	Algorithmic	Consultative

Table 3: Characteristics of Lean and Agile Supply Chains. Reproduced from Christopher, Martin and Denis Towill “Supply chain migration from lean and functional to agile and customized” *Supply Chain Management: An International Journal*, Vol. 5, No. 4 (2000), pp. 206-213.

In 2001, Harland, Lamming Zheng and Johnsen offer their own taxonomy of supply networks. Their taxonomy is very similar to the efficient/responsive and lean/agile

paradigms, however they also include the issue of power in the channel. The four network types established in their paper were the 1) dynamic/low degree of focal firm influence, 2) dynamic/high degree of focal firm influence, 3) routinized/low degree of focal firm influence and 4) routinized/high degree of focal firm influence.

Both types of dynamic supply networks operate under dynamic conditions and tended to compete primarily on innovation rather than cost. Both types of routinized supply networks operated under stable conditions and competed on cost minimization and quality improvement. Thus, the routinized network can be likened to the lean or efficient supply chain type and the dynamic network can be likened to the agile or responsive supply chain type. Mason-Jones et al. (2000) also outline the market qualifiers and market winners for lean and agile supply chains. Quality, cost and lead time are market qualifiers for the agile supply chain while service level is the market winner for the agile supply chain. Quality, lead time, and service level are the market qualifiers for the lean supply chain and cost is the market winner for the lean supply chain.

Christopher and Towill (2001) make the proposition that a company need not choose to be exclusively lean or exclusively agile in their supply chain operations. Rather the demand pattern for the product should determine the strategy. Firms may implement hybrid strategies in which lean methods are used for the higher volume product lines that have stable demand and agile methods are used for the slower moving product lines. A supply chain may be lean up to the de-coupling point and agile downstream from the decoupling point. Similarly, if a firm knows what the base level demand is for a product line, it can use lean methods to manage that

forecastable element and use agile methods to manage the less predictable element.

Lamming et al. (2000) attempt to classify supply networks (or supply chains) using several case studies. The type of product was used as the differentiator between the network types. They found that the competitive priorities for supply networks of unique-innovative products differed from those for functional products. Supply networks for unique-innovative products focused on speed, flexibility, innovation and quality supremacy. Supply networks for functional products focused on cost reduction and quality sustainability. Thus, there is initial evidence suggesting the existence of different types of supply chains that require different sets of competitive priorities from its members. According to Fisher (1997) suppliers for efficient supply chains should be chosen based on cost and quality while suppliers in responsive supply chains should be chosen based on speed, flexibility and quality.

Tan, Kannan, Handfield and Ghosh (1999) attempted to link certain supply chain management practices with firm performance. In particular, they examined the effects of quality management, supply base management and customer relations practices on firm financial performance. They found that some aspects of quality management – use of performance data in quality management, management commitment to quality, involvement of quality department, and social responsibility of management -- all were positively related to firm performance. Managing the supply base was found to have a significant impact on firm growth but not on overall performance. Customer relations were positively associated with firm performance, indicating the need for firms to have a customer orientation. Customer orientation is also highlighted in many of the supply chain management definitions presented

earlier in this section. The significance of supply base management highlights the need for companies to actively manage their supply chain to maximize their performance. As Mentzer et al. (2001) said, a supply chain will exist whether a firm actively manages it or not. Fewer managers are letting the supply chains be controlled through external forces but are taking proactive roles in the supply chain management process. This proactive stance indicates the increased need for a greater understanding of supply chain management and how it affects a firm's functions.

Cavinato (1999) attempted to link how logistics is viewed in a supply chain management context to the five stages of strategic management. He was attempting to show how different managerial skills and outlooks are required in the different stages of strategic management. Thus, firms need to match their management of logistics to their current strategic outlook. The advantage of acknowledging the current state of a firm is that it can also examine how to move to the next developmental level. The five stages are basic financial planning, forecast-based planning, externally oriented planning, strategic management and knowledge-based business. The Knowledge-based business has a process view and sees supply chain strategy as it affects the overall firm and each particular product. Thus, in order to move to becoming a knowledge-based firm, firms must recognize how their supply chain management activities affect each individual function as well as each individual product line. Logistics and manufacturing strategies, in particular, are significantly affected by supply chain management activities. The strategic orientation of the firm will determine how these functions are managed.

3.4 Manufacturing Strategy

Manufacturing strategy has been defined as the pattern of decisions that, over time, enable a business unit to achieve a desired manufacturing structure, infrastructure and set of specific capabilities (Hayes and Wheelwright, 1984). As seen in Figure 2, manufacturing strategy and other functional strategies cannot be determined in isolation. Changing customer demands and competitive environments necessitate the careful consideration of each decision since the wrong decision can have dire long-term consequences. The typical manufacturing competitive priorities are low cost, delivery, flexibility and quality.

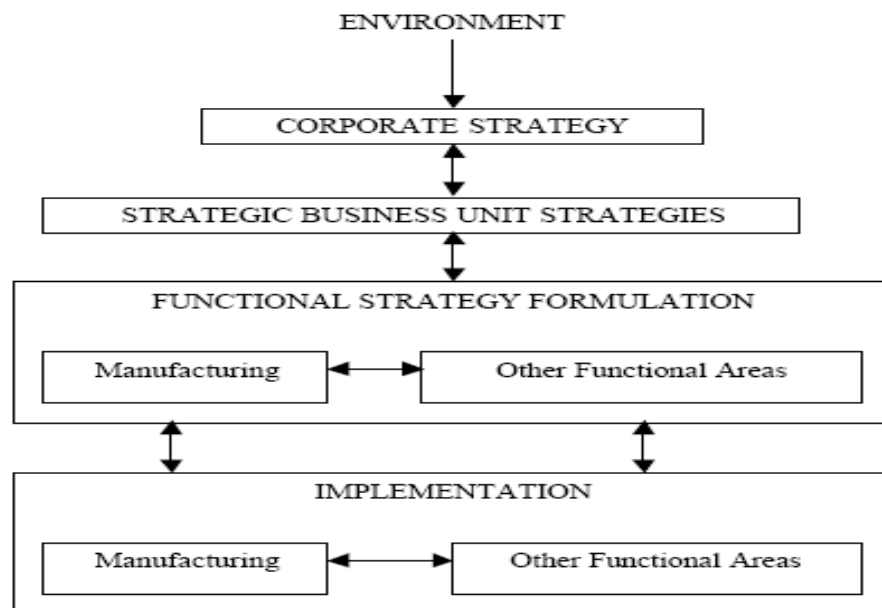


Figure 2: Strategy Formulation. Adapted from Leong, Snyder, and Ward, "Research in the Process and Content of Manufacturing Strategy" *International Journal of Management Science*, Vol. 18, No. 2, (1990), pp. 109-122.

Williams et al. (1995) examine manufacturing strategy, business strategy and firm performance in a mature industry (broadwoven fabric industry). Williams, et al. (1995) find a significant relationship between manufacturing and business strategy. They also find that businesses that choose higher levels of differentiation emphasized innovative manufacturing processes, product quality and variety of product offerings.

Ward et al. (1995) examine manufacturing strategy, business environment and performance among Singaporean firms. They find that high performers emphasize different manufacturing competitive priorities than low performers. The typical business/competitive environment factors considered are munificence, dynamism and complexity (not included in their study). Munificence refers to the extent to which an environment supports growth of organizations within it. Dynamism refers to the unpredictable change in environmental conditions faced by firms. Complexity refers to the heterogeneity and range of an organization's activities.

Ward et al. (1995) find that higher environmental dynamism is associated with higher emphasis on delivery performance, flexibility and quality. In particular, low performers focus on flexibility, delivery, quality and cost reductions in the presence of high dynamism while high performing firms focused only on delivery, quality and flexibility. In addition, low performers focused on cost reduction and differentiation when in the face of increased competition while high performers emphasized only differentiation through delivery performance. Thus, there is not one particular strategy that is appropriate in all circumstances.

3.5 Logistics Strategy

Though the manufacturing strategy literature has very well defined competitive priorities, the logistics strategy literature is not as conclusive to date. Bowersox and Daugherty (1989) proposed a framework for logistics strategy classification. The three strategies they articulated were the process, market and channel strategies. The process-based strategy is concerned with managing a broad group of logistics activities as a value-added chain. Emphasis is on achieving efficiency from managing purchasing, manufacturing, scheduling, and physical distribution as an integrated system. The market-based strategy is concerned with managing a limited group of logistics activities for a multidivisional single business unit or across multiple business units. The logistics organization seeks to make joint product shipments to common customers for different product groups and seeks to facilitate sales and logistical coordination by a single order-invoice. The channel-based strategy is concerned with managing logistics activities performed jointly with dealers and distributors. The strategic orientation places a great deal of attention on external control. Significant amounts of finished inventories are typically maintained forward or downstream in the distribution channel. These strategies, however, are very descriptive in nature and do not attempt to identify the competitive priorities or capabilities that a firm may attempt to exploit or develop through their logistics operations.

Clinton and Closs (1997) attempt to identify the underlying factors for the process/market/channel classification. They find that the framework is “promising.” However, significant overlap among the strategies was observed though the relative emphasis on activities (e.g. alliances, planning, control, etc.) differed slightly. Thus,

a more illuminating framework is needed for logistics strategy.

McGinnis and Kohn (1990) performed a factor analysis study of logistics strategy. Four strategies were identified: (1) intensive logistics strategy; (2) integrated logistics strategy; (3) low integration strategy; (4) low effectiveness logistics strategy. Definitions of these strategies can be found in Table 4.

Strategy	Description
Intensive Logistics Strategy	Highest emphasis on customer service commitment, coordinated logistics, integrated customer service and logistics coordination effectiveness.
Integrated Logistics Strategy	Highest emphasis on integrated computer systems and also emphasized coordinated logistics, integrated customer service and logistics coordination effectiveness.
Low Integration Strategy	Low emphasis on integrated computer systems and logistics coordination effectiveness with moderate emphasis on customer service commitment, coordinated logistics and integrated customer service.
Low Effectiveness Logistics Strategy	Low emphasis on customer service commitment, coordinated logistics and logistics coordination effectiveness with moderate emphasis on computer system and customer service integration.

