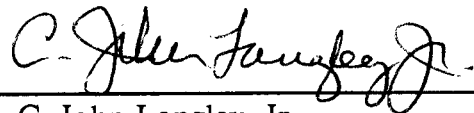


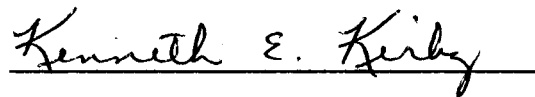
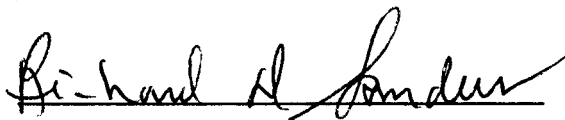
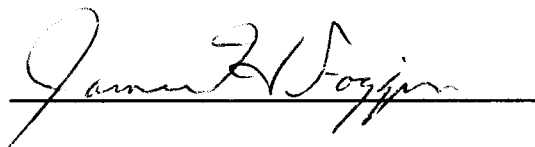
To the Graduate Council:

I am submitting herewith a dissertation written by Mary Collins Holcomb entitled "Customer Service Measurement: A Methodology for Increasing Customer Value Through Utilization of the Taguchi Strategy." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Business Administration.



C. John Langley, Jr.
Major Professor

We have read this dissertation
and recommend its acceptance.



Accepted for the Council:



Associate Vice Chancellor and
Dean of the Graduate School

CUSTOMER SERVICE MEASUREMENT:
A METHODOLOGY FOR INCREASING CUSTOMER VALUE THROUGH
UTILIZATION OF THE TAGUCHI STRATEGY

**A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville**

MARY COLLINS HOLCOMB

May 1992

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DEDICATION

This dissertation is dedicated to my husband, Brady, and my three children - Darcie, Amy, and Dereck. Their unwavering support and continual enthusiasm and willingness to help me achieve my goals has made this effort possible. The completion of this dissertation represents a long desired achievement; may I always be able to help others see and realize such possibilities.

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The quality of this research effort can be attributed to the dedication and involvement of many individuals. To my dissertation committee supporting members - Kenneth Kirby and Richard Sanders - I wish to express my appreciation for their constant support and dedication to my research, their helpful suggestions, and their encouragement throughout this entire process.

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One of the most important members of the dissertation committee has been James Foggin. During my years at the University of Tennessee, he has been mentor, teacher, and friend. It is not possible to detail all the help that he has

given me nor will I ever be able to fully express my thanks. The quality of this dissertation is the direct result of his commitment and involvement in the process from the very beginning. He has been a constant source of support and provided me with many opportunities to develop this research topic.

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ABSTRACT

Technological and environmental change in logistics systems in the 1980s demand new approaches and tools for firms to establish and maintain competitive advantage through value creation. Logistical customer service has long been recognized as a key area for creating customer value, and evidence suggests that this component will become more important in the future. Dynamic market forces have created a need to continually improve customer service systems as customer expectations increase.

The traditional approach of quality improvement is statistical process control. However, by utilizing the Taguchi strategy and methods it was possible to demonstrate that higher quality service can be achieved at no, or reduced cost to the customers through reduction and elimination of variation. Furthermore, it is also possible to design customer service delivery programs without controlling or eliminating causes of variation, and still obtain "on target" performance.

The research was conducted in two phases. Data for Phase 1 was collected using a survey mailed to over 200 buyers and warehouse managers, each, who were customers of a major consumer goods company. Frequency distributions, chi-square analysis, Thurstone's CASE 5, analysis of variance, and multivariate analysis were used to analyze the data. Phase 2 involved the use of historical data taken from the firm's customer service measurement system within the structure of

an orthogonal array for experimental design.

The major findings of this research was that length of order cycle, on-time deliveries, and completeness of shipments are key drivers of buyers and warehouse managers quality perception. These factors are two to three times more important than other components of the customer service delivery process. In addition, it was shown that the measurement of unacceptable order cycle length can be used to build customer service profiles for differentiating service level. The largest gain in benefit to the consumer goods company can be realized by shortening the order cycle time, particularly for promotional orders.

Another finding of the research was that promotional orders and brand introductions are direct contributors to customer service delivery performance which is not "on target." For promotional orders, order size is critical to performance while order lead time significantly impacts brand introduction delivery. It was also determined that order size and carrier type affects neither average nor variation of customer service delivery performance.

To conclude, the differences in approach and method of research design add to the strength and depth of knowledge of the research findings. The combination of the two phases offers the consumer goods company the opportunity to improve the quality of its customer service delivery process - both from a perceptual and actual measured performance within the complicated, current operating environment of regular, promotional, and emergency orders, and new brand introductions.

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CHAPTER I

INTRODUCTION

The decade of the 1980s introduced a significant amount of technological and environmental change in logistics systems. Global competition in domestic markets prompted many firms to view the logistics function as a comprehensive process with boundary-spanning capabilities. Technology also changed rapidly during this decade, and it is expected to change even faster in the foreseeable future.¹

These changes demand the development of new approaches and tools for firms to establish and maintain competitive advantage through value creation. Logistical customer service has long been recognized as a key area for creating customer value, along with management of the supply chain, the development of strategic alliances, and dedication to formal quality processes.² Furthermore, evidence suggests that the customer service component will become more important in the future as compared with product, price, and promotion.³

¹Sloan, Robert M., "Integrated Tools for Managing the Total Pipeline," Annual Conference Proceedings, Vol. II, October 22-25, 1989, St. Louis, MO, (Oak Brook, IL: Council of Logistics Management), p. 95.

²Langley, C. John, Jr. and Mary C. Holcomb, "Achieving Customer Value Through Logistics Management," Quality Management Systems: Competing With Customer Value (M. J. Stahl and G. C. Bounds, eds.), Westport, CT: Quorum Books, 1991.

³LaLonde, Bernard J., Martha C. Cooper, and Thomas G. Noordewier, Customer Service: A Management Perspective, Oak Brook, IL: Council of Logistics Management, 1988, p. 95.

However, the focus on customer service is not new. A number of studies have been conducted over the years by various authors on determining requirements for logistics customer service. These studies have ranged from generic in form ("average" customer requirements) to specific customer needs. The contribution of these efforts has been an awareness by many firms that using logistics customer service proactively can differentiate them from competitors.

But as a firm gets better, so does its competition. The dynamic market forces are such that as competitors acquire similar customer service systems, customer expectations also increase. The trend becomes one of an upward and never-ending spiral of increased competition and heightened expectations.⁴ The need to continually improve requires a constant focus on the determinants of customer value: quality and cost of service.

The traditional method of quality improvement is statistical process control. At best, the tools and techniques associated with this approach are a maintenance device to be used only after a process is brought under control.⁵ More powerful quality techniques, such as design of experiments, strive to reduce variation thereby affecting both quality of service delivered and its cost. Improvements in the design of the customer service process, through statistical experimentation, will

⁴Stahl, M. J. and G. C. Bounds (eds.), Quality Management Systems: Competing With Customer Value (Westport, CT: Quorum Books, 1991).

⁵Bhote, Keki R., "DOE, The High Road to Quality," Management Review, January 1988, p. 28.

provide significant gains in the performance of the logistics system, and are more meaningful in the long run.⁶

The purpose of this research is to develop a comprehensive method for designing, assessing, and improving customer service offerings, from both a quality and cost perspective. Customers do not want processes which barely meet specifications. They want service performance clustered around a specified target value. Furthermore, while it has been proven that there is no more powerful cost-reduction tool than quality improvement, some firms continue to hold the view that higher or better levels of service cost the firm more money.⁷ Part of the research objective will be to demonstrate that higher quality service can be achieved at no, or reduced, cost to the customers through reduction and elimination of variation. By utilizing the Taguchi methods and strategies of parameter design in a logistics context, it will be possible also to establish a theoretical basis for the design of a customer service program, without controlling or eliminating certain causes of variation, and still obtain "on target" performance.

The research is organized into five major sections: introduction, literature review, research methodology, findings and analysis, and research implications and future direction. The introduction includes the problem definition and an overview of the research objectives. The literature review covers a diversity of

⁶Foggin, James H., "The Importance of Quality and Continuous Improvement in Logistics Customer Service," Survey of Business, Knoxville, TN: University of Tennessee, 25, 1 (1989), p. 46.

⁷Bhote, op. cit., p. 28.

topics related to the research including: customer service approaches and tools, quality in design and systems performance, and the Taguchi methodology.

The organizational framework for the research methodology section consists of two distinct research phases, each with its own objectives and design. Although the findings and analysis for each research phase are presented separately, the integrative issues of the two phases are also discussed. Finally, the theoretical and managerial implications of the research are examined, with closure provided by future direction of research efforts related to the dissertation.

The research effort for this project was sponsored by the Management Development Center of the University of Tennessee in conjunction with a major company in the consumer goods industry. The industry participation in the research spans both the corporate and plant level, and involves interaction with marketing research, quality, and logistics staff. Throughout the dissertation research a transfer of knowledge and information has taken place, thereby ensuring the development of a robust methodology with theoretical and managerial contribution.

1. BACKGROUND

Just a few decades ago, most managers involved in logistics had operational responsibility for a single function such as inventory, order processing, warehousing, or transportation. As customer requirements became more complex,

however, the integration of physical distribution and materials management took place. The coordination of both the inbound and outbound movements of product and information resulted in a more effective and responsive organizational structure.⁸

The traditional concept of value added in logistics has been viewed as that of cost efficiency versus competitive service levels. This "tradeoff" reflected a customer-oriented philosophy which integrated all elements of the customer interface with a pre-determined optimum cost service mix.⁹ In this role, customer service was viewed as a prime variable, that when utilized effectively, could have a significant impact on creating demand and retaining customer loyalty.

The scope and role of logistics has expanded beyond the integrated logistics concept to the extent that many firms now believe that a strategic logistics orientation is required to create customer value and sustain competitive advantage.¹⁰ The customer service mix increases the number of primary attributes that can be adapted to the different levels desired by customers. The various assortments of attributes offer customers a customized bundle, and aids in differentiating the product. This environment requires that effectiveness of

⁸Langley, C. John, Jr., "The Evolution of the Logistics Concept," Journal of Business Logistics, 7, No. 2, p. 5.

⁹LaLonde, Bernard J. and Paul H. Zinszer, Customer Service: Meaning and Measurement (Chicago, IL: Council of Logistics Management, 1976).

¹⁰Bowersox, Donald J. and Robert E. Murray, "Logistics Strategic Planning for the 1990's," Annual Conference Proceedings, Vol. I (Oak Brook, IL: Council of Logistics Management, 1989), p. 234.

customer service be measured, and that coordination and management of simultaneous logistics activities across traditional functional boundaries takes place.

The proposition that logistics can add value to a firm's product and service offerings is a simple and intuitively appealing statement which firms have increasingly come to accept. However, implementation of a value-added logistics customer service process can represent a challenge for firms because it involves a changing and repositioning of perspective and strategic outlook. Based on the premise that logistics customer value is created through effectiveness, efficiency, and differentiation, customer service within the logistics function has evolved to mean much more than simply having the "right product, at the right place, at the right time, in the right quantity, and in the right condition."¹¹

Research has indicated that different customer service packages are not only feasible, but highly desirable.¹² It is also suggested that firms which view customer service as a uniform package are in danger of missing significant opportunity in the marketplace. Furthermore, the "one size fits all" approach does not contribute to customer satisfaction or the perception of high quality service.

¹¹Gecowets, George A., "Physical Distribution Management," Defense Transportation Journal, 35, No. 4 (August 1979), p. 11. (Original source: Grosvenor Plowman, retired Vice President - Traffic, U. S. Steel Corporation.)

¹²Kyj, Larissa S. and Myroslaw J. Kyj, "Customer Service: Product Differentiation in International Markets," International Journal of Physical Distribution & Materials Management, 19, No. 1, p. 37.

The attainment of quality in products and services became a major focus in the 1980s. Yet, few academic researchers have attempted to define and model quality because of the difficulties involved in delimiting and measuring the construct.¹³ In the area of customer service, earlier research on standards has also been inconclusive and limited in scope.

The Taguchi strategy, developed by Dr. Genichi Taguchi in the late 1950s in Japan, offers a systematic method for working with a large number of variables, interactions, and levels of variables in different environments. The technique simplifies complex analysis through the design and analysis of experiments, for the purpose of designing and improving product and process quality. Successful use of the Taguchi methods by Nippondenso, Ford Motor Company, and ITT, has resulted in significant cost savings to these firms as well as improving the quality of the product. This approach has also helped some Japanese companies become world economic competitors. By using and understanding the Taguchi methods in their context, logistics managers will be able to continuously improve the quality of customer service, while reducing the cost of the service to the firm.

To date, however, applications of the Taguchi methods in the U. S. have focused mostly on improving production processes that were known to produce acceptable quality levels. There are few existing applications in the service area; none are available beyond a limited internal distribution. Taguchi is currently in

¹³Parasuraman, A., Valarie A. Zeithaml, and Leonard L. Berry, "A Conceptual Model of Service Quality and Its Implications for Future Research," Journal of Marketing, Vol. 49, Fall 1985, p. 41.

the process of translating his work in this area for publication in the U. S. through the American Supplier Institute. It should be possible, nonetheless, to implement the same procedures used for products in customer service systems design. The intention is to choose those design characteristics that will lead to the most consistent, desired functional performance.

2. DEFINITION OF THE PROBLEM

The repetitive implement/survey/adjust approach to customer service design is analogous to product design with quality "inspected in" at the factory floor level. Inspection at the end of a manufacturing process only identifies problems that result from excessive variation of parts. Alternatively, inspection of the design would reveal these problems as well as possibly more severe problems due to the product design's inability to cope with system and process variation.

For service processes the results of an inspection-type approach are far more serious. According to information presented by Albrecht and Zemke, the average business never hears from 96 percent of its unhappy customers.¹⁴ This statistic is even more alarming when it is known that complainers are more likely than non-complainers to do business with the firm again. External service failures will result in a loss to the firm approximately 75 percent of the time, either in

¹⁴Albrecht, Karl and Ron Zemke, Service America: Doing Business in the New Economy (Homewood, IL: Dow-Jones Irwin, 1985), pp. 6-7.

terms of sales or lost customers. The implication is that firms must be fully aware of all aspects of what the customers desire in products and service. Furthermore, potential problems and their root causes need to be identified before they occur.

In addition to determining what the customer values, the firm must also realize that continuous improvement is necessary in today's market. The Kano model shown in Figure I-1 suggests that the degree of customer satisfaction that can be obtained from spoken and unspoken basic factors is of diminishing return for effort over time, even as performance achievement increases. On the other hand, the continuous improvement of performance for "exciting" or new quality attributes, in combination with basic high performance, can lead to increasing and greater customer satisfaction. However, because quality is dynamic in nature, exciting quality attributes become expected performance standards in the future.

The role and scope of logistics has broadened to the extent that more creative approaches to the design and administration of logistics systems is required. Because of the unprecedented and accelerated change which is currently taking place in the firm's environment, Poist suggests that logistics can currently be characterized as being in a neologistics (or second generation) era.¹⁵ Neologistics concentrates on management of interfunctional interfaces and ensuing trade-offs involving other functional areas within the firm. This approach demands a different systems design focus from previous eras. To achieve

¹⁵Poist, Richard F., "Evolution of Conceptual Approaches to the Design of Logistics Systems: A Sequel," Transportation Journal, Spring 1989, p. 35.

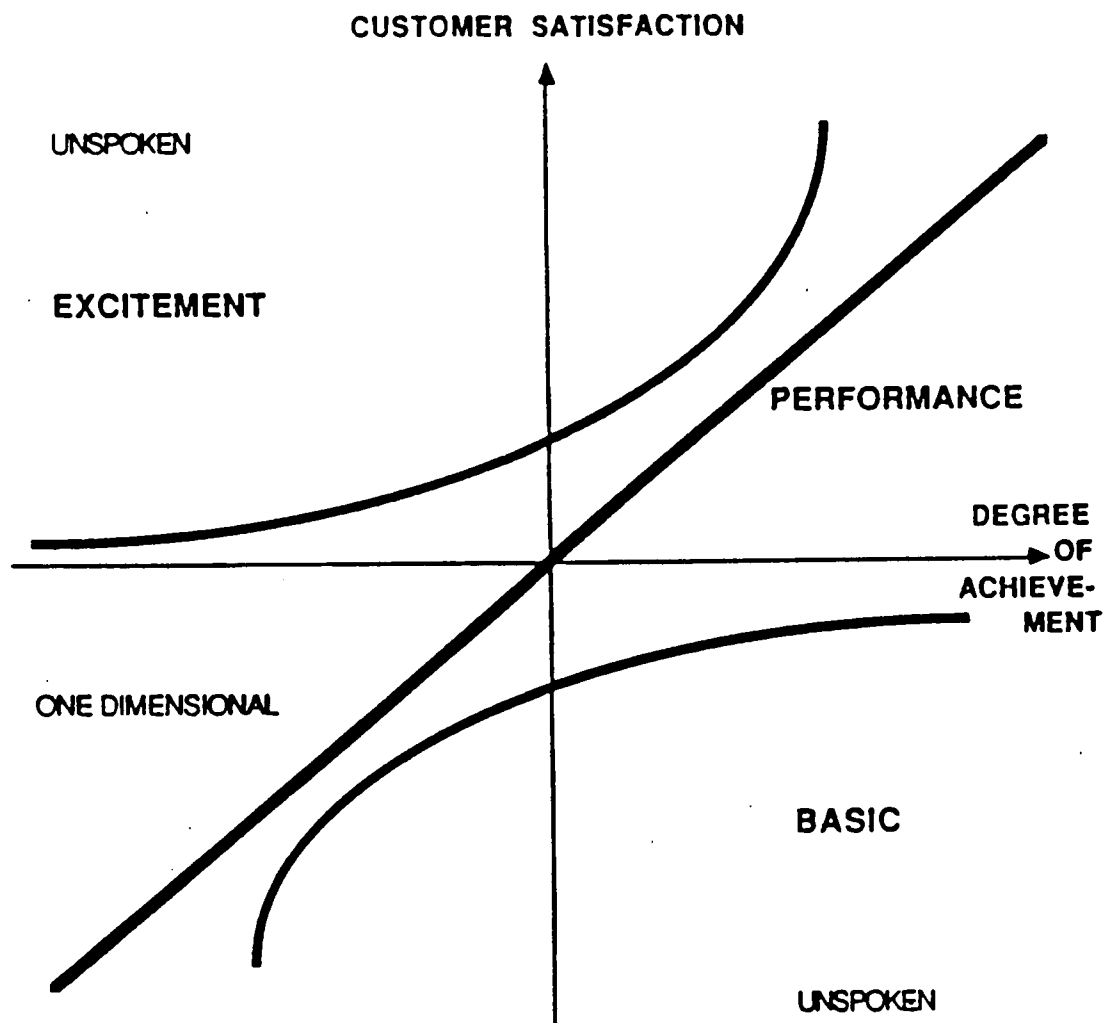


Figure I-1. The Kano Model

Source: Bob King, Better Designs in Half the Time: Implementing Quality Function Deployment in America, GOAL/QPC, 1987, p. 3-5.

improved quality, lower costs, and increased levels of service, the approach and thinking of the firm must embrace the quality engineering concept of performing to target values. This adherence to customer targets is in sharp contrast to the current problem solution approach of conformance to specifications.

Designing a logistics customer service system in isolation of functional interfaces can also lead to sub-optimal performance. Major consideration must be given to ensuing trade-offs involving marketing, production, engineering, finance, and so forth. Vollmann, Berry and Whybark define the functional trade-offs as demand management.¹⁶ Managing these day-to-day interactions between the customers and the company requires critical coordination in scheduling inter- and intracompany resources. Timing and consistent, reliable delivery of services becomes an important issue in demand management as the objective is to "bridge" the firm and the customer. Customers depend on the firm's capability and capacity to respond.

Most firms feel that 100 percent service is simply beyond the realm of financial possibility. However, this should not be interpreted as a reason for poor customer service. It is possible to make and have major system improvements without having "emotional" responses. The demand management concepts can be used to make substantial improvements in customer service without massive inventories or idle capacity.

¹⁶Vollman, Thomas E., William L. Berry, and D. Clay Whybark, Manufacturing Planning and Control Systems, (Homewood, IL: Irwin, 1988), 2nd ed., p. 408.

The time development line necessary for this type of product and process capability is presented in Figure I-2. In the past, customer service research has been limited to an examination of the trade-offs that exist among a limited number of customer service/physical distribution elements. Significant future contributions can be made by measuring trade-offs in terms of observable effectiveness, and in context of uncontrollable variations in the factory and the field.

In the area of logistics, little research has been done to test the cause-effect relationships of design to performance in customer service. Models developed to date have focused on variables that narrowly define customer service, and many have failed to measure customer service from a customer's point of view.¹⁷ Because customer service is a multi-dimensional phenomenon, which often spans a array of several functional areas, a comprehensive method is needed to analyze the relationships of the elements from a total responsibility approach.

Previous methodological frameworks also have not successfully defined the mix of elements of customer service for which reduced variability in performance would lead to higher quality perception and lower cost. The Taguchi engineering approach to quality for product design and development has proven to be an effective method for achieving both of these objectives. It should be possible to realize these same results by utilizing this strategy in a customer service context.

¹⁷Sterling, Jay U. and Douglas M. Lambert, "Customer Service Research: Past, Present, and Future," International Journal of Physical Distribution & Materials Management, 19, No. 2, 1989, p. 10.

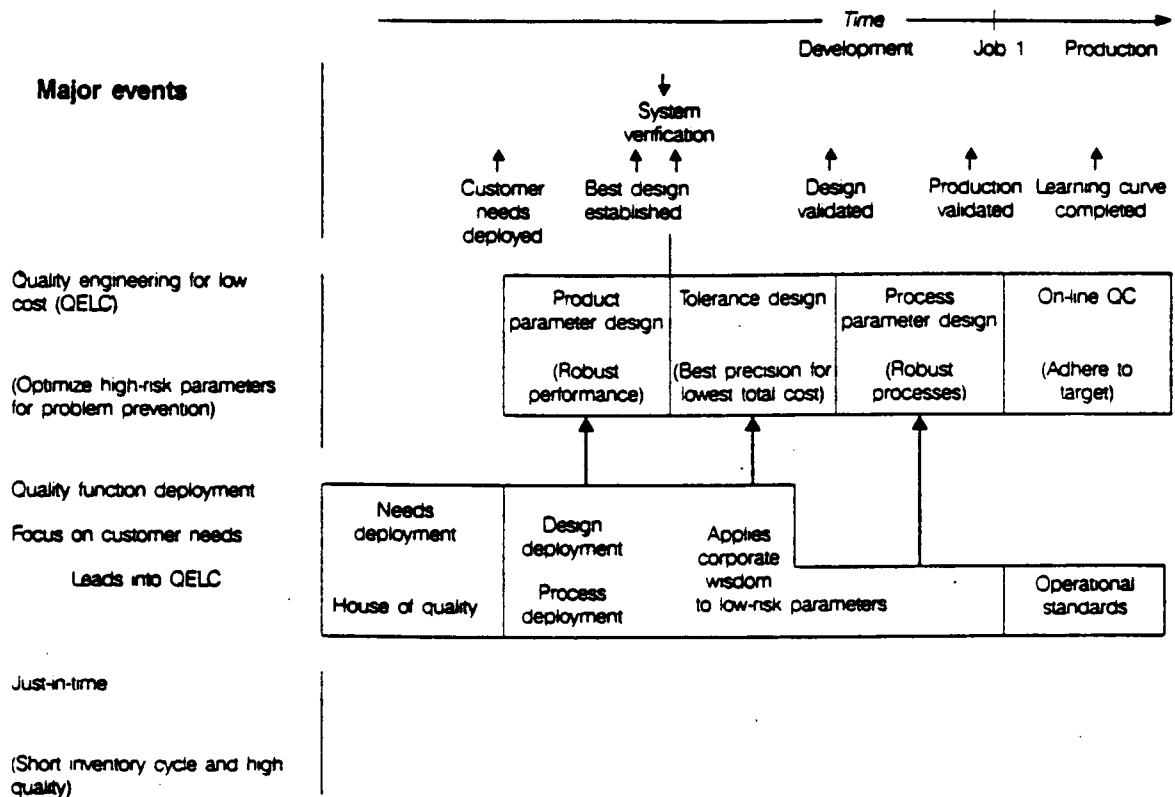


Figure I-2. Time Development Line for Quality Design

Source: Don Clausing and Bruce H. Simpson, "Quality by Design," Quality Progress, January 1990, p. 43.

Such analyses will be important to logistics managers because of their need to continuously strive for value creation through customer service maximization.

3. OBJECTIVES OF THE RESEARCH

In the first systematic and comprehensive industry-wide study of customer service, LaLonde and Zinszer defined customer service as the integration and management of all the elements of the customer service interface within a predetermined cost service mix.¹⁸ Other methodological frameworks, while adding to the knowledge and understanding of this component in the logistics function, have not definitively identified the mix of elements of customer service for which reduced variability in performance would lead to higher quality perception and lower cost. The Taguchi engineering approach to quality has been demonstrated to be an effective method for achieving better product quality and performance while maintaining or reducing current costs.

The overall objective of this research is to develop a comprehensive method for designing, assessing, and improving customer service offerings, from both a cost and a customer satisfaction perspective. The current view held by some firms is that higher or better levels of service cost more money. Part of the research objective will be to show that higher quality service can actually cost less. By utilizing the Taguchi methods and strategies in a logistics context, it will also be

¹⁸LaLonde and Zinszer, op. cit., p. 3.

possible to establish a theoretical basis for the design of a customer service program, without controlling or eliminating certain causes of variation.

There are relatively few existing applications of the Taguchi strategy in the service area. To date, none of these have been published other than for internal distribution purposes.¹⁹ Instead, the preponderance of applications have focused on improving production processes that were known to produce acceptable quality levels.

The research is not intended to be a study of the Taguchi methods, but rather a study with the aim of improving logistics customer service and its interface with the other components of the firm through a systematic and quantitative methodology. Neither is the Taguchi strategy presented as a "stand alone" approach. A major objective and contribution of the research to the discipline is to demonstrate the effectiveness of this methodology as an integral part of the logistics customer service process.

In order to accomplish these research objectives, several stages were completed. First, the measurement of the attributes of interest was a necessary requirement for achieving consistent quality performance. With physical, tangible products this task is relatively simple. For services, however, this activity calls for an operational approach to quantify the variables for methodological development.

¹⁹Based on personal conversations with various individuals including: Don Schenck - Texas Instruments; Bill Ross - Storage Transfer, Inc.; and Morris Katz - American Supplier Institute.

The situation is further complicated in that customers may be unable to specifically identify their own needs.²⁰

Phase 1 of the research utilizes conjoint measurement as a means of determining consumer preferences among multi-attribute alternates. The objective of this research stage was to determine how customers value certain service attributes from rank-ordered data. The results from a computer-generated conjoint analysis of respondent rankings provided an importance weight for recognition of the relative contribution each attribute level makes toward the importance of the attribute.

Once this was accomplished, some amount of interpretation was done. In comparing the relative importance of service dimensions, it was possible to gain insight concerning the preferred mix of elements across different customer segments. Firms interested in making continuous improvements in the quality of their logistics systems will be able to use these results to concentrate on improving those parts of the logistics process that contribute the most value to customers. According to Foggin, this is a very effective strategy for competing in today's environment.²¹

Phase 2 of the research involved Taguchi parameter design for determining which customer service factors cause measured performance to deviate from its

²⁰Schary, Philip B., "Customer Service as a System Process," Contemporary Issues in Marketing Channels, (R. F. Lusch and P. H. Zinszer, eds.), Norman, OK: University of Oklahoma, 1979.

²¹Foggin, op. cit.

target value. Referred to as noise, these factors cause variability and loss of quality. The overall aim of this stage of the research was to produce a mix of customer service elements which are robust with respect to noise factors.