Table 4: Descriptions of Logistics Strategies Determined by McGinnis and Kohn (1990), "A Factor Analytic Study of Logistics Strategy" *Journal of Business Logistics*, Vol. 11, No. 2, pp. 41-63.

Similarly, these four strategies also are data driven and do not explain the logistics capabilities a firm may try to develop or exploit in order to enhance or maintain their competitive advantage.

McGinnis and Kohn in 1993 examined the relationships between logistics strategy, organizational environment and time competitiveness. Using both the Bowersox and Daugherty (1989) and the McGinnis and Kohn (1990) frameworks for logistics strategy, they found that competitive responsiveness, dynamism and hostility affect logistics strategy. They also found that high levels of dynamism, hostility and competitive responsiveness were associated with the Intensive Logistics Strategy. The Process and Market strategies are emphasized in the Intensive Logistics Strategy and customer service and logistics coordination are high priorities.

Some authors attempted to identify the logistics capabilities a firm may possess and their relationship to other variables. Lynch, Keller and Ozment (2000) studied the effects of logistics capabilities and corporate strategy on firm performance. They examined process capabilities, value-added service capabilities, cost leadership strategy, and differentiation strategy. Their results indicated that process capabilities were positively linked to a cost leadership strategy while value-added service capabilities were positively linked to a differentiation strategy. Firms that exhibited a “match” between their capabilities and strategy had better performance than those who did not exhibit such a “match.” Their results support the notion that one strategy is not applicable in all competitive situations.

Morash, Dröge and Vickery (1996) examined the relationship between logistics

capabilities and performance. The capabilities were grouped into two areas, demand-oriented and supply-oriented capabilities. Demand-oriented capabilities included pre-sale and post-sale customer service, delivery speed, delivery reliability and responsiveness to target market(s). Supply-oriented capabilities included widespread and selective distribution coverage, and low total cost distribution.

Among the capabilities studied, the demand-oriented capabilities were ranked higher in importance and implementation than supply-oriented capabilities. Only four capabilities were linked to performance: delivery speed, delivery reliability, responsiveness and low cost distribution. These capabilities closely mirror the competitive priorities used in manufacturing strategy literature.

Since Hayes and Wheelwright (1984) describe strategy as the pattern of decisions that, over time enable a business unit to achieve a desired manufacturing structure, infrastructure and set of specific capabilities, logistics strategy can similarly be viewed as the pattern of decisions that enable a business unit to achieve specific logistics capabilities. Logistics capabilities, determined by Morash et al. (1996) in the research, are shown in Table 5.

Also, the subjects of competitive advantage (Porter, 1985) and the resource-based theory of the firm (Barney 1991; Rumelt 1984; Penrose 1959) have both received a considerable amount of attention in the strategy literature. Researchers in some disciplines, such as logistics and marketing, have recognized the applicability of these subjects to their areas (Day 1988; McGinnis and Kohn 1990; Stock 1990).

Traditionally, these two subjects have been examined independently of one another as the competitive advantage literature has focused more on favorable environmental conditions in the creation of competitive advantage, while the resource-based view of the firm has taken an internal focus in identifying the unique resources that can give a firm an advantage in the marketplace.

Logistics Capabilities*
Low total cost distribution
Pre-sale customer service, Post-sale customer service
Delivery speed, delivery reliability
Responsiveness to target market, widespread distribution, selective distribution

Table 5: Morash, Droge and Vickery “Strategic Logistics Capabilities for Competitive Advantage and Firm Success” *Journal of Business Logistics*, Vol 17, No. 1 (1996), pp. 1-22.

3.6 Competitive Advantage

Most of the research in the competitive advantage literature has focused on identifying the sources of competitive advantage and how it can be sustained over time (Hall 1993; Hitt and Ireland 1985). Porter (1985) states that competitive advantage is the result of a firm creating value for its' buyers that exceeds the costs associated with creating the value. There are many different ways a firm can create the type of value identified by Porter (1985). The manufacturing, marketing, or distribution activities of the firm can all be used to construct value. However, firms have to be aware of what products/services, activities, and/or processes are valued by the customer.

Research has identified several ways in which a firm can achieve a competitive advantage. Porter (1985) identified cost leadership and differentiation as the two primary methods. To achieve a cost advantage, companies have to understand the underlying cost structure of their activities and how the interrelationships among activities affect costs. Functional areas within the firm that share activities or knowledge can realize lower costs if the activities are similar or the knowledge is significant to minimize or eliminate inefficiencies. Similarly, Porter (1985) indicated coordination of activities across companies could impact costs. Linking activities among members of the supply chain can reduce costs, but they can also increase costs. Therefore, companies should approach the identification of areas to be integrated from a strategic perspective, which can distinguish the benefits versus the costs of various activities to be coordinated.

To achieve a competitive advantage based on differentiation, companies have to

understand the potential sources of differentiation. Examples include the physical product, marketing activities, distribution activities, and human resources. Porter (1985) defines differentiation as, “providing something unique that is valuable to buyers beyond simply offering a low price.” The key is customers have to perceive the offering as providing value greater than what could be obtained from other firms.

While it is important to understand what can lead a firm to obtain a competitive advantage, it is also imperative to identify how a competitive advantage can be maintained over time. To achieve a *sustainable* competitive advantage, the strategy implemented must not only provide value to buyers, but also prevent imitation by competitors (Porter, 1985). Barney (1991) suggests it is not the amount of “calendar” time that determines whether a firm has a sustainable competitive advantage, but rather the inability of competitors, both current and potential, to duplicate that strategy. For example, the degree to which differentiation results in sustainable competitive advantage depends on whether buyers continue to perceive value in the form of differentiation and whether it can be easily imitated by competitors (Day 1988; Porter 1985).

Researchers, such as Porter (1985; 1980), were initially concerned with how external environmental factors influence conditions of competitive advantage within a particular industry. For example, the five forces model developed by Porter (1980) suggests firms in industries characterized by high entry barriers will have greater opportunities to achieve high levels of firm performance. The assumptions inherent in the industry focus are that firms are identical in terms of resources and strategies and any resource heterogeneity that exists within the industry will be transitory due

to the ability of others to acquire the resource (Barney 1986; Rumelt 1984; Porter 1980). However, others have suggested resource heterogeneity can be a source of competitive advantage based on the resource-based view of the firm (Penrose 1959; Rumelt 1984; Barney 1991). In fact, it has been suggested that competitive advantage can only be achieved when resources are combined in such a way that they create a unique capability that is valued by customers (Morgan and Hunt, 1999).

3.7 Resource-Based Theory of the Firm

The analysis of the firm as “a collection of productive resources” was first proposed by Penrose (1959), and serves as the foundation for the resource-based theory of the firm. Essentially, this theory implies a firm possesses specialized assets, skills, or resources that can be utilized to improve firm performance and to create a competitive advantage. Penrose (1959) suggested the level of rents achieved by an organization is based on how it takes advantage of its core competencies to utilize its resources. Rents are the result of accumulating and utilizing heterogeneous resources that are better than those of the competition.

A resource can be thought of generally as a strength or weakness of the firm or, more specifically, as the tangible and intangible assets that are associated with the firm (Wernerfelt, 1984). Tangible resources include physical resources, such as facilities, transportation equipment, or production equipment. Improvements in tangible resources may lead to lower costs, and thus, improved performance. However, it has been suggested that tangible resources cannot serve as a source of sustainable advantage since others can purchase them in the market (Dierickx and Cool, 1989). As a result, intangible resources such as corporate culture, knowledge, distribution

control, relationships, and customer loyalty have received more attention in the resource-based literature (Itami and Roehl 1987; Winter 1987). Intangible resources have been classified as both assets (e.g., trademarks, data bases) and competencies (e.g., knowledge, skills) (Hall, 1993), and are the major source of firm heterogeneity (Mahoney, 1995).

Not all firm resources may lead to a sustainable competitive advantage. Researchers have investigated the link between the resources of the firm and sustainable competitive advantage (Rumelt 1984; Lippman and Rumelt 1982) and found a resource needs to possess certain attributes in order to lead to a sustainable competitive advantage. Resources should be valuable, rare, imperfectly imitable, and imperfectly substitutable (Barney 1991; Lippman and Rumelt 1982). A resource creates value if it can enable a firm to improve performance through the implementation of a particular strategy. Valuable resources enable a firm to take advantage of opportunities and minimize threats in the environment, which should lead to improved performance (Barney, 1991). The resource must not only be valuable, but also rare in that not all competitors within an industry possess the resource. If competitors do possess common resources, those resources cannot be used to gain a competitive advantage since each of the competitors can implement a common strategy based on the resources.

For a resource to be imperfectly imitable, it must be causally ambiguous (Barney 1986; Lippman and Rumelt 1982; Rumelt 1984). For example, the resource must be difficult for competitors to understand exactly how a firm achieves its benefits from the resource. Causal ambiguity has been identified as a source of “isolating

mechanisms and firm heterogeneity” and is most likely to be created by intangible assets (Itami and Roehl 1987; Hall 1992).

The final requirement for a resource to contribute to the creation of competitive advantage is other resources must not be equally as valuable from a strategic perspective. It must not be possible for another firm to use some other resource to implement the same strategy to achieve the same benefits. If two different resources used by two different companies are strategically equivalent, then neither company will have a competitive advantage.

How resources of the firm are converted into a sustainable competitive advantage has commonly been thought to depend upon the competitive situation of the industry (Seth and Thomas, 1994). However, the resource-based view may be able to explain differences in firm profitability that cannot be attributed to industrial differences (Peteraf, 1993). Day and Wensley (1988) indicated that firms have to identify “the skills and resources that exert the most leverage on positional advantages and future performance and then allocate resources toward those high leverage sources” in order to get the greatest performance improvement at the least cost. Positional advantages refer to the ability of the firm to provide superior customer value or to achieve low costs relative to competitors (Day and Wensley, 1988). As a result of achieving positional superiority, the firm should be able to realize greater performance in terms of profitability or market share. However, there is a lack of research on how to convert positional advantages into superior performance outcomes. Research on how to identify distinctive capabilities and how positional advantages are linked to particular capabilities has been called for in the literature (Day, 1994).