A summary of the research objectives for each of the phases, and the research questions addressed for purposes of attaining these goals is presented below:

PHASE 1

OBJECTIVES:

- o To determine the utility scales (relative preference rankings) of various customer service attributes among multi-level alternatives.
- o To gain an understanding of the trade-offs that various customer groups (market segments) are willing to make among specified attributes.
- o To build customer service profiles based on segmentation factors.
- o To determine which attributes, and levels of these attributes, are statistically significant.

RESEARCH QUESTIONS:

- o What components of the customer service mix contributes the most to creating customer value?

- o What level of each customer service element is required to develop an effective service strategy?
- o Can managerially useful market segments be identified based on the needs of customers?
- o How important are individual customer service elements with respect to the other components of the mix?
- o What variables offer the best opportunity for the firm to improve its perceived performance with regard to customer service?

PHASE 2

OBJECTIVES:

- o To identify the settings of design parameters that improve quality of service delivery.
- o To identify those design parameters that have a large influence on the mean value of the performance characteristic, but have no effect on its variation.
- o To identify those design parameters that have no detectable influence on performance characteristics.

RESEARCH QUESTIONS:

- o Which customer service variables can be manipulated to reduce variation of performance within the current operating environment?

- o Do customer service variables exist for which the level of service provided is immaterial to performance effectiveness?
- o Is it possible to design customer service programs whose performance is not sensitive to variations of the uncontrollable noise factors?

Phase 1 of the research provided utility measures for evaluating customer service trade-offs. While this approach has been used in previous modelling efforts, the research for dissertation goes beyond earlier studies in that the utility scores from the conjoint analysis provided the basis for further analysis of results using a design of experiments approach. The Taguchi strategy of parameter design for Phase 2 represented a research methodology that is new and innovative in the area of customer service. Overall, the research study for dissertation will be of considerable significance to the discipline due to the lack of previous quantitative methods in this area.

4. RESEARCH METHODOLOGY

The dissertation research was a separate, stand-alone component of a larger customer satisfaction research design whose purpose was to establish a measure of customer perception regarding the quality of products and services the consumer goods company offers. The dissertation component was used to identify opportunities for improvement, focusing on those elements that have the greatest

impact on customer perceptions. Both research efforts were designed in conjunction with the other, and particular attention was given to overall research design to meet the corporate research objective stated above.

Phase 1 of the research involved conjoint analysis to assess the utility of alternative levels of several customer service elements. The three components of the conjoint measurement are: 1) a technique of data collection requiring a respondent to consider "trade-offs" among desirable alternatives, 2) a computational method which derives "utilities" accounting as nearly as possible for each respondent's choice behavior, and 3) a simple market simulation model which attempts to determine those characteristics of a product (or process) which will maximize its share of preference within any particular competitive context.

The customer satisfaction portion of the research, directed by the consumer goods company, was conducted by an independent, third-party entity with considerable knowledge and expertise in data collection, assimilation, and analysis. This component was administered by telephone. The same independent entity was used for the dissertation research, but only for mailing lists and questionnaire distribution. The entity was also used for pre-test of the survey instrument, and participated in the design of the final questionnaire.

Phase 2 of the research involved Taguchi parameter design for determining which customer service factors cause performance to deviate from its target value. The goal of parameter design is to identify values of the attributes so that service exhibits a high level of performance and is minimally sensitive to certain

environmental factors. The parameter design used in Phase 2 examined the interactions between the customer service factors and specifically selected "noise" factors in order to achieve robustness. It was a search for parameter levels at which a characteristic is stable, despite external conditions.

Phase 1: Sample and Procedure

The population of customers for the specified division of the consumer goods company consists of ten market channels - hi-lo, every-day-low price (EDLP), wholesaler, drug, mass merchandiser, deep discount drug, club, convenience, toy, and variety. Due to the preponderance of customers within the grocery segment (hi-lo, EDLP, and wholesaler), a convenience sample was used to balance research results, i.e. random selection would have resulted in a predominant grocery sample. For the grocery segment, samples were selected from the market channels based on volume of business. The remaining market channels were small enough (in terms of number of customers) that all customers could be used in the research effort. These methodological issues are discussed in detail in Chapter 3, Research Methodology.

The initial set of customers contacted were delineated by buyer or warehouse/distribution management. The telephone interviews were conducted during March/April/May 1991 for the warehouse sample; buyer interviews were conducted in the June/July 1991 time frame. The groups included 221 buyers and 186 warehouse/ distribution managers. Of the buyer sample, over 50 percent of

those contacted participated in the interview. More than 75 percent of the warehouse/distribution management responded.

At the conclusion of the telephone interview, each respondent was asked to participate in the mail survey portion of the research. Both those customers who completed the telephone interview and the non-telephone respondents were sent the customer service questionnaire. Based on the original sample of customers, the survey response rate was 19.9 percent for the buyers, and 22.6 percent for the warehouse/distribution managers. As expected, the majority of respondents to the mailed survey also participated in the telephone interview.

Self-addressed, postage envelopes for returning the questionnaires were provided. After several weeks, a follow-up postcard was sent to those individuals who had not yet responded. For the warehouse sample, the postcard resulted in four additional survey responses. The postcard mailing generated no additional responses to the buyer questionnaire.

Descriptive statistics are used to analyze the survey results. Measures of central tendency and dispersion are also presented for survey data. These simple methods of describing patterns of variation help explain and aid the understanding of results from other statistical techniques such as rank correlation and item analysis.

Phase 2: Sample and Procedure

Ex post facto research was conducted in Phase 2 of the dissertation research. Investigation started with observation of the dependent variable - perfect order score - and retrospectively study independent variables for their possible effects on the dependent variable. This type of research, although different from experimental design in matters concerning manipulation, shares similar structure and design features. The purpose of this phase of the research was to measure system variation to determine influence on performance characteristics over a number of operational events.

Data for Phase 2 of the dissertation research are taken from the logistics management information system at one of the manufacturing plants of the consumer goods company. While specific events were selected for study (e.g. product promotions, new product introductions, and rolling conversions) data records for customer orders were randomly chosen over a defined time period. An attempt was made to balance the sample with grocery versus non-grocery customers. This issue is discussed in detail in Chapter 3, Section 2, "Research Design." Customer service is currently not differentiated at the plant level for either of these segments.

5. IMPORTANCE AND CONTRIBUTION OF THE RESEARCH

The results of this research contribute to the theoretical, methodological, and managerial aspects of customer service within the logistics function.

Theoretical Contribution

Although customer service has received a considerable amount of attention as an area of research, a large portion of the published studies in this area is exploratory in nature. The current theory of customer service is basically qualitative. The efforts within this realm have dealt with discussions of the concepts, their elements, and their relative importance. Models developed to date also have a tendency to focus on a limited set of relevant variables and relationships.

By moving the focus of the research from a downstream quality control perspective to an upstream continuous quality improvement viewpoint, it will be possible to determine optimal levels of customer service elements which will lead to quality that is distinctly superior to planned performance. This type of design for performance will shift the current theoretical perspective from a service performance window to a customer service target specification. The result is a significant and important contribution to the logistics discipline in both a theoretical and applications context.

Methodological Contribution

The research utilized a particular design of experiment procedure for analyzing the relationships of the various customer service elements. The Taguchi method represents a new and innovative approach in the logistics area. Little research has been done in the area of logistics customer service to test the cause-effect relationships of design to performance. Yet this type of analysis has the potential to improve the quality of service by reducing the variation in performance, thereby helping the firm to achieve on-target process specifications.

Several methodologies have been used to evaluate customer service programs. While each offers a means of measuring certain aspects of the process, they have inherent problems and weaknesses which detract from their effectiveness. The development of the methodology for this research offers firms the means to determine the importance of a number of services, as perceived by the customers, and then provide better service on those items considered to be of highest value.

Managerial Contribution

The traditional approach to quality in the U. S. has been a heavy reliance on control. In today's dynamic business environment this is no longer an effective or efficient way to create customer value. In the 1990s, competitiveness will require firms to provide product and services with less variation than the

competition. This reduced variability will translate into greater repeatability, reliability, and ultimately greater cost savings for both the firm and consumer.

By providing management with a means of improving the quality of customer service with statistical design and analysis methods, it is possible to identify opportunities for the firm which will lead to superior quality performance. The basic strategic target that faces management in the 1990s is to offer an essentially "perfect" product and service. This research makes a significant contribution to the firm's understanding and application of quality approaches to achieve this objective.

6. LIMITATIONS OF THE STUDY

Although research within a specific industry provides the most reliable data, generalization cannot and should not be made unless research is conducted in other industries or product divisions with similar results. Lambert and Harrington²² replicated the findings of Sterling and Lambert²³ in that six customer service variables - ability to meet promised delivery date, accuracy in filling orders, advance notice of shipping delays, action on complaints, information exchange, and length of promised lead times - were the same in both the plastics

²²Lambert, Douglas M. and Thomas C. Harrington, "Establishing Customer Service Strategies Within the Marketing Mix: More Empirical Evidence," Journal of Business Logistics, 10, No. 2, 1989, pp. 44-59.

²³Sterling and Lambert, op. cit.

industry and the office systems studies. In both industries, customer service and product quality variables comprised over 75 percent of the variables evaluated as most important by customers. These findings suggest that some degree of generalization is possible regarding the relative importance of customer service variables across various industries or product divisions. Based on these results, it is also believed that further research across other divisions of the consumer goods company will yield similar results.

The sampling frame for the population did not include all customers for the specific division of the consumer goods company. For that reason, it is recognized that inferences to the total population is restricted. However, given the response rates for the buyer and the warehouse/distribution groups, as well as the response rates for individual segments, inferences about the large accounts and some individual market segments can be drawn from the survey instrument used in Phase 1.

CHAPTER II. LITERATURE REVIEW

The purpose of this chapter is to provide an understanding from the literature of the approaches and tools which have previously, and are currently being utilized in customer service management. In order to fully understand the research objectives as outlined by the dissertation, the literature review also encompasses the topics of quality and the Taguchi strategy. Due to the breadth and depth of available material in the quality and customer service areas, the literature focuses on aspects of systems design and performance.

The chapter is organized into three major sections. Because the focus of the research is customer service measurement, this material will be presented and discussed first. The second section examines the various approaches for achieving quality in products and processes, as well as quality and control issues in logistics. Finally, these two sections provide the background and basis for the review of the Taguchi strategy in Section 3 for its applicability and relevance to the research effort.

1. CUSTOMER SERVICE

Importance and Definition of Customer Service

Internal and external business factors in the early 1970s such as the oil boycott, inflation, increasing transportation costs, and high interest rates, prompted companies to re-evaluate the management of corporate resources. Customer service for most firms during this time was mostly a descriptive, reactive activity.¹ But by the late 1980s, many firms were using customer service as a way of strategically differentiating their product or service in the marketplace. Times and circumstances also dictated this change as global competition became a way of life.

Some firms today view customer service as one of the most important interfaces they have with the customer. For some products, customer service plays a critical role in shaping the buyer's perception of the total product offering. Customer service has been proven to be effective in penetrating, building, and maintaining market share.² Although an increasing number of companies are measuring the cost and sales implications of changes in customer service levels, there is still a significant amount of research that remains to be done in this area.

It is often difficult to define, measure, or evaluate customer service because the meaning of this function can vary considerably from one company to the next,

¹LaLonde, Bernard J., Martha C. Cooper, and Thomas G. Noordewier, Customer Service: A Management Perspective, Oak Brook, IL: Council of Logistics Management, 1988, p. 5.

²Ibid, p. 15.

or from one market segment to the next. Heskett listed various ways in which customer service has been defined.³ Ranked according to the popularity of the definition, this list includes:

- o the elapsed time between the receipt of an order at the supplier's warehouse and the shipment of the order from the warehouse;
- o the minimum size of the order, or the limits of the assortment of items in an order which a supplier will accept from the customer;
- o the percentage of items in a supplier's warehouse which might be found to be out-of-stock at any given point of time;
- o the proportion of customers orders filled accurately;
- o the percentage of customers, or volume of customer orders, which are served within a certain time period from the receipt of the order at the supplier's warehouse;
- o the percentage of customer orders which can be filled completely upon receipt at the supplier's warehouse;
- o the proportion of goods which arrive at a customer's place of business in saleable condition;

³Heskett, James L., Nicholas A. Glaskowsky, and Robert M. Ivie, Business Logistics (New York: Ronald Press), 1973, p. 89.

- o the elapsed time between the placement of an order by a customer and the delivery of goods ordered to the customer's place of business; and
- o the ease and flexibility with which a customer can place his order.

In the first comprehensive study of customer service, LaLonde and Zinszer defined customer service in three ways: as an activity, as performance measures, and as an element of the total corporate philosophy.⁴ In their 1987 study of customer service, LaLonde, Cooper and Noordewier re-confirmed these three broad definitions of customer service: 1) as a defined set of functions resident in a specific organizational setting, 2) as performance expectations, and 3) as a process for providing significant value-added benefits to the supply chain in a cost effective way. For the most part, respondents to the 1987 study viewed customer service as the activities of the position such as accepting orders, maintaining inventory availability, and generating inventory status reports, or as a performance standard.

A broader view of customer service is proposed by Schary which goes beyond the limited perspective of activities such as product availability, delivery time, and its variability.⁵ Schary defines customer service as a "product" whose

⁴LaLonde, Bernard J. and Paul H. Zinszer, Customer Service: Meaning and Measurement (Chicago, IL: Council of Logistics Management, 1976), p. 2.

⁵Schary, Philip B., "Management Control Over Customer Service," International Journal of Physical Distribution and Materials Management, 10, No. 4, 1980, p. 147.

dimensions of service are analogous to a new product which must be launched successfully in the marketplace and accepted by customers if it is to be effective. This idea was also supported as early as 1969 by Willett and Stephenson whose empirical findings indicated that subjective estimates (perceptions) of customer service are both multidimensional and not solely dominated by factors such as delivery time.⁶ However, this broad view of customer service makes the service process much more difficult to control and evaluate using existing models and methods.

The meaning of customer service will also vary from one company to another. Stock and Lambert suggest that the one of the greatest impediments to effective customer service strategy is the misdefinition of the term customer service.⁷ Currently most companies define "customer" in too simplistic terms.⁸ Depending on their physical distribution requirements - deliveries to a central warehouse or to retail outlets across the country - two firms may vary substantially in terms of the cost to the firm for servicing them.

Understanding customer service requirements has direct cost implications for the firm's response. In defining customer groups and market segments, several guidelines are suggested by Anandarajan and Christopher including:

⁶Ibid, p. 147.

⁷Stock, James R. and Douglas M. Lambert, Strategic Logistics Management (Homewood, IL: Irwin), 2nd ed., 1987.

⁸Anandarajan, Asokan and Martin Christopher, "A Mission Approach to Customer Profitability Analysis," International Journal of Physical Distribution & Materials Management, 17, No. 7, 1987, p. 56.

1) segmenting members who need and receive a homogeneous mix of service offerings, 2) segmenting on clearly differentiated and significant factors from the other segments, and 3) segmenting in groups large enough to be economically serviceable.⁹ The potential exists for reducing customer service costs and/or improve the level of customer service provided by recognizing differential customer service requirements for individual customer segments.¹⁰

The different conceptualizations of customer service has influenced the measuring and modelling of this activity to the extent that two major approaches to customer service have been identified: physical distribution and the marketing orientation.

Physical Distribution Approach to Customer Service

Under the physical distribution approach, customer service is viewed as a measurable activity. The measurement can vary as different standards of service or service levels exist across industries and customer segments. In a comprehensive examination of customer service research, Tucker compiled a summary of methodology and findings of the major studies in this area.¹¹ This

⁹Ibid, p. 66.

¹⁰Gilmour, Peter, "Customer Service: Differentiating by Market Segment," International Journal of Physical Distribution, 7, No. 3, 1977, p. 142.

¹¹Tucker, Frances G., "Creative Customer Service Management," International Journal of Physical Distribution & Materials Management, 13, No. 3, 1983, pp. 34-50.

information is presented in Table II-1. It is important to understand the various orientations of each of these studies due to their influence in defining customer service measurement and modelling. Physical distribution customer service research has covered a myriad of topics including:

- o cost advantages of offering different customer service packages to different types of customers;¹²
- o the perceived relative importance of customer service activities across industries and between individuals in a single company;¹³ and
- o the importance of customer service activities and the effect of the customer service mix on purchase decisions.¹⁴

LaLonde and Zinszer proposed a very complete, yet parsimonious model comprised of seven steps.¹⁵ The elements of the model include:

- o Customer service audit;
- o Establish customer service standards;

¹²Hutchinson, William H., Jr. and John F. Stolle, "How to Manage Customer Service," Harvard Business Review, November-December 1968, p. 89.

¹³LaLonde and Zinszer, op. cit.

¹⁴Perreault, William D. and Frederick A. Russ, "Improving Physical Distribution Service Decisions," International Journal of Physical Distribution, 7, No. 3, 1977, pp. 117-127.

¹⁵LaLonde and Zinszer, op. cit.

Table II-1. Summary of Major Customer Service Studies

Channel studies	Simon 1965		Hutchinson and Stolle 1968		Willett and Stephenson 1969	
	Emphasis of study	Chemicals, electronic data processing and electrical equipment	Index of technical services	Not specified	Drugs and drug sundries (manufacturers and retailers)	Buyers' perceptions of changes in service levels
Comparisons of opinions at different channel levels		No	No	No	No	No
If yes, which		Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Number of customer services		31	7	7	2	2
How derived		Interview	Not stated	Not stated	Literature	Literature
Number of dimensions		14	None derived	None derived	Not applicable	Not applicable
How derived		Intuition	Not applicable	Not applicable	Not applicable	Not applicable
Types of measures of customer service (level of measurement)		Importance (interval) Satisfaction (interval)	Service level	Service level	Satisfaction (interval)	Satisfaction (interval)
Market segment		None	<i>A priori</i> —by class of buyer: retail vs. institutional	<i>A priori</i> —by class of buyer: retail vs. institutional	No	No
Conclusions		An index of satisfaction can be constructed to optimise service levels and expenditures	Customer service affects profits	Customer service affects profits	Satisfaction is a linear function of service time	Satisfaction is a linear function of service time

table continued

Table II-1 (continued)

	Hopkins and Bailey 1970	Wagner 1973	Perreault 1973
Channel studies	Survey of many industries	None	Various
Emphasis of study	State of the art in customer service research	How to formalise customer service in physical distribution	Physical distribution customer service
Comparison of opinions at different channel levels	No	No	No
If yes, which	Not applicable	Not applicable	Not applicable
Number of customer services	65	Implied 55	9
How derived	Literature	Empirically interview	Literature
Number of dimensions	6	4	Attempted. Two found by factor analysis but were not constant across industries
How derived	Unknown	Unknown	Literature
Types of measures of customer service (level of measurement)	None	Frequency of occurrence (nominal)	Satisfaction (interval) Preference (paired)
Market segmentation	None	None	None found based on operating characteristics
Conclusions	Customer service has many definitions	Customer service needs to improve methods for acting and reacting to customers	Customer service is important to purchasing managers. The importance of its elements varies in different situations. Purchasing managers do not evaluate customer service as they should. Constant sum method of trade-off analysis is superior to other methods

Table II-1 (continued)

		Cunningham and Roberts 1974	Lalonde and Zinszer 1976
Channel studied		Valve and pump industries	Several industries
Emphasis of study		Role of customer service in industrial marketing	Definition of customer service
Comparison of opinions at different channel levels		No	No
If yes, which		Not applicable	Not applicable
Number of customer services		9	21
How derived		Literature	Literature, interview
Number of dimensions		2 (convenience and reliability)	6,3 (depending on classification)
How derived		Literature	Literature and interview
Types of measures of customer service (level of measurement)		Importance (nominal) Performance (interval)	Importance (ordinal) Importance (nominal) Importance (ratio) Service level
Market segmentation		By industry within industry by operating characteristics	None found by industry or operating characteristics
Conclusions		There is probably a threshold of minimally satisfactory service (Note: study replicated by Banting, 1976)	Definitions of customer service vary by function within the company, by company and industry

Table II-1 (continued)

	LaLonde and Levy 1977		Levy 1978
Channel studied	Frozen foods	OTC drugs	
Emphasis of study	Differences of opinion about customer services	Economic trade-offs among customer services	
Comparison of opinions at different channel levels	Yes	Yes	
If yes, which	Distributor-packer/ processors	Manufacturers and wholesalers	
Number of customer services	29	71	
How derived	Interview, literature	Interview	
Number of dimensions	7	7	
How derived	Literature, empirical	Factor analysis	
Types of measures of customer service (level of measurement)	Importance (interval)	Importance (interval) Performance (interval) Utility (through conjoint analysis) service level	
Market segmentation	Yes, by dollar volume	Attempted without success using operating and geographic characteristics to identify groups found by clustering on importance scores	
Conclusions	Differences of opinions do exist	Different service packages can be assigned costs	

Table II-1 (continued)

Christopher, Schary and Skjott-Larsen 1979		Tucker 1980
Channel studied	Several	Prescription drugs
Emphasis of study	Use of customer service in distribution strategy	Perceptions of customer service
Comparisons of opinions at different channel levels	Yes	Yes
If yes, which	Wholesaler—retailer	Manufacturers and wholesalers Wholesalers and retailers
Number of customer services	Varied	39, 41
How derived	Interview, literature	Interview, literature
Number of dimensions	Varied	8
How derived	Factor analysis	Literature, intuition
Types of measures of customer service (level of measurement)	Service level perceptual measures	Importance (interval) Satisfaction (interval)
Market segmentation	No	Yes, using corporate sales, growth, etc.
Conclusions	Perceptions vary between suppliers and customers. Also, differences found between managers in different areas of one firm Customer service can be both strategic and tactical tool	Suppliers do not accurately attribute importance and satisfaction to their customers Research designs in customer service must anticipate divergent attitudes toward customer service which can lead to heteroskedastic data and inhibit the use of multi-variate analysis Services provided by manufacturers to wholesalers may influence the services provided by wholesalers to retailers

Source: Frances G. Tucker, "Creative Customer Service Management," International Journal of Physical Distribution & Materials Management, 13, No. 3, 1983, pp.34-50.

- o Test cost sensitivity of standards;
- o Implement standards;
- o Develop reporting system;
- o Performance evaluation; and
- o Periodic review of standards and programs.

The one particular element of importance to this research effort is the testing of standards for cost sensitivity. LaLonde and Zinszer propose two ways to determine the cost sensitivity of service levels.¹⁶ The first method is to experiment with different levels of customer service in either different geographic segments of the market or different end user segments of the market. The second method is to use computer simulation models which will test the impact of changes of service levels.

Perreault and Russ developed a model for implementing or improving a physical distribution package which was very similar to the LaLonde and Zinszer effort.¹⁷ Perreault and Russ suggested that the firm should determine the perceived dollar value of service changes to the customer. To accomplish this objective, preference data would be collected and analyzed using either conjoint scaling or a multi-factor variation of Thurstone's model of comparative judgment.

¹⁶Ibid.

¹⁷Perreault and Russ, op. cit.

Christopher and Willis provided a summary of customer service concepts and procedures for implementing customer service policies which draws heavily on the efforts by others.¹⁸ The authors present an activity-oriented approach to the subject by identifying the components of customer service. The model proposes that an optimal cost/service combination can be achieved by trading-off one aspect of service for another. Preliminary research efforts by Schary and Becker have been made to try to establish a theoretical basis for the response of customers to varying service offerings.¹⁹ However, the research did not extend beyond one or two variables. Because customer service is a multi-dimensional phenomenon, with significant differences between customer segments, this measurement is not sufficient for establishing customer service policies.²⁰

Various approaches have been suggested for the development and implementation of customer service policies. Levy summarized these paradigms into four basic steps.²¹ First, the present customer service standards and policies within the firm and within the industry are identified. Second, the specific areas of customer service that need changing are defined. In the third step, customer

¹⁸Christopher, Martin and Gordon Willis, "Developing Customer Service Policies," International Journal of Physical Distribution, 4, No. 6, 1974, pp. 321-353.

¹⁹Schary, Philip B. and B. W. Becker, "The Marketing-Logistics Interface," International Journal of Physical Distribution, 4, No. 6, 1974.

²⁰Gilmour, op. cit., pp. 141-148.

²¹Levy, Michael, "Customer Service: A Managerial Approach to Controlling Marketing Channel Conflict," International Journal of Physical Distribution and Materials Management, 11, No. 7, 1981, p. 46.

service standards are implemented. Finally, a method of monitoring and controlling customer service policies is established.

Methodologies which have been used to evaluate customer service programs include field experiment intervention, analysis of historical data, cross-sectional analysis, qualitative interviews of selected customers, and surveys.²² Although each of these methodologies offer a means of measuring certain aspects of customer service, they have inherent problems and weaknesses which detract from their effectiveness. For example, customer service surveys are used to measure customer satisfaction. Yet these surveys are difficult to quantify and even more difficult to use as an indicator of the quality of the service.²³ Thus, many logistics managers may not be aware that their customer service system is out of control until it is too late to improve the situation.

Although customer service has received a considerable amount of attention as an area of research, a large portion of the published research in this area exploratory in nature.²⁴ The efforts within this realm have dealt with discussions of the concepts, their elements, and their relative importance. Models which have

²²Ritz, Christopher J., "Analytical Methods for Measuring the Effect of Customer Service on Sales," Proceedings, San Francisco: Council of Logistics Management, 1982, Vol. II, pp. 540-544.

²³Mundy, Ray A., Russell Passarella, and Jay Morse, "Applying SPC in Service Industries," Survey of Business, Knoxville, TN: University of Tennessee, 21, No. 3, 1986, p. 27.

²⁴Langley, C. John, Jr. and Rammohan Pisharodi, "A Perceptual Process Model of Customer Service Based on Cybernetic/Control Theory," Journal of Business Logistics, 11, No. 1, 1990, p. 26.

been developed to date also have a tendency to focus on a limited set of relevant variables and relationships.

LaLonde and Zinszer concluded from their research that customer service perceptions and measurement are situational to specific industries.²⁵ Further, customer service tends to be related to specific firms. Taken one step further, customers have different preferences for service attributes and characteristics and varying levels of sensitivities to those elements.

The Marketing Orientation to Customer Service

The marketing approach to customer service views this activity as in interface between the demand creation portion of marketing and demand supply.²⁶ It incorporates the physical distribution customer service, as well as a wide range of marketing related customer services. Researchers in marketing-related customer service have examined topics including:

- o the importance of customer service as perceived by suppliers and customers;²⁷

²⁵LaLonde and Zinszer, op. cit.

²⁶Sterling, Jay U. and Douglas M. Lambert, "Customer Service Research: Past, Present, and Future," International Journal of Physical Distribution & Materials Management, 19, No. 2, 1989.

²⁷Levy, Michael, Methodology for Improving Marketing Productivity Through Efficient Utilization of Customer Service Resources, unpublished doctoral dissertation, Ohio State University, 1978.

- o differences in perceptions of importance among different channel levels;²⁸ and
- o the identification of the package of service elements in terms of cost versus benefits.²⁹

Research by LaLonde and Zinszer indicated that most firms do not measure the cost implications of changes in customer service levels.³⁰ In fact, when the firm establishes specific performance standards without carefully surveying customers, there is a tendency to set higher standards than customers actually require. Their research further showed that perceptions and measurement of customer service is unique with respect to specific industries. The awareness of this difference has led to a mix of customer services that is firm-specific.

A decade later, the comprehensive industry-wide study of customer service indicated that customer service will become significantly more important in the marketing mix of the firm.³¹ Although most firms are measuring the cost and sales implications of changes in customer service levels, there is still the perception

²⁸Stern, Louis W. and Adel I. El-Ansary, Marketing Channels (Englewood Cliffs, NJ: Prentice-Hall, Inc.), 2nd ed., 1982, p. 160.

²⁹Perreault, William D. and Frederick A. Russ, "Quantifying Marketing Trade-Offs in Physical Distribution Policy Decisions," Decision Sciences, Vol. 7, 1976, pp. 186-201.

³⁰LaLonde and Zinszer, op. cit.

³¹LaLonde, Cooper, and Noordewier, op. cit., p. 32.

that more should be done in this area to assess the cost/benefits of proposed customer service standards.