3.8 Role of Logistics in the Firm

The view of logistics within the organization has evolved over the past 30 years from a cost center and revenue generator to a core competency and differentiator for the firm (Langley, 1986). It has predominantly been viewed as a cost center, and the focus has been on how to reduce costs associated with the activities of inventory management, warehousing, transportation, materials handling, and order processing. However, it has also been recognized that firms should not consider logistics simply from a cost perspective, but should also recognize the revenue generating capabilities of the area (Christopher, 1986). By focusing only on costs in logistics, managers may fail to recognize the impact of cost reductions on customer service levels. Companies that attempt to improve logistics processes may improve customer service. The revenue generated from better customer service may offset any costs incurred as a result of improving logistics processes. Of course, managers need to have a good understanding of the customer service levels desired by customers.

Logistics is increasingly viewed as a core competency of the firm. Firms are recognizing the strategic importance of logistics just as they have manufacturing and marketing. While marketing has long played a role in the strategic decisions of the firm, logistics has only recently been recognized in terms of its value at the strategic level. As Bartels indicated back in 1976, "distribution is becoming an increasingly important aspect of the strategic plans of marketing-oriented companies." Hutt (1995) also indicated many organizations are recognizing that various functional areas participate to differing degrees in the design, development, and implementation of strategy.

How logistics is considered within the organization has evolved from an operational perspective to a tactical perspective to a strategic perspective (La Londe, 1990). Fuller et al (1993) stated, “logistics has the potential to become the next governing element of strategy as an inventive way of creating value for customers and as an immediate source of savings.” Cooper, Innis, and Dickson (1992) indicated that organizational structure and management style indicate how logistics fits into corporate strategy. Similarly, Sharma et al (1995) developed a framework that examines the impact of a firm’s logistics policy on customer satisfaction, profitability, and strategic planning. As a competence, logistics can be used to create superior service or value to customers.

Finally, logistics is also viewed as a resource that can differentiate the firm in the marketplace. According to the resource-based view of the firm, the way to achieve a sustainable competitive advantage is through the implementation of strategy based on the firm’s unique resources. Essentially, resources should determine a firm’s strategy (Mahoney, 1995). Coyne (1986) indicated that companies can develop different types of capability differentials as sources of sustainable competitive advantage. For example, if a firm has the appropriate knowledge and skills in the logistics area, it can develop the functional capability to do specific things through logistics to gain a competitive advantage. Similarly, if an organization can improve its logistics performance through integrated decision-making, it may be able to provide a higher level of customer service and create value for its customers. A study by Sterling and Lambert (1987) revealed that physical distribution/customer service could provide firms with an opportunity to gain a competitive advantage in the market place. Imitating logistics activities is somewhat more difficult due to the interdependence

and integration of several processes within the company and often across companies.

While the potential for an organization to differentiate itself through its logistics capabilities alone may exist, the importance of integrating logistics capabilities with other areas of the firm should not be ignored. It has become necessary to integrate business processes and recognize that horizontal decision-making across functional boundaries is essential to organizational performance (Smart, 1995). Driven by needs to reduce costs and improve customer service, many companies pursuing a market orientation are discarding their traditional organizational structures. Often functional units within an organization develop their plans in isolation without knowledge or consideration of the plans being developed by other functional areas. However, each functional area needs to understand the impact it can have on other areas, the decision-making process of the firm, and the market response to the firm's product/service offering (Lim and Reid, 1992).

Traditionally, the provision of customer service, and more recently the creation of customer value, has been viewed as the responsibility of the marketing area within the organization. However, it has been recognized in the literature that customer service should be the responsibility of the entire firm, not just one area (Barwise 1995; Webster 1988; Christopher 1973). Similarly, the firm should be viewed as a collection of activities that are aimed at providing value to its customers (Porter, 1985). Barwise (1995) suggested this is particularly important if organizations have adopted a market orientation. "Marketing can no longer be the sole responsibility of a few specialists. Everyone in the firm must be charged with responsibility for understanding customers and contributing to developing and delivering value for

them” (Webster, 1988). Some organizations, though, fail to implement cross-functional management even though they are aware of the value that can be created (Ames and Hlavacek, 1989).

While there is a considerable amount of literature on the subject of interfunctional relationships, some areas of the organization have received more attention than others. For example, marketing’s relationship with areas such as manufacturing and research and development has received quite a bit of attention in the literature (Song et. al. 1996; Ruekert and Walker 1987; La Londe 1990; Gupta et. al. 1986). Rinehart, Cooper, and Wagenheim (1989) indicated that marketing and logistics activities should be the focus of integration within a firm since they are the primary functions that interface with the customer. “Three of the marketing mix elements (product, price, and promotion) are dependent on the cost of making the product available to the customer” (Voorhees and Coppett, 1986). Essentially, companies must consider all of the interfaces where customer contact can be enhanced by service and consider all of the costs and benefits received from such service offerings. “The logistics service package should be considered a marketing tool and subjected to the same cost-effective scrutiny as any other marketing expenditure” (Christopher, 1973).

3.9 Logistics and Marketing Integration

The marketing and logistics areas, especially marketing’s role in the distribution process, should be integrated in order to enable companies to successfully cope with future strategic problems (Schneider, 1985). Research has addressed the importance of a logistics-marketing relationship from a strategic perspective. In considering the impact of integration of logistics and marketing on strategy, three levels of decision-

making (strategic, tactical, and operational) within an organization should be considered (Christopher, 1973). These levels are interdependent and decisions in one area impact decisions and performance of other areas. If the company does not consider itself as a total system, but rather as separate functional silos, then total performance will be diminished. To change to an integrated, process-oriented organization, Fawcett and Fawcett (1995) suggested change has to begin with top management and the strategic planning process. Strategic planning can be defined as, “the process of identifying the long-term goals of the entity and the broad steps necessary to achieve these goals over a long term horizon, incorporating the concerns and future expectations of the major stakeholders” (Cooper, et. al., 1992).

Rommel (1991) presented a framework for integrating the concepts of marketing and logistics to create a competitive strategy. The steps of the strategy are to: (1) investigate customer wants; (2) assess logistics and marketing performance; (3) assess competitors’ performance; (4) develop an integrated strategy; and, (5) implement the strategy. The fourth and fifth steps focus on the integration of logistics and marketing to satisfy customer requirements. Porter (1980) stated, “the fundamental basis of above average performance in the long run is sustainable competitive advantage.” The marketing manager can succeed in achieving above average performance in the marketplace by developing a competitive advantage for the product/service offered to the consumer. Competitive advantage is often derived by taking into account the expected utilities or benefits associated with the product (Barry, 1980). Once again, this can be accomplished through the addition of a service component - service components that fall within the boundaries of logistics such as timeliness of delivery and delivery reliability. By recognizing the potential benefits

of integrating logistics and marketing decisions, organizations may be able to achieve logistics leverage. This may provide them with a competitive advantage, especially if competitors are not integrating their functional activities.

3.10 Logistics Leverage

The literature presented in the areas of competitive advantage, the resource-based theory of the firm, and the strategic importance of the integration of the logistics and marketing areas culminates into the idea of logistics leverage. Bowersox, Mentzer, and Speh (1995) first introduced the concept and defined it as “the ability to effectively influence market demand through the application of excellent logistics systems, techniques, and programs.” They indicated that it is not only becoming necessary for companies to develop logistics superiority, but also to strategically integrate logistics and marketing to create a competitive advantage. By doing so, firms may be able to more effectively implement marketing strategies as well as recognize improvements in sales, market share, and customer satisfaction.

To “influence market demand” or to create a competitive advantage, the logistics superiority of the firm has to be valued by its customers. To create value, the logistics processes of the firm have to provide customers with the opportunities to improve performance, reduce costs, and/or improve customer service. Mentzer and Williams (2001) extended the logistics leverage concept to include such a focus. Through the extant literature and case studies, they developed a revised definition of logistics leverage as,

“the achievement of excellent and superior, infrastructure-based logistics performance, which - when implemented through a

successful marketing strategy - creates recognizable value for customers.”

The definition suggests it is not sufficient to simply develop “excellent and superior” logistics performance to create customer value. This capability has to be communicated to customers in such a way that they recognize the value that can be received by working with a company that possesses such a capability. In trying to achieve logistics leverage, a company must strive to create and maintain logistics service that is superior to its competitors’ service offerings in providing value to customers.

The Mentzer and Williams (2001) conceptualization of logistics leverage recognizes that factors such as technology, people, facilities, and strategic relationships provide the infrastructure to create logistics leverage. Through the development of these infrastructure components, companies should be able to achieve improved company performance through reduced costs and improved customer satisfaction. In addition, it is recognized that to achieve logistics leverage, coordination between the marketing and logistics areas of the firm has to occur.

Only one study has empirically examined the concept of logistics leverage. Kent (1996) examined the coordination of the information technology and logistics areas of the firm and the resulting impact on performance. The logistics leverage concept was extended to what is referred to as “Leverage.” Leverage is defined as,

“the maximization of customer value, process efficiency, and differential advantage through the interfunctional coordination between logistics and information technology” (Kent, 1996).

This definition extended the one developed by Bowersox, Mentzer, and Speh (1995) in two ways. First, there is the recognition that decisions in logistics and information technology are interrelated; thus, there should be interfunctional coordination between the two areas. Second, logistics leverage can do more than stimulate temporary demand for a company's product/services. By creating customer value, companies may be able to develop customer loyalty and ensure sales and profitability in the long run. In addition, competitors may not be able to imitate the logistics service, which creates differential advantage. Using in-depth interviews, Kent (1996) found some support for improved internal efficiencies through the coordination of information technology and logistics.

Achieving superior logistics performance can result in many benefits to customers. The benefits may include improved satisfaction with the company's products/services and overall improved customer value. These benefits are the result of improved customer service and reduced costs, which may be realized as a result of logistics leverage. La Londe, Cooper, and Noordewier (1988) defined customer service as, "a process for providing significant value-added benefits to the supply chain in a cost-effective way." Logistics plays an important role in the creation of customer service.