If the logistics manager does not have a means of analyzing the perceived value to his customers of the different services that he might offer, he may be lowering profits by giving better services (at a higher cost) than customers require, or conversely offer poorer services which will result in diverted patronage and foregone revenues. Perreault and Russ suggest using conjoint analysis to determine changes in the estimated value (utility) a customer receives from various overall service levels.³² Management attention would then focus on the most important of these elements.

Levy proposed that the best approach to setting customer service standards was to determine the importance of a number of services as perceived by the customers, and then provide better service on those items considered to be of highest value.³³ Within this context, two factors are key: 1) what elements of the service mix are the most important to customers, and 2) how can better (improved quality) service be provided for those services. Such analyses are important because of dual goals of logistics managers - cost minimization and service maximization. However, Levy's work with conjoint analysis indicated that

³²Perreault and Russ, op. cit.

³³Levy, Michael, "Toward an Optimal Customer Service Package," Journal of Business Logistics, 2, No. 2, 1981, pp. 87-109.

increasing service levels may not result in proportional increases in marginal utility to the customer.³⁴

Customer Service and Logistics Systems Evolution

During the past twenty years, the integration of logistics systems has seen significant progress in measuring and understanding logistics trade-offs. Within this realm, the order cycle has been used as the basis for evaluating customer service levels, and much progress has been made in the area of formal systems for accounting and control. As a result of this evolution a clearer understanding of the relationship of logistical cost and customer service began to emerge. The movement toward coordinated logistics systems resulted in the identification of cost elements and improved the overall accuracy in measurement of customer service.³⁵

The role and scope of logistics has broadened to the extent that the firm is using customer service/logistics as a means of differentiating its offerings to customers. Poist refers to this as the neologistics era because the logistics system's perspective goes beyond traditional functional boundaries.³⁶ Neologistics

³⁴Levy, Michael, "Diminishing Returns for Customer Service," International Journal of Physical Distribution & Materials Management, 11, No. 1, 1981, pp. 14-24.

³⁵Bowersox, Donald J. and Robert E. Murray, "Logistics Strategic Planning for the 1990's," Annual Conference Proceedings, Vol I (Oak Brook, IL: Council of Logistics Management, 1989), p. 242.

³⁶Poist, Richard F., "Evolution of Conceptual Approaches to the Design of Logistics Systems: A Sequel," Transportation Journal, Spring 1989, p. 37.

concentrates on management of interfunctional interfaces and ensuing trade-offs involving other functional areas within the firm.

As shown in Table II-2, this total responsibility approach demands a different systems design focus from previous eras. Rather than designing a system that is optimal from a logistics point of view, the approach calls for designing logistics systems that are optimal and compatible in terms of the firm's overall goals and objectives, i.e. creating customer value. This approach provides an opportunity to enhance the visibility of the logistics function internally as well as externally to the firm.

As the business environment changes, new customer-driven strategies are emerging. According to Stern and Sturdivant, today's strategy of effectively managing product cost and productivity is moving toward developing a service responsive orientation and managing logistics costs.³⁷ This stage is characterized by value-added products and services and responsiveness to customer needs. In the future, successful companies will be even more likely to be customer oriented. The firm will focus on quality, instantaneous value-added services, and mass customization through integrated products and services.

In their study of leading edge firms in the area of logistics, Bowersox et al found that these firms:

³⁷Stern, Louis W. and Frederick D. Sturdivant, "Customer-Driven Distribution Systems," Harvard Business Review, August 1987, No. 4, pp. 34-42.

Table II-2

Comparison of Logistics Eras and Conceptual Approaches

Era	Nature of the job	Nature of the design task	Nature of basic tradeoff	Perspective for broadening systems	Systems design criterion	Degree of implementation difficulty
<u>Prelogistics</u>						
Modal rate approach	Technician	Designing transport systems	Rate tradeoffs	Rates	Minimum rates	Low
Modal cost approach			Transport cost tradeoffs	Looking beyond rates	Minimum overall transport costs	Low
<u>Logistics</u>						
Total cost approach	Management specialist	Designing logistics systems	Intrafunctional tradeoffs	Looking beyond transport costs	Minimum total costs	Moderate
Total profit approach			Cost-service tradeoffs	Looking beyond total costs	Maximum total profits contributed by logistics	High
Total channel approach			Interfirm logistics tradeoffs	Looking beyond the firm	Maximum profits channelwide contributed by logistics	Very high
<u>Neologistics</u>						
Total enterprise approach	Management generalist	Fitting logistics subsystems into broader systems (e.g., the enterprise as a system; also the enterprise and society as an interactive system)	Interfunctional tradeoffs	Looking beyond the logistics function	Maximum profits for overall enterprise	Very high
Total responsibility approach			Societal tradeoffs	Looking beyond economic considerations	Maximum benefit-cost ratios	Very high

Source: Richard F. Poist, "Evolution of Conceptual Approaches to the Design of Logistics Systems: A Sequel," Transportation Journal, Spring 1989, p. 35.

- o have more flexibility for dealing with special or non-routine customer requests;
- o utilize various measurements for regularly evaluating performance; and
- o are more likely to use performance measures that include cost, customer service, productivity, and quality.³⁸

This approach is consistent with Poist's neologistics era in which logistics contributes to achieving the overall goal for the firm. Considerable attention has been directed toward the integrative aspects of logistics, and its contribution to customer value. As a result, logistics managers have been actively repositioning their efforts in the interests of facilitating cross-functional coordination in order to best serve the customer.³⁹

Measures of Customer Service

Customer service can be measured in several ways. First, service performance can be compared to a standard or specification established by the

³⁸Bowersox, Donald et al., "Integrated Logistics: A Competitive Weapon," Annual Proceedings, Vol I, (Oak Brook, IL: Council of Logistics Management), 1987, pp. 13-14.

³⁹Langley, C. John, Jr. and Mary C. Holcomb, "Achieving Customer Value Through Logistics Management," Quality Management Systems: Competing With Customer Value (M. J. Stahl and G. C. Bounds, eds.), Westport, CT: Quorum Books, 1991.

firm. Another approach is to measure perceptions such as importance and satisfaction. Third, it is possible to measure customer service on the basis of its utility to customers.

In a study by Rhea and Shrock, distribution-related performance factors were used to determine the effectiveness of the organization in fulfilling customer's expectations, i.e. creating customer satisfaction.⁴⁰ Performance measurements for product and information flow included factors such as: adequacy, consistency, responsiveness, accuracy, timeliness, and initiative. The results indicate that consistency of product flows and accuracy of information flows do not properly measure customer service. However, initiative and timeliness measures of delivery service attributes appear to be particularly strong indicators of creating customer satisfaction.

Resource variables such as amount and variability have also been used in many distribution studies as measures of product flow performance.⁴¹ An item such as delivery time measures the acceptability of the amount of service provided versus customer requirements. Variability on the other hand measures the extent to which deviations in delivery times are acceptable to the customer. Rhea and Shrock have identified determinants and measurement dimensions for both

⁴⁰Rhea, Marti J. and David L. Shrock, "Measuring the Effectiveness of Physical Distribution Customer Service Programs," Journal of Business Logistics, 8, No. 1, 1987, pp. 31-45.

⁴¹Rhea, Marti J. and David L. Shrock, "Physical Distribution Implementation Effectiveness: The Customer Perspective," Transportation Journal, Fall 1987, pp. 36-42.

product and information flows.⁴² Shown in Table II-3, these factors represent a selective sampling of publications for differentiating between physical distribution activities and their measures of effectiveness.

Measurement of service levels is limited by the fact that one can only use services for which the firm has formulated specific numerical policies and goals. Service levels have usually only been established for physical distribution services, while other elements in the marketing mix do not easily lend themselves to measurement by service level.⁴³ Very few firms have established specific quantifiable goals for these other service categories. For this reason, perceptual measures of customer service has been the preferred approach.

The perceptual process model developed by Langley and Pisharodi provides a means of conceptualizing customer service from a behavioral perspective.⁴⁴ It is also useful for identifying the relevant variables and processes which should be measured in relation to customer response. A clear understanding of the factors which influence customer service is necessary to segment customers according to "reference values."

Langley and Pisharodi suggest that a survey of customer perceptions of customer service be conducted to identify the relevant service elements. For each of these elements, a comparison of the actual performance levels to the industry's

⁴²Ibid.

⁴³Tucker, op. cit.

⁴⁴Langley and Pisharodi, op. cit., pp. 26-48.

Table II-3

Differentiating Between Effectiveness Determinants and Dimensions

PRODUCT FLOWS		INFORMATION FLOWS	
Satisfaction Determinants: What Should Be Measured	Satisfaction Dimensions: The Measures	Satisfaction Determinants: What Should Be Measured	Satisfaction Dimensions: The Measures
Order Cycle Time	Average	Order Procedures/Entry	Frequency
Lead Times	Consistency/Variability		Convenience
Inventory	Length	Invoicing/Billing	Efficiency
	Availability		Accuracy
	Reliability		Efficiency
	Completeness/Fill Rate		Timeliness
Order Condition	Proximity of Nearest Stock	Customer Service	Formalization
	Accuracy	Policy/Promises	Distribution to Customer
	Damage-Free	Order Information	Availability
Back Orders	_____		Reliability
Returns	_____		Timeliness
Substitutions	_____		Preciseness
Damages	_____		Rapidity
Transshipments	_____	Inquiries/Complaints	Ease
Unitized Loads	_____		Responsiveness
Freight Pickup	Availability	Claims	_____
Allowance		Returns	Cooperativeness
Carrier Selection	Availability	Alteration	_____
Emergency Service/	Availability	Replacement	_____
Rush Orders		Emergency Service/	_____
Service During	_____	Rush Orders	_____
Promotions		Promotion Support	_____

Source: Marti J. Rhea and David L. Shrock, "Measuring the Effectiveness of Physical Distribution Customer Service Programs," Journal of Business Logistics, 8, No. 1, 1987, p. 42.

standards, major competitors' levels of service, and service level expectations resulting from past experiences with similar suppliers, should be made. Hard data internal to the organization can be used to measure the firm's actual performance. The collected data can be used for several purposes including:

- o determination of whether the supplier and customers place the same emphasis and significance on the various customer service elements;
- o identification of which gaps in expectations contributes to decreased customer satisfaction;
- o determination of differences in customers' perceptions and the firm's actual service levels; and
- o identification of determinant customer service elements for focus of management attention.

Importance and satisfaction measures used in both physical distribution and customer service are easy to respond to. However, these measures are often ambiguous because: 1) data on perceptions may contain respondent bias, 2) there is no measure of how much and which services are required by a particular customer or market segment, and 3) there are few studies of the stability of perceptions across respondents over time.⁴⁵

⁴⁵Tucker, op. cit.

Utility measures allow a respondent to evaluate trade-offs between several customer services, at various levels, even when the services are expressed in different units. To date, trade-off analyses have most often been used for physical distribution service levels. Just as with the service levels, other elements of the marketing mix are not easily expressed in terms of trade offs. In addition, respondents must be able to realistically evaluate alternative packages of services, some of which vary only to a small degree.

Measuring customer service levels is important because it allows the firm to be very specific about how customer service should be designed. Utility measures, derived through conjoint analysis, offers the firm an opportunity to quantitatively trade off customer services, and to segment customers based on the relative importance of physical distribution service elements.

Study results indicate that the relative importance of physical distribution service elements depends on the type of product being purchased.⁴⁶ No differences were found based on the size of the firm or industry type, indicating that the relative importance of distribution services was relatively homogeneous across these factors. Thus, a segmentation strategy based on either of these attributes did not seem warranted. Offering the proper mix of service to the various customer segments has two potential benefits: increased customer

⁴⁶Jackson, Donald W., Janet E. Keith, and Richard K. Burdick, "Examining the Relative Importance of Physical Distribution Service Elements," Journal of Business Logistics, 7, No. 2, 1986, pp. 14-32.

satisfaction, and the possibility of lowering costs by not offering excessive services which are not deemed important by customers.

Models of Customer Service

There is a wide variety of logistics decisions for which managers require some assistance from models and the information they provide. To meet this variety of needs there is a variety of models and solver techniques.⁴⁷ There is no single analytic method that is appropriate for dealing with the complexities of the logistics system. The critical management skill is knowing what approach to fit to each need.

There are many factors acting upon and influencing the logistics system as shown in Figure II-1. These factors are often "moving targets" creating pressures that logistics systems must handle. Some of the methods and analytic tools identified by Copacino and Rosenfield as being used for handling the complexities and difficulties of the logistics system include: cost analysis, decision-support models, traditional manufacturing strategy tools, grid framework, and cost service trade-off curves.⁴⁸

⁴⁷Powers, Richard F., "Optimization Models for Logistics Decisions," Journal of Business Logistics, 10, No. 1, 1989, pp. 106-121.

⁴⁸Copacino, William and Donald B. Rosenfield, "Analytic Tools for Strategic Planning," International Journal of Physical Distribution & Materials Management, 17, No. 2, 1987, p. 86.

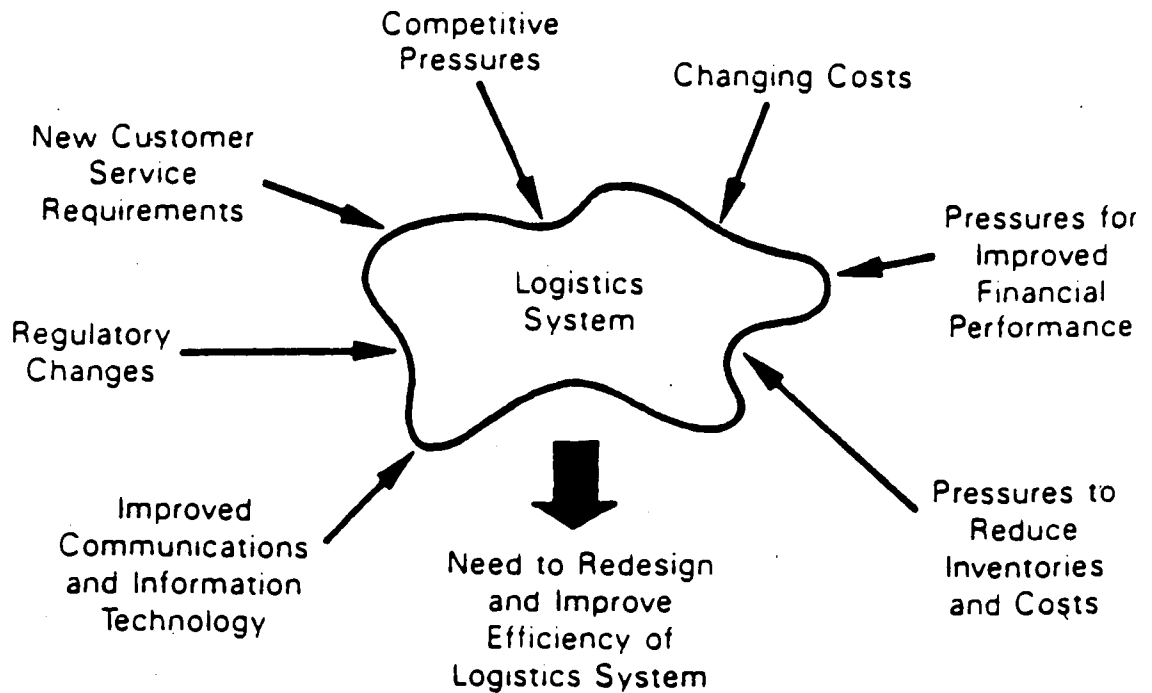


Figure II-1. Pressures Influencing Logistics Systems

Source: William Copacino and Donald B. Rosenfield, "Analytic Tools for Strategic Planning," International Journal of Physical Distribution & Materials Management, 17, No. 2, 1987, p. 84.

Cost analysis, which is useful in its own right for helping the firm understand the breakdown of marginal contribution or profits, is also used as an input to decision-support systems. Decision-support models are becoming more common in company use for determining the most effective way to support the organization's plan. These type of models can also be used for determining the network and facility requirements necessary to obtain a given level of service.

Manufacturing strategy tools that have been employed in the area of logistics include the learning curve, life cycle costing, and the product-process matrix which determines how manufacturing should be matched with a given product. Cost-service trade off curves have been used to simultaneously examine both of these areas. This approach is based on the fact that service is a multi-dimensional concept.

Studies to date have assumed that the relationship between customer service performance and satisfaction is linear. The linear additive model is most frequently used by studies. Overall, there has been little research to examine this functional relationship. Perceptual models are useful for describing the relationship between independent variables, but they cannot predict future actions. In order to understand and predict what customers will do if there is a change in customer service, a quantitative approach such as utility measurement is needed.

Tucker classified the research studies and their ensuing models by company and industry configurations.⁴⁹ As shown in Figure II-2, most of the physical

⁴⁹Tucker, op. cit.

		Specific	Industry	General
Company	Specific	Levy	1	2 Not applicable
	General	Tucker La Londe and Levy	3	4 Perreault La Londe and Zinszer

Figure II-2

Classification of Research Efforts: Examples of Context of
Customer Service by Company and Industry

Source: Frances G. Tucker, "Creative Customer Service Management,"
International Journal of Physical Distribution & Materials
Management, 13, No. 3, 1983, p. 37.

distribution customer service studies have been company and industry general.

Tucker cites several advantages of this approach including:

- o the ability to make comparisons between companies in different industries;
- o the ability to sample a large number of firms; and
- o the ability to generate hypotheses concerning customer service in a "generic" sense.

It should be noted, however, that the major disadvantage of this approach is loss of detail.

At the opposite end of this approach is the company and industry specific research. This type of customer service study is of immediate benefit to the cooperating firm. While the level of detail is a major advantage of this type of research, there are several disadvantages including:

- o small sample size;
- o generalization to other firms or industries is low; and
- o hypothesis generation is difficult.

Increased management attention to customer service has been justified by the belief that this activity creates customer value. Yet models which extensively explore maximum levels of effectiveness and minimum levels of acceptability have

not been developed. Future directions for customer service modelling calls for experimental and quasi-experimental designs which attempt to verify and quantify the relationships between customer service and its elements.

Construction of Customer Service Variables

Most of the variables used in past empirical research defines customer service in a broad and general context. In some cases, this has led to difficulties in interpreting the meaning and significance of the variables to the respondent's industry. Tucker concluded from her research that ambiguous, vague and non-channel specific variables were probable causes for "no opinion" and/or "not applicable" responses.⁵⁰ Sterling and Lambert believe that studies which emphasize variables which narrowly define customer service fails to measure this concept from the customer's point of view.⁵¹

A review of the variables and the experience of prior researchers in customer service studies will be examined in detail in Chapter III, Research Methodology. While these studies provide significant insight and understanding of variables for which continued or improved service will or could lead to differential advantage, it is believed that the importance of many variables related to customer service will be unique to a single echelon. As a result, this study chooses not to rely on past research for variables to be included in the questionnaire.

⁵⁰Tucker, op. cit., p. 50.

⁵¹Sterling and Lambert, op. cit., p. 4.

Conclusions and Implications of Past Studies

Sterling and Lambert have identified ten findings of past studies in the area of customer service research which are notable and relevant to this research effort:

- 1) Most customer service research suffers from relatively small sample sizes which effects the statistical techniques which can be utilized for analysis.
- 2) Ambiguous definitions of customer service and its specific elements has led to questionable and "not applicable" survey responses.
- 3) Deletion of low variance variables in importance scores from further analyses may have significant implications for meeting certain minimum standards.
- 4) A number of researchers have found that the relationship between customer service performance and satisfaction is linear.
- 5) Many of the studies of customer service and channel relationships have been unable to identify meaningful factors (underlying constructs).
- 6) Prior studies have either examined multiple industries as a homogenous group or did not extend the findings for a unique industry to the firm-specific level where alternative marketing strategies must eventually be tested.

- 7) Relatively few studies reported specific attempts to direct the surveys to those who were able to affect customer service decisions and/or evaluate performance and importance.
- 8) Most researchers have not included all of the variables that influence purchase behavior and customer service has been isolated from the rest of the marketing mix.
- 9) Many of the past studies have narrowly focused and defined customer service; in addition, prior studies have failed to measure customer service from a customer's point of view.
- 10) Customer service studies have generally examined only one level of marketing channels that exist in most U. S. industries, thereby ignoring the fact that different levels require different marketing strategies and services.⁵²

These issues and their implications for the research are discussed in detail in the chapter on research methodology.

⁵²Sterling and Lambert, op. cit., p. 15.

2. DESIGN AND PERFORMANCE WITH A QUALITY EMPHASIS

Service Quality Determinants

The existing quality paradigm, with the definition that a quality product or process conforms to specifications, is inadequate.⁵³ Customers expect that their needs will be met even when those needs are imperfectly defined. While engineering specifications normally define product functions and ensure reliability, it is sometimes left to other customer-oriented disciplines to address design aspects that impact customer satisfaction.

In comparing customer expectations with customer satisfaction, Kenny identified three distinct types of quality.⁵⁴ At the lower level, if quality is improved, the customer typically will not be aware of changes. Service failures at this level, however, would be noticeable quickly and lead to customer dissatisfaction. Acceptable quality levels must be maintained for features of this type. At its lowest level this leads to a reactionary mode of quality control that focuses on problem solving.

A second type of quality is an optional feature of which customers are aware. An example of this is automobiles where more features are thought of as

⁵³Kenny, Andrew A., "A New Paradigm for Quality Assurance," Quality Progress, June 1988, pp. 30-32.

⁵⁴Ibid.

higher-quality vehicles by the customer. Management of quality at this level involves choosing the right combination of factors.

The third type of quality perception by customers involves adding a new feature to an existing product, or significantly restructuring the existing offering. New product features result from seriously addressing customer needs. Designing quality into a product or process has the potential for changing the way quality is managed in the firm. It allows for early and meaningful interaction between manufacturing, product design, marketing, logistics, and other functional areas.

According to Parasuraman, Zeithaml, and Berry, quality is an elusive and indistinct construct, which presents problems to consumers and researchers in articulating and measuring its dimensions.⁵⁵ Even when guidelines exist for performing services well and treating customers correctly, high quality service performance may not be a certainty. In their research efforts to identify service delivery gaps, Parasuraman, Zeithaml, and Berry suggest that gaps between service quality specifications and actual service quality will affect service quality from the consumer's viewpoint. The focus groups used in their study revealed ten key service quality determinants which consumers/customers use to evaluate service quality. These items include:

- o reliability;
- o responsiveness;

⁵⁵Parasuraman, A., Valerie A. Zeithaml, and Leonard L. Berry, "A Conceptual Model of Service Quality and Its Implications for Future Research," Journal of Marketing, Vol. 49, Fall 1985, pp. 41-50.

- o competence;
- o access;
- o courtesy;
- o communication;
- o credibility;
- o security;
- o understanding/knowing the customer; and
- o tangibles.

Cost of Service Failures

Based on in-depth interviews of customers (purchasing agents, buyers, and purchase decision makers) in a variety of industries, Shycon identified the impact of customer service failures.⁵⁶ As shown in Figure II-3, service failures can be costly to the firm in the short-term as well as impact a future stream of sales and profits. Even more significant is Shycon's finding that it takes six months or more to restore customer confidence in a supplier - such that he returns to the original volume of business - even after the problem has been resolved.

⁵⁶Shycon, Harvey N., "How to Design the Logistics Service Program," Annual Conference Proceedings (Oak Brook, IL: Council of Logistics Management), St. Louis, MO, 1989, p. 259.

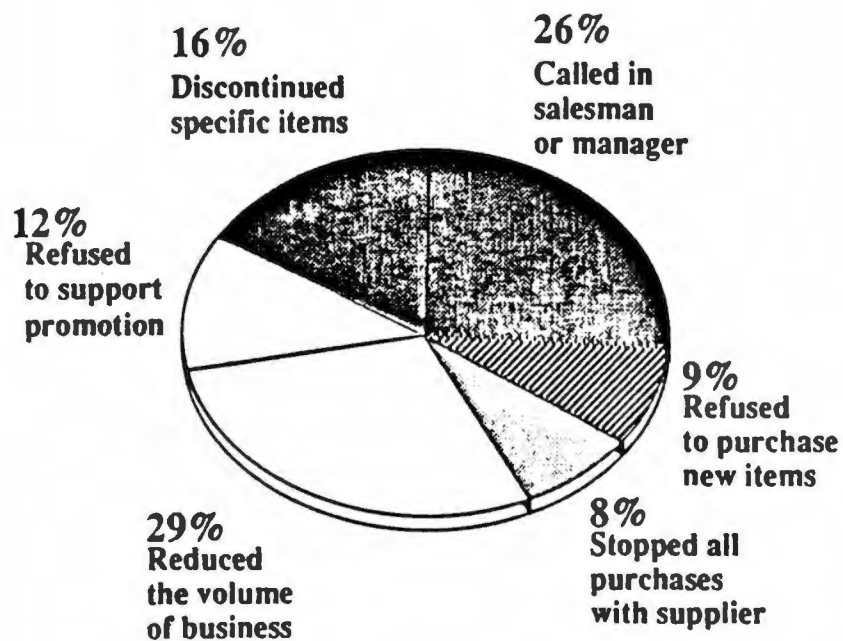


Figure II-3

Penalties for Customer Service Failures

Source: Harvey N. Shycon, "How to Design the Logistics Service Program," Annual Conference Proceedings (Oak Brook, IL: Council of Logistics Management) St. Louis, MO., 1989, p. 260.

Bennion formulated a generalized model of reactions to customer service failures for both short- and long-run reactions.⁵⁷ Presented in Figure II-4, this model shows that initial service failures in the form of stockouts, short ships, and/or order cycle failure may result in a range of undesirable customer reactions from cutting shelf space to refusing new product offerings. Even short-run customer reactions can cause the producer problems as backorders and substitution may impact the firm's ability to meet other customer's needs.

In today's competitive environment, however, good problem solution is totally inadequate. Although it is still necessary to solve problems when they occur, the best approach is prevention. The old adage that "an ounce of prevention is worth a pound of cure" is indeed relevant to process design and development in quality achievement. An example of dependence on the reaction mode to problems is inspection in the factory. Unfortunately, this approach does not allow for analysis of product variation due to uncontrollable operating conditions or use in the hands of the customer.

⁵⁷Bennion, Marcus L., "An Investigation of Wholesale Buyer Reaction to Manufacturer Customer Service Failures in the Grocery Channel," unpublished Ph.D. dissertation, Michigan State University, 1980, p. 163.