In addition to the benefits received by consumers, there are also benefits to the company. Mentzer and Williams (2001) identified reduced operating costs, improved market share, and improved profitability as potential outcomes of achieving logistics leverage. Another potential outcome as a result of improved service and reduced

costs may be customer loyalty. If customers are consistently provided with desired levels of service, they may develop loyalty for the company and its products/services. The fact that logistics leverage may be difficult to duplicate enhances the possibility of building customer loyalty. The figure 3 represents the drivers, facilitators, and outcomes of Logistics Leverage.

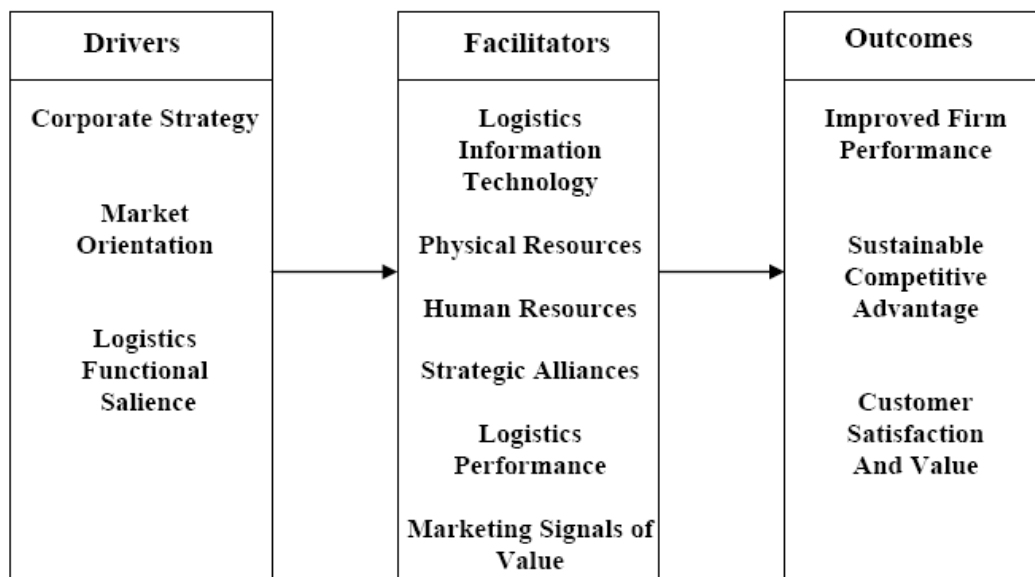


Figure 3: Drivers, Facilitators, and Outcomes of Logistics Leverage.

3.11 Logistical Goal

The logistical goal mix is the fundamental balance between service, costs and tied-up capital, which all affect profitability. Although all firms try to reach high profitability the problem, or dilemma, is that if a firm improve one part of the business it will have negative effects for other parts. An example can be to reduce transport costs by decreasing the number of shipments. The firm gets lower transportations costs but at the same time increased tied-up capital as a result of larger volumes in stock. Furthermore, the service to customers is lowered due to the decrease in number of shipments. Important here is to look at the entire picture and try to arrange these

three components in order to optimize the total result (Lumsden, 2002).

To be able to reach the best possible solution to this dilemma firms must often come up with new and intellectual ideas. This is of great importance when it comes to lowering the tied-up capital in order to decrease costs is the efficiency of the materials flow, and the layout of the storage. Large savings can be made in this area (Lumsden, 2002).

3.11.1 Logistical Profitability

There are mainly three ways of increasing profitability. This can be done partly through cost reduction, partly through increasing the incomes and partly through reducing the amount of capital tied up in stock, an increase of the rate of capital turnover. The best way to improve profitability is to use all three methods simultaneously and materials management is a cost effective combination of the three methods (Lumsden, 2002).

3.11.2 Logistical Efficiency

The logistical efficiency can be described in terms of service, costs and tied up capital. However, the problem is that a measure taken to improve one part of the business might lead to negative effects for other parts. For example, a measure used to reduce the costs might at the same time have bad effects on the service level, and thereby the revenue in the long run (Lumsden, 2002).

3.11.3 Delivery Service

To obtain a good delivery service, low costs for logistics, low amount of capital tied

up and a high quality is demanding. Delivery service is the part of logistics that generates revenue, at least in a longer perspective. A good delivery service can be everything from being a fast deliverer and always keeping its promises, to having such a reliable distribution that the goods are never damaged during transport. There is also an important interrelationship between marketing and logistics primarily when discussing service. However, the delivery service only refers to the parts in customer service that deals with the physical flow. Delivery service is a comprehensive concept that can be broken down into different parts, such as lead-time, delivery reliability, delivery security, degree of service, flexibility, and information (Lumsden, 2002). This dilemma and cost trade-off between delivery service, tied up capital and logistical cost is, according to Professor Kenth Lumsden, called the “logistical mix of goals”.

3.12 Information

Information and communication are two widely discussed words that lately have gained more focus than ever. Information is often mistakenly translated with data, which is somewhat incorrect. Information could be described as a collection of facts organized in such a way that they add value beyond the value of the facts themselves.

Data is more a collection of raw facts about e.g. inventory, part numbers etc (Stair, et. al., 2001). The most important issues in order for information to be useful are that it should be accurate, complete, reliable and timely. Information transfer can be limited by the speed of paper, faxes etc. Nowadays this problem could be easily solved by the use of electronic tools. There are four reasons why accurate information has become more critical for logistical systems. The *first* is that

customers perceive information as an element of customer service. *Second*, right information can help a company-reducing inventory and human resource requirements. Information is also a way to increase the flexibility in a company, to know where to focus money and energy, this *third* is a strategic advantage. As a fourth point, enhanced information transfer and exchange capability of information might bring buyer and sellers closer to a channel relationship (Bowersox, et. al., 2002).

3.12.1 Information Systems and its Components

The world is overflowing with different kinds of information systems that can be found in all kinds of organizations and everywhere e.g. barcode scanners automatic telling machines etc. All information systems have one common goal and that is to improve the productivity of its purpose (Bowersox, et. al., 2002).

“An information system (IS) is a set of interrelated components that collect, manipulate, and disseminate data and information and provide a feedback mechanism to meet an objective” (Stair, et. al., 2001).

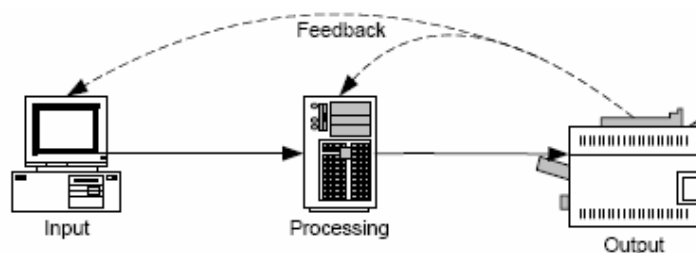


Figure 4: Components of an Information System

Source: Stair, et al, 2001, p. 13

3.12.1.1 Input

The input in an information system is the activity of gathering raw data. Everything that is put into as system is called input and could therefore be everything from

work-hours to phone calls. The important thing is that the type of input is determined by the desired output (Stair, et. al., 2001).

3.12.1.2 Processing

The processing part involves the activities of converting the input data into useful information for the output. These activities could be done either manually or preferably automatically depending on what system is used (Stair, et. al., 2001).

3.12.1.3 Output

The output is the production of valuable information. This information is then often used as input in other systems in a company. Output can be produced in various ways depending on its purpose e.g. through a printer or just handwritten reports (Stair, et. al., 2001).

3.12.1.4 Feedback

Feedback is output that is used for changes of the new input in the system. The feedback could for example show that something in the input data is very wrong and therefore have to be changed. Feedback is very important in management decision-making since this gives managers a hint of what is right or wrong in e.g. the present production (Stair, et. al., 2001).

3.12.2 Information Systems in a Company

The purpose for a company of having an information system is to be able to control various activities inside and outside the company more efficiently. Early information systems were mainly focusing on the financial activities e.g. accounting and to be an

instrument for controlling the company's economy. During the 90's, a new system was developed that supported other parts of the organization e.g. material flow as well as logistical activities (Lumsden, et. al., 2003). The new type of information system is called Enterprise Resource Planning (ERP) systems and supports the whole company, nearly all inbound as well as outbound activities. Examples of activities that can be handled with a system like this are accounting support, purchase of material, delivery of products and production activities (Lumsden, et. al., 2003).

There are many types of ERP systems that are focusing on different branches e.g. some systems are directed towards wholesaling companies, others to purchase and vendor management companies, etc. Large systems like SAP can cover nearly all types of activities in a company but even these systems have their problems, this being that it often takes a very long time to have them implemented i.e. 3-5 years (Lumsden, et. al., 2003).

3.12.2.1 Enterprise Resource Planning (ERP) Systems

Computer applications for business were first developed in the mid 1950s. These first systems were stand-alone applications. The first applications included payroll processing systems, general ledger systems, accounts payable systems, and inventory management systems. Each system involved its own logic, data and users. With these stand-alone systems it was impossible to coordinate information systems planning across business functions (Davenport, 2000). Business systems were described as "islands of automation (McKenny and McFarlan, 1982)." When new systems had something in common with existing systems they were often loosely coupled, usually manually, rather than tightly integrated (Markus and Tanis, 2000).

Data was often described differently in different functional systems. Attempts to combine data across various systems were difficult and error-prone.

Material requirement planning (MRP) systems were first developed in the 1960s to help manufacturers produce the right part at the right time with a minimum investment in inventory. Manufacturers had used inventory as a buffer to keep from running out of product that is needed to meet customer demand. The combined result of buffers at all levels of production cause inventory investment to increase dramatically. Not only did this increase in inventory put demands on the firm's cash flow to support the investment, but also made the firms more vulnerable to write-offs resulting from inventory obsolescence.

MRP works backward in time from the planned quantities and due dates for each end product as specified in the master production schedule. Using the bills of material to determine the sub-components for each final product, MRP systems determine planned production order release dates and quantities and planned material requisition requirements, taking into account existing inventory on hand and on order, and production orders in process (Sneller, 1986).

Changes in the manufacturing environment have made manufacturing planning and control systems, such as Manufacturing Resource Planning (MRP II), less relevant.