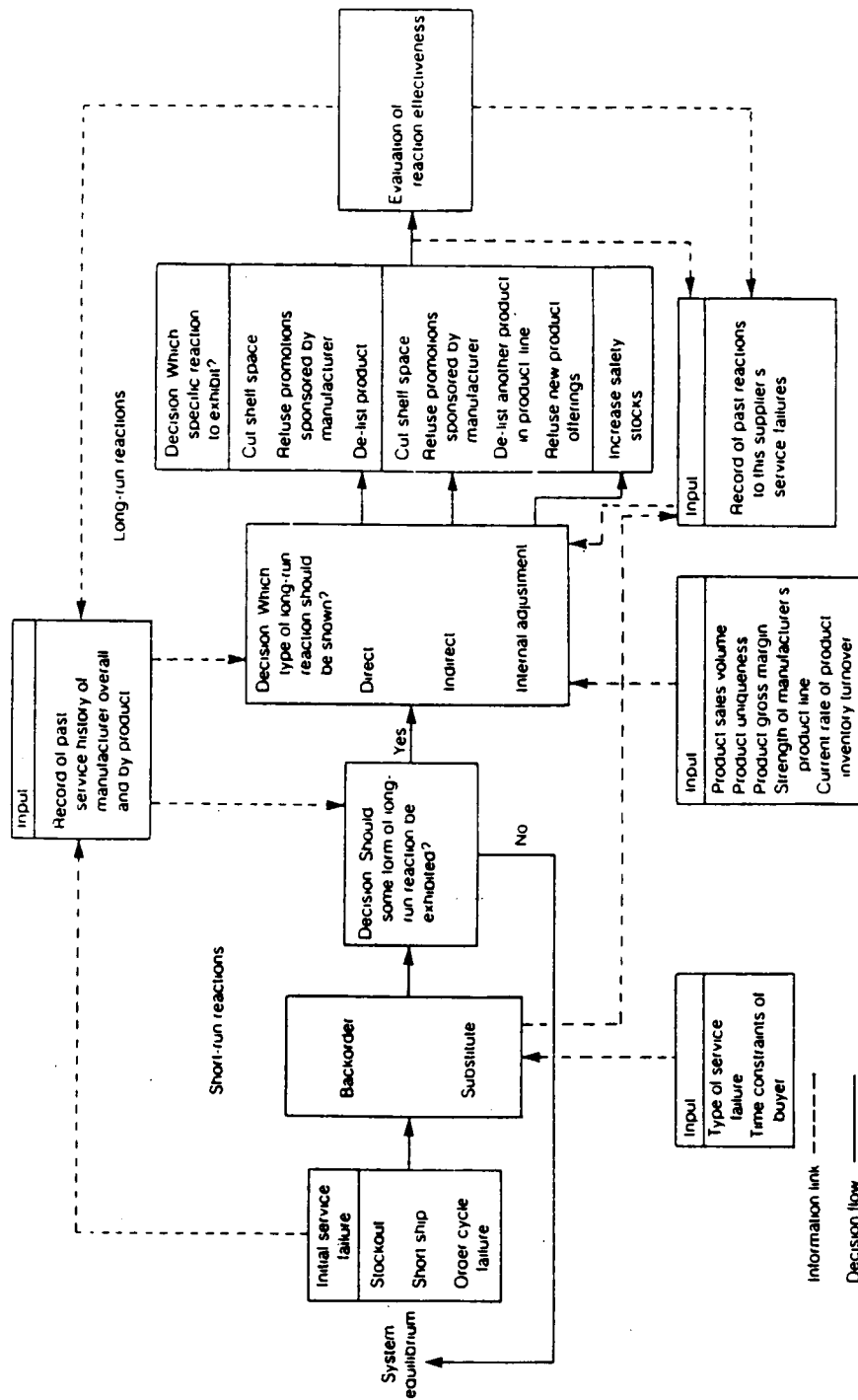


Figure II-4. Generalized Model of Reactions to Customer Service Failures

Source: Marcus L. Bennion, "An Investigation of Wholesale Buyer Reaction to Manufacturer Customer Service Failures in the Grocery Channel," unpublished Ph.D. dissertation, Michigan State University, 1980, p. 163.

Quality Control vs. Quality Design and Performance

Novack defined achievement of quality in customer service as meeting the standards and tolerance limits of customer's needs.⁵⁸ In order to ensure customer satisfaction, quality in customer service is necessary. Novack also suggested that control is the key component in a firm's quality achievement process. The nine steps, or components, of his model include:

1. Identification of internal and external environment forces which can alter the performance of the process.
2. Definition of customer service activities, and necessary quality levels for customer satisfaction.
3. Establishment of performance standards.
4. Establishment of allowable variances.
5. Performance of the activities.
6. Measurement of activities output.
7. Comparison of standards versus actual variance analysis.
8. Corrective action, including removal of assignable causes, redesign of the process, and investigation of standards.
9. Continual monitoring of the activity output.

⁵⁸Novack, Robert A., "Quality Control in Logistics: A Process Model," International Journal of Physical Distribution & Materials Management, 19, No. 11, 1989.

The ability to match the control system with the quality levels by the customer is critical to this model's effectiveness. In fact, as the control system becomes more sophisticated, so does the cost of its design and implementation. This is one of the reasons why many firms today are focusing their resources on "upstream" quality achievement.

Quality control is in reality just a post-mortem inspection of service failures or inspection of defects produced in the production process.⁵⁹ It is known that inspection does not necessarily lead to improvement in the product or process quality. This is why quality control in Japan was started from the inspection phase, moved back to the phase of building quality into the production process, and has finally come to mean building quality into the product at the time of its development.

In the past, quality control was thought of only in terms of the downstream side of the process, with an emphasis on control charts and inspection schemes.⁶⁰ Now the focus is upstream in the process such that a product or process are well designed, thereby virtually eliminating unsatisfactory performance. This reduces the need for inspection and provides economic gains. Direct experimentation is needed to reach this goal.

⁵⁹Imai, Masaaki, Kai'zen: The Key to Japan's Competitive Success (New York: Random House Business Division), 1986.

⁶⁰Box, George E. P., "Off-Line Quality Control, Parameter Design, and the Taguchi Method, A Discussion," Journal of Quality Technology, 17, No. 4, 1987, pp. 189-190.

The topic of quality design in logistics or customer service has not been treated in significant depth. The focus of quality in logistics models has in most cases been on performance measurement and control.^{61,62} For example, Heskett's model (Figure II-5) shows the relationship between development of standards, performance measurement (or variance analysis), and the feedback or corrective action loop. The plan includes both a set of goals and limits around those goals which represent the "bounds" of acceptable performance. This window of acceptability is in direct conflict with the Taguchi quality engineering method of on-target performance.

Heskett's model includes a redesign of the plan/system which is analogous to the tolerance design phase in the Taguchi strategy. The system is redesigned when control efforts have not proven adequate in reducing variation, or in producing the desired performance. However, tightening tolerances or redesigning the system may be expensive and completely unnecessary if parameter design is used first.

It has long been recognized that the business environment represents dynamic influences that the logistics system must be able to accommodate. The four major environmental components identified by Busch and Houston include: external influences, intra-organizational influences, inter-organizational influences,

⁶¹Heskett, Glaskowsky, and Ivie, op. cit., p. 712.

⁶²Novack, Robert A., "Logistics Control: An Approach to Quality," Journal of Business Logistics, 10, No. 2, 1989, pp. 24-43.

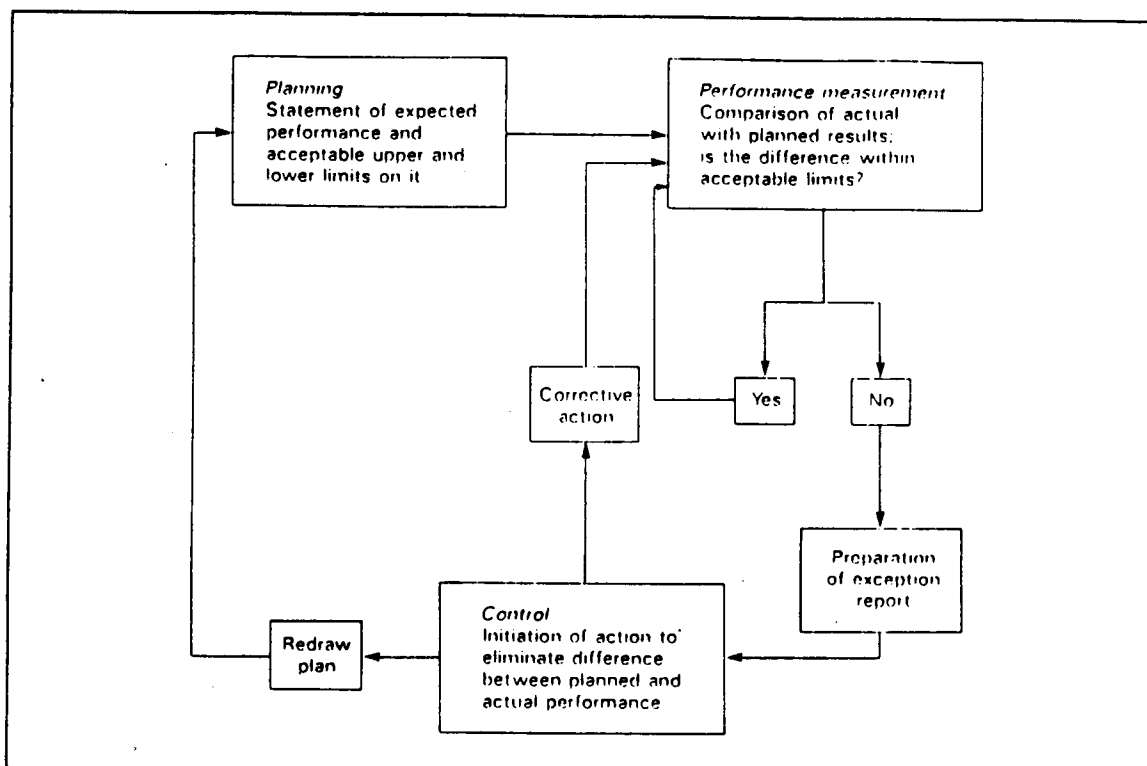


Figure II-5

Relationship between Planning and Performance Measurement and
in the Management Process

Source: J. L. Heskett, N. A. Glaskowsky, and R. M. Ivie, Business Logistics
(New York: Ronald Press), 1973, p. 713.

and personal factors.⁶³ A change in any one of these dynamic factors changes the manner in which the customer service/logistics system performs. However, to date, only the control models developed by Ballou⁶⁴ and Foggin⁶⁵ have incorporated the impact of environmental forces on the performance of the system. It should be noted that no models currently exist which incorporate these factors into the design of the customer service process using a quantitative and systematic technique. Rather, a qualitative, strategic management approach has been used to deal with the environmental influences that have a direct impact on performance.

Design with a Quality Emphasis

According to Clausing and Simpson the transition from problem solution (inspection mode) to problem prevention perspective requires that the firm do several things differently including:

- o constantly thinking in terms of how one can design or manufacture products better;
- o defining customers' wants and then going one better;
- o optimizing desirable features of results; and

⁶³Busch, P. S. and M. J. Houston, Marketing: Strategic Foundations (Homewood, IL: Irwin), 1985.

⁶⁴Ballou, R. H., Business Logistics Management (Englewood Cliffs, NJ: Prentice-Hall), 1973.

⁶⁵Foggin, James H., "Improving Motor Carrier Productivity with Statistical Process Control Techniques," Transportation Journal, Vol. 24, Fall 1984, pp. 58-74.

- o minimizing the overall cost without compromising quality of function.⁶⁶

Three approaches have been used to achieve effective problem prevention and reduced cost: 1) quality engineering (Taguchi strategy), 2) quality function deployment (QFD), and 3) just-in-time manufacturing. Each of these methodologies are distinct and separate parts for improving quality of a product or process. The combination of these techniques aids the firm in meeting customer needs, optimizing critical parameters of the design and manufacturing processes, and creating a system that emphasizes the achievement of high quality.

Quality engineering for low cost optimizes the critical functions of the product and related processes such that they adhere to the target values most desired by customers. This is done to achieve high quality while minimizing total cost. The performance to on-target values is in sharp contrast to the problem solution approach of conformance to specifications.

Traditionally, cost and quality has been viewed as mutually exclusive where one would be at the sacrifice of the other. With the quality engineering approach these two goals are no longer in conflict. Using system, parameter, and tolerance design as proposed by Taguchi, it is possible to have performance that is relatively insensitive to all uncontrollable variations internal and external to the firm.

⁶⁶Clausing, Don and Bruce H. Simpson, "Quality by Design," Quality Progress, January 1990, pp. 42.

Quality (or reliability) engineering is nothing new.⁶⁷ It has been practiced in the aerospace industry in this country for at least 20 years. Most of the effort is focused up front in trying to determine the failure probabilities of individual systems and subsystems, and then strengthening the weak links by product redesign or incorporation of more reliable parts. Managers used statistical techniques to predict reliability (or quality) of performance and collected information on potential failure modes. These data formed the basis for continual improvement.

When quality is defined as conformance to specifications, it is detrimental to achieving improved productivity and reduced costs by quality improvement.⁶⁸ By establishing specifications or tolerances for products and processes the implication is that large amounts of variation are not acceptable to the customer. Originally intended as boundaries within which a product or process could be expected to operate, specifications have evolved to define acceptable versus unacceptable performance.

The second methodology, quality function deployment (QFD), is a systematic way to help identify customer requirements and expectations. By interpreting the "voice of the customer" it will be possible to deploy these desires

⁶⁷Garvin, David A., "Quality on the Line," Harvard Business Review, September-October 1983, p. 64.

⁶⁸Sanders, Richard D., Gipsie B. Ranney, and Mary G. Leitnaker, "Continual Improvement: A Paradigm for Organizational Effectiveness," Survey of Business (Knoxville, TN: University of Tennessee), Summer 1989, pp. 12-20.

throughout all functions of the organization. During this deployment, QFD helps identify the critical parameters that are then optimized by quality engineering to reduce functional variation and costs.

When utilized as an improvement tool, QFD helps firms make use of all its knowledge and information from competitive benchmarking. QFD also guides the selections of the right values for many of the design parameters in which the decision-making risk is relatively low because those parameters are within the realm of experience. Thus, QFD leads directly to the best decisions for the low-risk parameters and helps prepare for the optimization of the high-risk parameters by quality engineering for low cost.

A common misconception about just-in-time (JIT), the third component of a problem prevention approach, is that it is only a technique for delivery of materials. What should be realized about JIT is that it goes hand-in-hand with good quality. In fact, it is essential to have good quality before JIT can be successful. JIT helps identify quality problems, some of which can be overcome by optimization methods and quality engineering for low cost.

Understanding System and Subsystem Interactions

Whenever technological components are linked together in order to carry out a particular activity, the possibility exists that the normal sequence of events the system has been designed to carry out may go awry when failures in two or

more components interact in an unexpected way.⁶⁹ Once this happens, the system is out of control. Systems are characterized by linear and complex interactions which determine the sequence of actions that will occur in unplanned or unexpected situations. Linear interactions occur along a single, invariable path, whereas complex interactions are characterized by unfamiliar sequences that either are not visible or not immediately comprehensible.

Quality problems identified as a part of an individual process most often have their roots in larger systems.⁷⁰ It is believed that reducing variance in the various components of a product or process will also reduce variances in the systems as a whole.⁷¹ The magnitude of improvement which can be made in an organization depends upon the level of where the change takes place. For this reason, management's focus on upstream processes provides the firm with targets of opportunity.