A move toward more customization is moving manufacturing from a make to stock environment to a make to order environment. The basis for competition is shifting from quality and cost to “delivery, lead times, flexibility, greater integration with the

customers and suppliers, and higher levels of product differentiation (Palaniswamy and Frank, 2000).” “The emergence of standard hardware and software platforms coupled with standards for business data capture and exchange in the form of enterprise resource planning (ERP) systems have made powerful and robust business processes affordable to companies of all sizes (Severance and Passino, 2002).”

APICS describes enterprise resource planning systems as follows:

“1) An accounting-oriented information system for identifying and planning the enterprisewide information needed to take, make, ship, and account for customer orders. An ERP system differs from the typical MRP II system in technical requirements such as graphical user interface, relational database, use of fourth-generation language, and computer-assisted software engineering tools in development, client/server architecture, and open-systems portability. 2) More generally, a method for effective planning and control of all resources needed to take, make, ship, and account for customer orders in a manufacturing, distribution, or service company (Cox and Blackstone, 1998).”

Donovan describes ERP systems as “quantum improvements over the old, rigid and often illogical MRPII systems. With today's configurable and more flexible ERP systems there's been a dramatic improvement in both the speed and ability to conform to logical, customer-oriented business processes.” MRP processes were “hard coded” with rigid, predefined business processes embedded in the software that were difficult to adapt to the real business needs.” In contrast many ERP products come “pre-packaged with multiple best practice options that management can choose from.” ERP capabilities provide the visibility and time links needed to manage the

entire supply chain (*ERP Systems Promise a Quantum Leap Over MRPII Systems*, 1998).

ERP software can result in a significant improvement over MRP and MRPII in the entire order-to-delivery process. Customers can be served at a lower cost and more predictability resulting in a competitive advantage to the firm. “Predictability means that the right inventory will be available, at the right time, to fill customer orders (*ERP Systems Promise a Quantum Leap Over MRPII Systems*, 1998).” Today's more demanding customers insist on predictability.

3.12.3 Barcodes

Bar coding is a technology for keeping track of goods in different flows. The bar coding technique is a simple technique since it only contains spaces and bars that form an arranged pattern. A special scanner that creates light waves reads the code. The information is then translated into a frequency of zero and one, the binary system (Coyle, et. al., 2000).

There are three different variations of encode-data into bar coding. The most commonly used bar code today is called Code 39. The name is given due to the codes pattern where three of nine are wide elements. Another common format is the Code 128. A third coding model is the 2-D that can be seen in various models and is one of the latest matrix barcode that has been developed. The matrix barcode can contain a lot more information than the other barcode models (Coyle, et. al., 2000).

A new technology that has been developed by Texas Instrument is called “tag-it”.

This technology is built upon a system that instead of using scanners uses radio frequency. The system has a great advantage to regular bar codes since it can be updated along the way in the supply chain (Coyle, et. al., 2000).

3.13 Summary of the Theoretical Framework

In this chapter, various theories have been outlined and explained in order to familiarize the reader with the relevant topics. Both theories with a direct connection to the research topics together with those having an indirect connection to the research topics have also been dealt with.

To get an overall view and overall thinking of the thesis, and to avoid sub-optimization theories relating to different types of processes including effective, flexible processes and identifying processes were discussed. Further, supply chain management, manufacturing/logistics strategy, and logistical goal (e.g. logistical profitability and logistical efficiency) were discussed in order to understand some of the pitfalls within logistics. These theories go hand-in-hand with the research questions because there are so many factors that influence how the distribution network can be changed to improve the efficiency and the effectiveness of delivery. Changing or improving one part of the business might have negative effects for other parts, and the total cost will increase.

The theoretical chapter also gives some general knowledge relating to information and communication as this crucial in all functioning organizations. Without a well-functioning information flow, the production at Company X will suffer leading to decreased customer satisfaction due to late or wrong orders.

EMPIRICAL FRAMEWORK

4 Empirical Framework

In this chapter, a short description of the Company X will be given followed by a competitive environment assessment. Furthermore, through this chapter the main questions will be used as a basis for describing the information provided from primary sources.

4.1 Introduction

Company X is a manufacturer and distributor of light and medium-sized construction equipment with its headquarters located in Manisa, Aegean Region, Turkey. The company purchases components for its manufacturing facilities and finished goods for distribution in Turkey on a global basis. Currently the firm's manufacturing and distribution centers are located as follows:

1. Diyarbakır, Southeast Anatolia Region – Distribution center.
2. Bursa, Marmara Region – Manufacturing facility and distribution center.
3. Manisa, Aegean Region – Headquarters and distribution center.
4. Kutaisi, Georgia – Distribution center.
5. Ağrı, East Anatolia Region – Distribution center.
6. Tokat, Black Sea Region – Distribution center.
7. Beirut, Lebanon – Manufacturing facility.

Ninety percent of the company's shipments are concentrated in Turkey, and one-half of the international shipments go to Georgia and Lebanon. Domestically the regions of Aegean, Mediterranean, Southeast Anatolia and East Anatolia concentrate about 40% of the total demand.

The distribution network mentioned above was the subject of study during the course of the 3 months-long internship that is being reported here. Due to the high volume of domestic sales a decision was made during the kickoff meetings to narrow the scope of the study to Turkey's demand only.

The work was done under the supervision of Mr. Melih Akdoğan, PhD., the management consultant for Company X, and it involved working in collaboration with a cross-functional team within the organization and even outside the organization with people in competing businesses, in third-party logistics providers, in professional associations and other organizations.

The first part of the project started on August 2005 and was concluded at the end of December 2005. Among other activities, this part of the project involved trips to the manufacturing facility in Bursa, Marmara Region, Turkey and the headquarters and distribution center in Manisa, Aegean Region, Turkey to get acquainted with the company and to observe its operations. Also an assessment of the company's competitive environment was performed, the logistics and operational practices at the distribution centers were analyzed, and data were gathered and analyzed on-site and from a distance via the company's SAP R/3 system.

The second part of the project, which concludes with the presentation of this report and mainly involved to find the optimal results for the company's current distribution network with the use of an optimization software, presenting the results to Company X's upper managers and assessing solution recommended.

It has been agreed with Company X that proprietary information including demand, cost and sales figures among other types of information would not be disclosed in the elaboration of this report. Hence the analyses and results are given in general form, that is, without revealing information sensitive to Company X.

4.2 Competitive Environment Assessment

To obtain the necessary information, we have conducted a survey and also evaluated the other sources of information. Furthermore, a conclusion is given at the end of this chapter.

4.2.1 Survey

In times of growth in the economy of an industry it is frequent for its individual members to expand its supplying capabilities in order to satisfy the also increasing demand from its customers. Naturally, when the economy faces a downturn companies focus their attention on the reduction of costs as the satisfaction of demand in itself stops being a constraint and attaining efficiency in its satisfaction becomes the main concern. Along with the national economy, the construction industry in the Turkey found itself in such a downturn at the beginning of this century and Company X, being a supplier of construction equipment had a decrease in sales as did all of its direct competitors, and thus reducing costs on the supply side of the equation became a priority.

The first step to assess the efficiency of Company X's distribution network and the potential for savings in distribution costs by changing its configuration was to perform an analysis of the company's competitive environment and the way in which competitors operate.

Due to the wide variety of products that are distributed by Company X, its number of competitors is also wide and many of them are direct competitors only in a few product lines. Therefore, a list of the most significant competitors was put together, and nineteen companies became the subject of the study in the initial phase of the project.

The study was carried out by sending the nineteen chosen firms a questionnaire about their distribution organization, their delivery commitment, their freight policy and after-sale support. The participation of the firms that filled out the questionnaire which is included on Appendix A was obtained by assuring them that their identity would not be disclosed at any time. Thus, the results of the study will be provided without revealing the name of any of the companies associated to the different responses. Out of the nineteen companies, five filled out and returned the questionnaires, for a response rate of 26%. However, only one in these five filled it out completely and with detailed responses. The rest of them failed to provide complete or suitable answers to every one of the questions in the questionnaire.

Information about ten of the companies that did not return the questionnaires was gathered from their websites, journals and other web-based publications. Therefore, some degree of information was obtained for fifteen companies, that is, 79% of the total, and no relevant information was obtained for four of the nineteen companies that represent the remaining 21% of the sample.

The answers provided by the participating companies indicated that they have a number of warehousing facilities that ranges between one and six. Also, three of the

five indicated that they have third party warehouses, and only two of them said that they also have customers used as distribution centers as is shown on Appendix B.

If we include the information provided by Company X in the results, these yield a preference for the Aegean Region to place warehousing facilities, as eight of the twenty four warehouses are located in that region. The regions of Black Sea, East Anatolia, Mediterranean, Central Anatolia, and also Georgia ranked second with a total of two facilities each.

Similarly, a preference for company owned facilities was indicated by the companies' responses. Company X's information on this subject will be omitted, but nine of the fifteen warehouses from the competitor's questionnaires belong to this category (53%), while five of them are third party owned (29%), and only three of them are customers used as distribution centers (18%).

Partial information about eight of the other competitors was gathered from their resources online, and other internet-based resources. This information includes the location of some of their distribution centers, but the type of facility it is unknown, as well as the total number of distribution centers that these companies have.

The obtained results from the questionnaires and other articles or web-based sources yield Aegean Region as the preferred region for the location of distribution centers with a total of nine. Second to Aegean Region came East Anatolia Region and Central Anatolia Region with four facilities each, and Black Sea Region, Southeast Anatolia Region and Mediterranean Region came in third place with three distribution centers each.

A summary of the remaining answers to the questionnaire is shown on Appendix C. The most relevant questions to the present study relate to the type of transportation used and the order-processing time. With respect to the first question, most of the respondents rely on a mix of company owned, common carrier, and contract transportation modes. However only two of them mentioned the use of company owned means of transportation, while the other three options were mentioned by at least three of the six respondents. In reference to the second question five of the six respondents indicated an order processing time smaller than 48 hours, and three of them reported to have order processing times of less than 24 hours.

In general, the responses obtained from the questionnaires indicated the following results about Company X's competitive environment:

1. The number of distribution centers per company ranges from one to six.
2. About one-half of these distribution centers are company-owned, while one-third of them are third-party owned and the remaining are customer-based.
3. The location of distribution centers was reported to lie in 7 different regions and Georgia. Aegean Region is home to most of the respondent's distribution centers with a total of nine, followed by East Anatolia Region and Central Anatolia Region with four distribution centers each; Southeast Anatolia Region, Black Sea Region and Mediterranean Region with three each and the remaining regions and Georgia with one or two distribution centers only.
4. Most respondents utilize different transportation strategies, but few of them utilize company-owned transportation.

4.2.2 Other Sources of Information

The sample responses that were obtained from the previous survey provide an indication of the prevalent practices in warehousing within Company X's competitive environment. However I also looked at other references on warehousing trends and I found a study called "Facility Trends 2001 – 2003" (Wilson 2002) by The Warehousing Education and Research Council (WERC). In this study they looked at the size and composition of warehousing networks and compare their findings to the results of similar studies they have performed in the past. WERC's study includes the responses of about 140 firms that hold membership in the council. The majority of these firms is in manufacturing (40%), and wholesaling (37%), with the rest of them in sectors such as retailing, government, utilities and others.

In terms of warehousing space, WERC's study found that the size of most warehouses in the US is smaller than 500,000 square feet as is shown on Table 6.

TABLE 6 Size of Distribution Centers from WERC's Study

<i>Warehousing Space (square feet)</i>	<i>Percentage of Respondents</i>
0 – 100,000	37%
100,000 – 500,000	31%
500,000 – 1,000,000	21%
1,000,000 – 3,000,000	6%
3,000,000 -	5%

Perhaps the most significant finding of WERC's study is the fact that the respondents' overall number of facilities in their network of distribution centers is decreasing. From 2001 to 2003, the size of distribution networks has decreased in number by 4.4% as is reproduced from WERC's study on Table 7.

TABLE 7 Number of Distribution Centers from WERC's Study

<i>Industry</i>	<i>2001</i>	<i>2002</i>	<i>2003</i>	<i>Change in 2 years</i>
Electronics / Computing	5.4	5.1	4.7	-14.2%
Pharmaceutical / Medical	2.7	2.5	2.7	0%
Grocery / Food / Beverage	12.5	12.7	12.1	-3.1%
Industrial / Office products	3.4	3.5	3.6	+5.3%
Consumer goods	4.7	4.0	4.1	-15.5%
OVERALL	5.5	5.3	5.2	-4.4%
* Number expected				

According to the analysis, the overall size in warehouse networks is expected to decrease in all sectors. However the industrial sector does show an increasing trend, but they argue that it may be due to the small size of that sector's sample (n=16) and their relatively small network size of 3.5 warehouses. The overall decline in the number of distribution centers is attributed to the slowdown of the economy, which has forced companies in all industries to become more efficient and do the same tasks with fewer resources.

According to WERC, larger and medium sized companies are most likely to have reduced the size of their distribution network during 2002. However, they say, the size of newly built distribution centers is getting bigger. In other words, the trend is for distribution networks to become smaller in number, but the size of the distribution centers is increasing. The factors mentioned to explain this increasing size of facilities include mergers and acquisitions, and "the fact that warehouses are being asked to do more value added services (VAS). In addition to traditional warehousing functions, DC's are now being called upon as facilities where light manufacturing takes place, customer center call centers are placed and corporate transportation headquarters are located. As the trend for VAS continues, it is probable that size of DCs will continue to increase." The respondents who have modified the configuration of their distribution networks indicated that the main

reason for such changes was sales-related (i.e. inventory turns), as well as overall inventory conditions. Other reasons included the need for increased labor flexibility, acquisitions and mergers, product sourcing changes, customs and duty and transportation costs.

With respect to the type of distribution centers mostly utilized, WERC classifies them as full-line, limited-line, or overflow. Also, they differentiate between private, public or contract facilities; this classification gives them nine possible warehouse combinations. For the purposes followed in our study we are only interested to know the preferences in terms of private, public and contract warehousing. Accordingly, the mix of distribution centers with respect to their contractual agreements is shown on Table 8.

TABLE 8 Type of Distribution Centers from WERC's Study

<i>Type of DC</i>	<i>1998 - 2002</i>
Private	65% - 73%
Public	27% - 14%
Contract	8% - 13%

In general terms, three observations can be made. First, private distribution centers are by far the most prevalent, and their usage is increasing. Second, the trend in public warehousing usage is going down, and third, contract warehouses represent a very small part of all warehouses being used, but the trend is for them to become more common.

4.3 Conclusions

The results of the survey with Company X's list of nineteen competitors yielded limited results in terms of the response rate. Even though response rates for similar

studies seldom go beyond forty percent, the small response rate coupled with the small sample size yielded results that couldn't be considered statistically representative of the industry average.

However, some insights could be drawn. First, the number of distribution centers in the competitor's distribution networks seems to be smaller than that of Company X. Second, it is known that at least one of the competitors in the study has joined the trend reported by WERC's study, namely, they have reduced their number of warehouses and increased its size with respect to what they had in the past. Third, three of the top six preferred regions for warehouse location in the study coincide with regions where Company X runs its distribution centers, that is, Aegean Region, East Anatolia Region and Southeast Anatolia Region.

In terms of transportation, only two of the respondents indicated that they utilize company owned resources, while four of the five indicated that they use common carrier transportation as one of their transportation means. In second place came the use of contract transportation with three competitors mentioning it as one of their transportation means. However, the difference between these three choices of transportation is too small to draw significant conclusions.

On the freight question, it is clear that all competitors view it as a marketing and sales tool. They offer reduced freight charges to stimulate the placement of larger orders or to close a deal, so any strategy to relocate a distribution center should pay close attention to the selection of sites with good availability of freight carriers and low freight rates.

Finally, the trends reported by WERC's study suggest that Company X's number of distribution centers is too large in comparison with industry standards, and it could be reduced thus forcing the remaining warehouses to be more efficient than currently.

ANALYSIS AND ALTERNATIVE CHANGES

5 Analysis & Alternative Changes

In this chapter, the empirical material will be analyzed, based upon the theoretical discussion, in order to fill the purpose of the thesis and answer the research questions.

5.1 Gravity Center Analysis

The results obtained from the Competitive Environment Assessment supported the opinions of Company X managers that a location analysis should be conducted to determine the most advantageous configuration of the firm's distribution network.

In order to obtain an initial solution to the warehouse location problem, a gravity center analysis was performed. The gravity center approach is an analytic tool that finds the single location that will minimize the transportation distance when considering all the shipments to the different customers. Mathematically, this problem solves for the minimum distance between two points in the Euclidean distance case.

The term "gravity center" arises for the following reason: If we were to place a map of the area in which the distribution center is to be located on a heavy piece of cardboard and weights proportional to demands were placed at the locations of demand points, then the gravity center solution would be the point on the map at which the entire system would balance (Nahmias, 2001).

The mathematical solution to the gravity center problem is given at the location:

$$x' = \frac{\sum_{n=1}^k D_n x_n}{\sum_{n=1}^k D_n}, \text{ and } y' = \frac{\sum_{n=1}^k D_n y_n}{\sum_{n=1}^k D_n} \quad (1)$$

where x_n and y_n represent the coordinate location of either a market or supply source n , and D_n represents the quantity to be shipped between facility and market or supply source n .

The demand data considered in this analysis covered the period of January, 2002 to August, 2003. Such information was downloaded from Company X's SAP R/3 system and it included the name and postal code of each customer as well as the dollar amount that was demanded during those 20 months. Coordinate locations for supply and demand points were given by the longitude and latitude of the different locations' postal codes which were available for the execution of this project from a commercial database. Given the great number of Company X customers or demand points, they were aggregated in two stages:

1. First, "shipped to" customers were aggregated into clusters according to the three-digit postal code, thus reducing its number from 10,307 individual customers to 846 customer zones. So for example, all customers in postal code areas starting with the three digits 359 were put together into one customer zone.
2. It has been documented in the literature that aggregating large amounts of

data achieves a significant reduction in variability, and forecast demand is much more accurate at the aggregated level. Furthermore, the aggregation of data into about 150 to 200 points usually results in no more than about 1% error in estimation of total transportation costs (Simchi-Levi, et. al., 2000). Therefore, the previous 846 customer zones were further aggregated into 141 demand clusters by geographical proximity, with all of them having about the same demand level. In other words, assuming that the total domestic demand for the 20 months mentioned above equaled \$11,635,650 then dividing this amount by 141, it would yield clusters of about \$82,522.

With the demand and location information aggregated in this fashion, a local gravity center was obtained for each of the 141 demand clusters. As it was explained before, the gravity centers were obtained in the form of a coordinate pair, one coordinate indicating the location's longitude and the other one its latitude, and seldom did these coordinates coincide with an actual city. Thus the distance from the gravity center to each of the individual locations in the demand clusters was calculated and the closest city was then chosen to be the cluster's gravity center.

Finally a "global" gravity center analysis was performed in three scenarios that follow along with its results.

1. First, an overall center of gravity was found for the whole of the Turkish national territory. The resulting location was Boğazlıyan, Central Anatolia Region, about 60 km north of Kayseri.

2. Second, the national territory was split into East and West by dividing the national territory from the centers of Black Sea Region, Central Anatolia Region, and Mediterranean Region separating the two blocks. The resulting demand is almost perfectly divided at 50% per block. The eastern gravity center where a distribution center would be located is in Pertek, Eastern Anatolia Region, about 42 km south of Tunceli, Eastern Anatolia Region, and the western gravity center falls in the Aegean Region. The city is İncehisar, Aegean Region, which is only 23 km southwest of Afyon, Aegean Region.

3. Finally, if we split the national territory into eastern, central and western blocks, we get the following DC locations: Karlıova, Eastern Anatolia Region for the eastern block, about 97 km southwest of Erzurum, Eastern Anatolia Region. Mucur, Central Aegean Region for the central block in the almost center of the region, 23 km southeast of Kırşehir, Central Anatolia Region. The western gravity center is in the city of Simav, Aegean Region, about 71 km northwest of Uşak, Aegean Region.

The location of the gravity centers show the heavy weight that four regions have for Company X as demand hubs, comprising about forty percent of domestic sales. These regions are Aegean Region (20%), Mediterranean Region (8%), Southeast Anatolia Region (7%) and East Anatolia Region (4%). The location of a single gravity center in Turkey is centered between the Eastern and Western blocks, and closer to the center where Kayseri is. As we increase the number of distribution centers, their location is dispersed but it always centers between the four main regions.

5.2 Analysis of Current Distribution Practices, Its Findings, and Results

The core business of Company X is the distribution of construction equipment, some of which it manufactures and some of which it purchases, but the core business activity is distribution. Therefore the main cost drivers are related to inbound and outbound transportation. On the supply side Company X receives finished product and parts from about 700 suppliers while on the demand side it ships product to more than 10,000 customers, hence the weight of outbound transportation costs is far greater than that of inbound transportation. Having that in mind, the next step in the analysis of Company X's distribution network was to study the company's current distribution practices and the associated outbound distribution costs associated to them.

The current policies have assigned a number of regions to each of the five distribution centers. In other words, each region's demand should be supplied from only one distribution center. In practice this is followed as closely as possible, but sometimes it is necessary to violate this policy due to inventory fluctuations, unexpected demand changes or other special circumstances. An analysis was performed to compare the distribution practices under the current policies to the optimal distribution practices without changing the number or location of the current distribution centers.

More specifically, the distribution network was modeled mathematically to minimize the total shipping cost from the existing distribution centers in Manisa, Diyarbakır, Tokat, Bursa and Ağrı to the different demand clusters.

Definitely, the most important piece of information for such formulation is the set of freight rates for transportation from distribution center i to demand location j of product k . The i demand locations are given by 137 of the 141 demand clusters obtained before. The remaining four clusters were ignored because they are located outside of Turkish territory, so these clusters include customers in Iran, Syria, and Greece.

With respect to the k product categories, some sort of aggregation strategy was needed. Thus we looked at how the carriers that provide Company X with transportation services calculate their freight rates. Because of impossibility of determining the freight rating system precisely in Turkey, we found and used a similar rating system called “US National Motor Freight Classification” which includes 23 different classes ranging from 500 to 35; like all freight forwarder (logistics-3PLs) companies in Turkey, in all cases, the higher the class, the greater the relative charge for transporting the goods. Some of the factors involved in determining a product’s rating class include product density, difficulty of handling and transporting and liability for damage. In the case of Company X, its products fall into 9 of the 23 different categories which provide with a good aggregation strategy for modeling purposes. A list of these is shown on Table 9, along with examples of the types of actual products that are included in each class.

TABLE 9 Aggregation of Products into Nine Classes

<i>Product Class</i>	<i>Examples of products included in product class</i>
50	Plate compactors.
60	Vibrator heads.
70	Generators, trowel handles and blades.
77.5	Dewatering pump accessories.
85	Rammers and accessories, dewatering pumps.
100	Walk-behind trowels.
150	Ride-on trowels.
250	Mixers.
300	Light towers.

Freight rates were then obtained from International Freight Forwarders Association of Turkey (UTİKAD) studies. These studies offer a market-based price list derived from studies of FTL and LTL pricing on a regional and interregional basis and therefore provides with very good estimates of actual freight rates for individual carriers. For the purposes of this analysis an average shipment was considered to range between 17,500 (7,94 kg) and 25,000 pounds (11,34 kg). The use of freight rates for shipments in that range effectively overestimates the shipping cost of many orders and underestimates that of a few, but on average the total error in shipping cost estimation is relatively small. Consequently, the freight rates obtained represented the transportation cost of such average shipment for each combination of distribution centers and customer zones. Finally, the demand data were transformed from dollar value to weight in pounds by considering the average weight of a product in each of the nine aggregation categories.

Mathematically, the solution to minimize the transportation cost of Company X's current distribution network can be modeled as an assignment problem. A simplified version of the Warehouse Location Problem was formulated as is shown below:

*FORMULATION 1**Indices*

i	demand clusters	$i = 1, \dots, 137$
j	distribution center	$j = 1, \dots, 5$
k	product families	$k = 1, \dots, 9$

Parameters

c_{ijk}	cost to transport 1 unit of product k from distribution center j to demand cluster i
d_{ik}	annual pounds (kg) of product k required by demand cluster i

Variables

x_{ijk}	fraction of demand d_{ik} supplied from distribution center j
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$$\text{Minimize } z = \sum_{i=1}^{137} \sum_{j=1}^5 \sum_{k=1}^9 c_{ijk} d_{ik} x_{ijk} \quad (2)$$

$$\text{Subject to } \sum_{j=1}^5 x_{ijk} = 1, \quad i = 1, \dots, 137; k = 1, \dots, 9 \quad (3)$$

$$x_{ijk} \geq 0 \quad i = 1, \dots, 137; j = 1, \dots, 5; k = 1, \dots, 9 \quad (4)$$

The linear nature of this mathematical formulation does not allow us to consider the economies of scale associated to the transport of larger shipments. Hence the solution to the model is equivalent to comparing the cost to satisfy the demand at a customer zone from each of the five possible distribution centers and choosing the one with the lowest cost and multiplying it by its associated demand. Then, repeating the process for all of the 137 demand clusters in each of the 9 product categories and adding up the 1233 subtotals would result in the same solution as the linear programming formulation does.

The data were downloaded from the company's SAP R/3 system and then organized

in Microsoft's Excel and Access. The model was formulated in AMPL[®] and solved with CPLEX 7.1[®]. The solution resulted in savings of 9.5% with respect to the current practice. The main result of this analysis is the benefit that could be achieved by reassigning the regions of Mediterranean, East Anatolia, East Black Sea, North Cyprus, South of Central Anatolia and East of Central Anatolia that are currently served from Tokat to be served by Diyarbakır instead. The resulting savings in outbound freight costs are broken down by reassigned region on Table 10.

Although Company X's main objective in conducting this study was to minimize costs it should not be done at the expense of customer service. Thus a measure of customer service was defined as the proportion of demand that can be supplied in one day, which occurs when the demand cluster is within 600 km of its servicing distribution center.

TABLE 10
Changes from Current to Recommended Configuration of Current Distribution Centers

<i>Region</i>	<i>Original Servicing DC</i>	<i>Suggested Servicing DC</i>	<i>% Annual Savings in Outbound Freight Cost</i>
Mediterranean	Tokat	Diyarbakır	5.57
East Anatolia	Tokat	Diyarbakır	1.59
East Black Sea	Tokat	Diyarbakır	0.75
North Cyprus	Tokat	Diyarbakır	0.65
South of Cent.Ana.	Tokat	Diyarbakır	0.56
East of Cent.Ana.	Tokat	Diyarbakır	0.37
	Total Savings		9.49%

The US Geological Survey suggests an approximation to measure fairly long distances while taking into account the curvature of the earth:

$$D_{ab} = 138 \sin^{-1} \sqrt{\sin\left(\frac{lat_a - lat_b}{2}\right)^2 + \cos(lat_a) \cdot \cos(lat_b) \cdot \sin\left(\frac{lon_a - lon_b}{2}\right)^2} \quad (5)$$

The formula is very convenient for its input data are the latitude and longitude coordinates of the two points of interest. However, this equation underestimates the actual road distances, so the literature suggests multiplying the value of D_{ab} by a factor of $\alpha = 1.14$. In our case the list of points is given by the customer locations' postal codes and their coordinates are known, so using this formula we calculated the customer service level in the current scenario to be 82% and 78% in the suggested scenario. Company X decided to define a minimum service level of 70%, so the suggested scenario is equally satisfactory in cost as it is in service level.

For the sake of completeness a slight modification to the mathematical model was made. The modification involves the introduction of a set of binary decision variables y_j to limit the number of distribution centers, where y_j takes on the value of 1 if the corresponding distribution center remains open or 0 if it does not, and a is a constant representing the number of distribution centers that will remain open.

FORMULATION 2

$$\text{Minimize } z = \sum_{i=1}^{137} \sum_{j=1}^5 \sum_{k=1}^9 c_{ijk} d_{ik} x_{ijk} \quad (6)$$

$$\text{Subject to } \sum_{j=1}^5 x_{ijk} = 1, \quad i = 1, \dots, 137; k = 1, \dots, 9 \quad (7)$$

$$-x_{ijk} + y_j \geq 0, \quad i = 1, \dots, 137; j = 1, \dots, 5; k = 1, \dots, 9 \quad (8)$$

$$\sum_{j=1}^5 y_j = a \quad (9)$$

$$x_{ijk} \geq 0 \quad i = 1, \dots, 137; j = 1, \dots, 5; k = 1, \dots, 9 \quad (10)$$

$$y_j \in \{0,1\} \quad j = 1, \dots, 5 \quad (11)$$

The solution to the model for the each one of the five scenarios of interest, as well as its resulting service levels are summarized on Table 11. From there one can see the relative importance of each distribution center from an outbound distribution perspective. The best one in terms of location is the one in Diyarbakır, Southeast Anatolia Region, followed by Manisa, Aegean Region; Ağrı, East Anatolia Region; Bursa, Marmara Region; and Tokat, Black Sea Region. Also we see that with the current set of locations it would be impossible to satisfy the minimum customer service level of 70% with less than 3 distribution centers.

TABLE 11 Summary of Results for Current Practices and Alternatives

<i>Scenario</i>	<i>Locations</i>	<i>% Savings</i>	<i>% Service Level</i>
Current Practice – 5 DCs	SA, A, EA, M, BS	0	82
Alternative – 5 DCs	SA, A, EA, M, BS	9.49	78
Alternative – 4 DCs	SA, A, EA, M	9.13	74
Alternative – 3 DCs	SA, A, EA	5.78	70
Alternative – 2 DCs	SA, A	0.81	52
Alternative – 1 DCs	SA	-52.43	29

As a result of the present analysis a suggestion was made to Company X that if it eventually decided to utilize the current configuration of its distribution network with a different approach, it could achieve attractive savings in its annual outbound freight expenditures as indicated previously on Table 10.

CONCLUSIONS AND RECOMMENDATIONS

6 Conclusions & Recommendations

This chapter serves a presentation of the conclusions and recommendations for the firm.

6.1 Conclusions

The thesis starts with explaining that the world economy is, and has been for some time, in a radical shift and that we are moving away from a world where national economies are isolated from each other. The globalization of markets is merging national markets into one huge global marketplace, where companies have large opportunities to earn money. However, the emergence of globalization has made the business world tougher. Competition between companies is fiercer than ever and there is great pressure from various stakeholders to be as profitable as possible.

To undertake this study in a satisfactory manner various theories have been outlined and discussed. Subjects such as logistical goals and information, among many others, have been discussed. Different types of processes including effective, flexible processes and identifying processes have also been discussed.

From the methodology chapter we learned that this study was mainly a descriptive and an exploratory research with both quantitative and qualitative data. Primary data such as visual observation and personal interviews have been used as well as secondary data such as the theories mentioned earlier.

As a result of all the technical and non-technical work and analysis performed on

Company X's competitive environment and current configuration of its distribution network the following conclusions are obtained:

1. Savings in the order of 9% in outbound shipping costs could be realized by reassigning the demand that is generated in some regions to the current distribution centers as indicated on Table 12.

TABLE 12
Savings in Outbound Shipping Costs

<i>Region</i>	<i>Original Servicing DC (Current Assigned Demand)</i>	<i>Suggested Servicing DC (After Reassigned Demand)</i>	<i>% Annual Savings in Outbound Freight Cost</i>
Mediterranean	Tokat	Diyarbakır	5.57
East Anatolia	Tokat	Diyarbakır	1.59
East Black Sea	Tokat	Diyarbakır	0.75
North Cyprus	Tokat	Diyarbakır	0.65
South of	Tokat	Diyarbakır	0.56
East of Cent.Ana.	Tokat	Diyarbakır	0.37
	Total Savings		9.49%

2. Company X should have a minimum number of three distribution centers, and a maximum of five. Having less than three facilities makes it impossible for the company to satisfy its minimum service level requirements, and having more than five facilities is not cost-effective. Furthermore, a number of four distribution centers should be the best strategy, because the cost increment with respect to having five facilities is only 0.36% of annual outbound freight expenditures, and it makes more sense from a logistics stand point to operate a less complex network of distribution centers. Table 13 represents the current and alternative scenarios for distribution centers.

TABLE 13 The Current and Alternative Scenarios

<i>Scenario</i>	<i>Locations</i>	<i>% Savings</i>	<i>% Service Level</i>
Current Practice – 5 DCs	SA, A, EA, M, BS	0	82
Alternative – 5 DCs	SA, A, EA, M, BS	9.49	78
Alternative – 4 DCs	SA, A, EA, M	9.13	74
Alternative – 3 DCs	SA, A, EA	5.78	70
Alternative – 2 DCs	SA, A	0.81	52
Alternative – 1 DCs	SA	-52.43	29

6.2 Recommendations

Further analysis should be conducted to determine alternative distribution strategies. For example, the possibility for Company X to partner with large customers to hold small inventories in strategic locations could be explored. Besides, a research to redesign of Company X's current distribution network could be carried out.

It is the author's opinion that the results and recommendations made to Company X during this research have been useful, and if implemented they could have an impact in the bottom line of the company through the potential cost savings.

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APPENDIX A

QUESTIONNAIRE FOR MANUFACTURERS AND DISTRIBUTORS OF CONSTRUCTION AND POWER EQUIPMENT

1. This questionnaire is for manufacturers and distributors of construction and power equipment. The questionnaire solicits information on your business's distribution organization, delivery commitment, freight policy and after-sale support in Turkey.
2. The information you provide will be used for an academic project in the Logistics Management department at Izmir University of Economics and it will be treated confidentially. The information gathered will be shared with all the participating companies who would like to have it, without revealing anyone's identities.
3. Please return this questionnaire by e-mail or fax, and direct any questions to:

Oktay Çoban
Master of Logistics Management Student, Izmir
University of Economics
E-mail: oktaycoban@yahoo.com
Phone: (0536) 345 64 70
Fax: (0232) 259 42 04
4. Please designate an individual from your organization to verify any unclear answers or receive additional information:

Contact Person	
Company	
Name	
Title	
Address	
City/Region/Postal Code	
Phone	
Fax	
E-mail	

Please keep a copy of this questionnaire in the event I need to contact you for clarification. Thanks.

APPENDIX A

Continued

I. Distribution Organization

A. How many distribution centers does your organization have?

B. Does your organization use customers as distribution centers (Yes/No)?

C. Please indicate the location of your organization's distribution centers. Also indicate whether they are company-owned (CO), third party warehouses (3P) or customers used as distribution centers (CUS).							
	City	Region	CO / 3P / CUS		City	Region	CO / 3P / CUS
1				26			
2				27			
3				28			
4				29			
5				30			
6				31			
7				32			
8				33			
9				34			
10				35			
11				36			
12				37			
13				38			
14				39			
15				40			
16				41			
17				42			
18				43			
19				44			
20				45			
21				46			
22				47			
23				48			
24				49			
25				50			

APPENDIX A**Continued**

D. Does your organization use common carrier, contract or company-owned transportation? Explain below.

II. Delivery Commitment

A. What is the order processing time for items in stock?

B. What is your organization's back order policy? Explain below.

III. Freight Policy

A. What is your organization's FOB point? Explain below.

B. Is freight used as a marketing or sales tool? Explain below.

APPENDIX A**Continued****IV. After-Sale Support**

A. How is your organization's after-sale service provided? Is it through company-owned service centers, third-party authorized centers or through the dealer network? Explain below.

B. Provide a description of your organization's warranty policy

APPENDIX B

WAREHOUSE LOCATION AND TYPE FROM QUESTIONNAIRES

Company X			
	<i>City</i>	<i>Region</i>	<i>CO / 3P / CUS</i>
1	Manisa	Aegean	n/a
2	Denizli	Aegean	n/a
3	Bursa	Marmara	n/a
4	Tokat	Black Sea	n/a
5	Diyarbakır	Southeast Anatolia	n/a
6	Ağrı	East Anatolia	n/a
7	Kutaisi	Georgia	n/a
<i>Competitor 1</i>			
	<i>City</i>	<i>Region</i>	<i>CO / 3P / CUS</i>
1	İzmir	Aegean	CUS
2	Muğla	Aegean	CUS
3	Afyon	Aegean	3P
4	Adana	Mediterranean	3P
5	Şanlıurfa	Southeast Anatolia	CO
6	Erzurum	East Anatolia	CO
<i>Competitor 2</i>			
	<i>City</i>	<i>Region</i>	<i>CO / 3P / CUS</i>
1	Antalya	Mediterranean	CO
2	İstanbul	Marmara	3P
3	Denizli	Aegean	CO
4	Kütahya	Aegean	CO
5	Şam	Syria	CUS
6	Kutaisi	Georgia	3P
<i>Competitor 3</i>			
	<i>City</i>	<i>Region</i>	<i>CO / 3P / CUS</i>
1	Denizli	Aegean	CO
2	Trabzon	Black Sea	3P
3	Ankara	Central Anatolia	CO
<i>Competitor 4</i>			
	<i>City</i>	<i>Region</i>	<i>CO / 3P / CUS</i>
1	Konya	Central Anatolia	CO
<i>Competitor 5</i>			
	<i>City</i>	<i>Region</i>	<i>CO / 3P / CUS</i>
1	İstanbul	Marmara	CO

APPENDIX C

RESPONSES TO REMAINING QUESTIONS FROM QUESTIONNAIRES

<i>Delivery Commitment</i>			
<i>Organization</i>	<i>Choice of transportation</i>	<i>Order processing time</i>	<i>Backorder policy</i>
Competitor 1	Common carrier	24 hours	If equipment is on backorder, the customer is notified and they are the first to get it when more equipment comes in
Competitor 2	UPS for parts, common carrier for parts and small equipment, trucking companies for larger equipment, and company owned transportation for	Orders placed by 3 p.m. are shipped the same day 96% of the time	We will inform the customer, and we'll tell them when we expect the product to be available. Then we will automatically ship the equipment to them as soon as it is available.
Competitor 3	Contract transportation and common carrier	1 to 6 days	The customer can choose to have the items placed on backorder status, and shipped to him when they're available.
Competitor 4	Company owned and MNG Cargo	24 to 24 hours	n/a
Competitor 5	Contract transportation and DHL	Within 12 hours of	n/a
Competitor 6	Common carrier	48 hours	Ship when available. If over 60 days contact customer to verify order before shipment.
<i>Freight Policy</i>			
<i>Organization</i>	<i>Is Freight used as a marketing</i>	<i>FOB point</i>	
Competitor 1	Yes. Freight rates vary with order size, customer type, etc. Freight charges are waived for special promotions.	FOB plant, customer takes ownership when material is shipped.	
Competitor 2	Yes, freight varies with order size and other factors.	FOB warehouse. Free freight for full truckload orders	
Competitor 3	Yes, freight is normally paid for by the company.	FOB Plant.	
Competitor 4	Yes, freight is used to get customers to order up	Freight is negotiated, but it's normally paid by company	
Competitor 5	Yes	FOB delivered on large orders	
Competitor 6	Yes, freight is sometimes used to close a deal	FOB warehouse	

APPENDIX C

Continued

After Sale Support

<i>Organization</i>	<i>How is your after-sale support provided?</i>	<i>Provide a description of your warranty policy</i>
Competitor 1	Dealers for some products and field service personnel	Different for all products. Warranty is determined by manufacturer but we have modified it with some product lines as a marketing and sales tool
Competitor 2	After-sale service is provided by two company-owned Service Centers, 75 Authorized Service Centers and some of the dealer network.	Most machines carry a standard 1-year warranty, some machines and engines carry 2 years. Parts standard warranty is 90 days, complete engines carry 1-year warranty.
Competitor 3	Network of company-owned and authorized service centers	30-Day, Warranty. If you're dissatisfied for any reason, just present your proof of purchase for a full refund within 30 days of purchase. One-Year Free Service contract. Full One-Year Warranty. We'll repair any defects due to faulty materials or workmanship at no cost to customer — for one year from the date of purchase
Competitor 4	Authorized service centers	2 and 5 year warranty plans
Competitor 5	Over 800 authorized centers worldwide	5 year transferable warranty
Competitor 6	10 authorized service centers	Three full years on parts and labor - with engines covered for at least two years by manufacturer