Implications for Future Research

While the focus groups in the Parasuraman, Zeithaml, and Berry study consistently reported similar factors for evaluating service quality, the participants differed on the relative importance of the factors to them, and their expectations

⁶⁹Cohen, Eliot A. and John Gooch, Military Misfortunes: The Anatomy of Failure in War (New York: The Free Press), 1990.

⁷⁰Sanders, Ranney, and Leitnaker, op. cit.

⁷¹Taguchi, Genichi and Don Clausing, "Robust Quality," Harvard Business Review, January-February 1990, pp. 65-75.

along various quality dimensions. Parasuraman, Zeithaml, and Berry suggest that future empirical research should be done to determine if distinct, identifiable service quality segments exist which would be useful to the organization.⁷² However, a service quality measurement instrument is needed for ascertaining whether, and in what ways, customer expectations differ.

In discussing the challenges facing logistics professionals and top management in the 1990s, John Buchanan of Westinghouse noted that quality is the basic strategic target of an increasing number of American companies.⁷³ However, this "ante to play the game" is being raised every day. In the future, companies must be able to offer an essentially "perfect" product and service. This requires processes and work ethics that demonstrate continuous quality improvement. Continuous quality improvement also requires the informed application of a wide range of new and existing quality technology that is used within the company quality process rather than as an end itself.

⁷²Parasuraman, Zeithaml, and Berry, op. cit., p. 50.

⁷³"Quality: The Ante to Play the Game," Traffic Management, July 1990, p.49.

3. TAGUCHI PHILOSOPHY, STRATEGY, AND TECHNIQUE

Introduction

Dr. W. Edwards Deming planted the seeds for continuous improvement in Japan in 1950.⁷⁴ These ideas were codified by Dr. Genichi Taguchi in the late 1950s while he was working for the Electrical Communications Laboratory of Nippon Telephone and Telegraph Company. Although Dr. Taguchi came to the U. S. in 1962 as a visiting Research Associate with Princeton University, it wasn't until 1980-1982 that companies such as AT & T Bell Laboratories, Ford Motor Company, and Xerox Corporation started implementing his methodology.

Taguchi's major contribution has involved combining engineering and statistical methods to achieve rapid improvements in costs and quality by optimizing product design and manufacturing processes. Taguchi's methods are aimed at reducing variability around a target value.

The traditional approach to quality in the U. S. has been a heavy reliance on control through a combination of in-process inspections and statistical methods employing control charts. The Japanese goal in the area of quality is to eliminate inspection procedures by designing products that are proven robust to conditions of normal use and material wear. In the 1990s, inspection will account for only a small portion of the quality contribution in Japanese firms. Instead, design of

⁷⁴Scherkenbach, William W., The Deming Route to Quality and Productivity (Washington, D.C.: CEEPress Books), 1988.

experiments will become the major contributor to constant quality improvement (Figure II-6).

Today dynamic competition has become the key concept in the industrial and service sectors. The heart of dynamic competitiveness is providing product and services with less variation than the competition. Reduced variability translates into greater repeatability, reliability, and ultimately greater cost savings for both the manufacturer and consumer. Effective approaches to quality must address the relationship between quality and cost.

Taguchi Philosophy of Quality

In his book, Crosby supports the position that a product made according to the print, within permitted tolerance, is of high quality.⁷⁵ However, this viewpoint embraces only the designers and the makers. Taguchi's philosophy states that quality has but one true evaluator, the customer.⁷⁶ A "quality circle" that describes this situation is shown in Figure II-7. The designer must take the customer's wants, needs, and expectations, and translate them into product specifications. The makers use this translated information to make the product, which is then delivered via marketing channels to the customer.

⁷⁵Crosby, Philip B., Quality is Free (New York: McGraw-Hill Book Company), 1979.

⁷⁶Ross, Philip J., Taguchi Techniques for Quality Engineering (New York: McGraw-Hill Book Company), 1988.

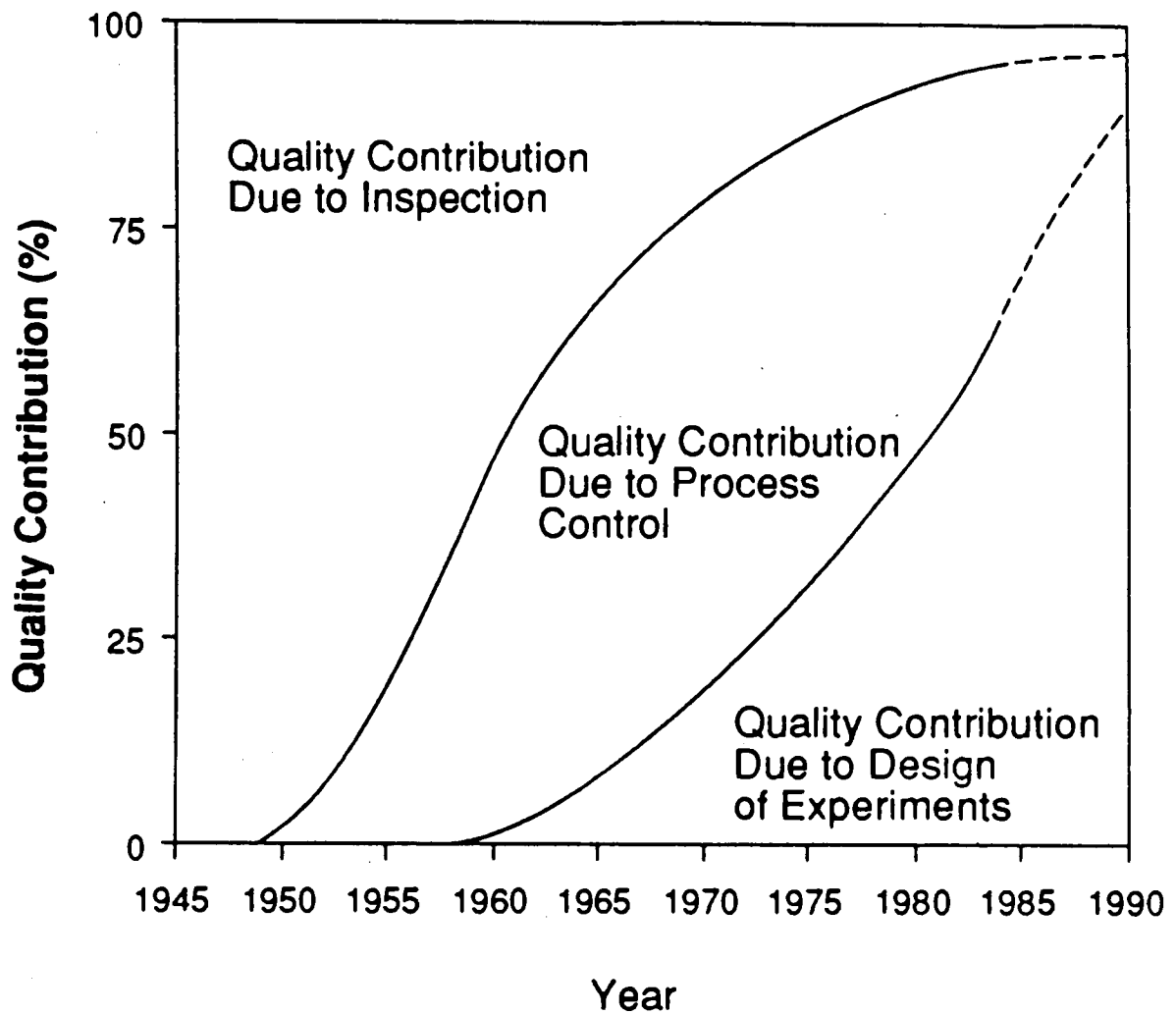


Figure II-6

Japanese Quality Evolution

Source: American Supplier Institute, Detroit, Michigan, 1990.

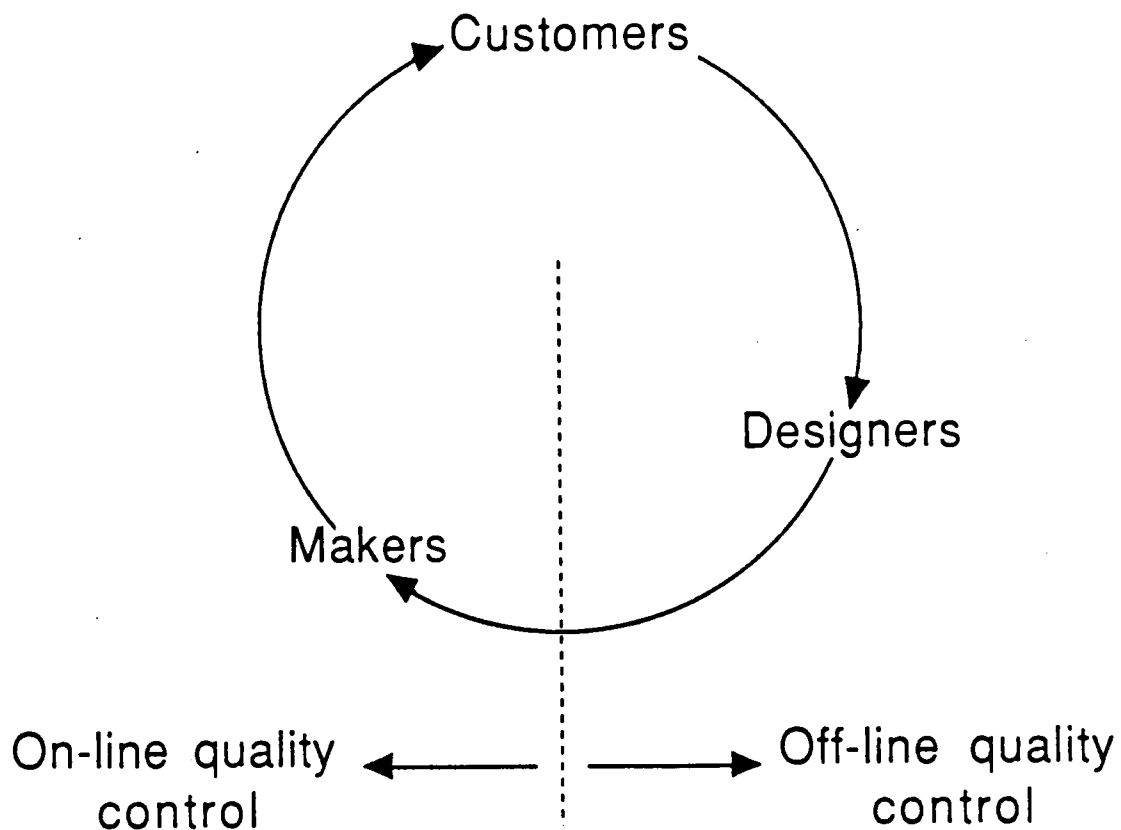


Figure II-7. Another Quality Circle

Source: Philip J. Ross, Taguchi Techniques for Quality Engineering (New York: McGraw-Hill Book Company), 1988, p. 2.

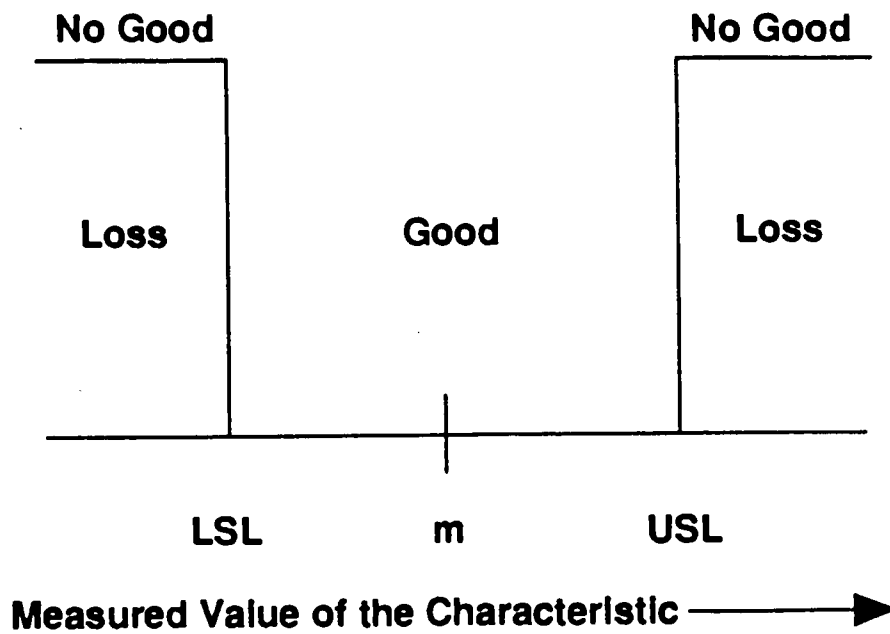
The heart of Taguchi's method is his definition of the term "quality" as the characteristic that avoids loss to society from the time the product is shipped. Taguchi's quality philosophy is best expressed as a "target-oriented" quality because quality is best when products or processes are on target. Quality decreases as products/processes deviate from the desired value (target). Customer dissatisfaction also grows with the deviation. This dissatisfaction can be expressed as a dollar loss to the company or to society in general.

This definition is somewhat limited in scope in that it does not recognize that quality loss in customer service goes beyond product warranties and service costs. When a product is delivered via market channels to the customer, the product must arrive in the right quantities, at the right time, at the right place, and provide the right functions for the right period of time.⁷⁷ In addition, all of these must be available at the right price.

The Taguchi method is essentially a marriage between quality philosophy and statistics.⁷⁸ It addresses the issues of how to evaluate quality and how to improve quality. The traditional quality evaluation embraces conformance to requirements or the "goal post" analogy which represents go/no go gauges as presented in Figure II-8. Any part whose dimension falls within the upper or

⁷⁷Coyle, John J. and Edward J. Bardi, The Management of Business Logistics (St. Paul: West Publishing Company), 3rd ed., 1984.

⁷⁸Roslund, Jerry L., "Evaluating Management Objectives With the Quality Loss Function," Quality Progress, August 1989, pp. 45-49.



USL = Upper Spec Limit
LSL = Lower Spec Limit

Figure II-8

Conformance to Specifications

Source: American Supplier Institute, Detroit, Michigan, 1990.

lower tolerance limits has no loss. Any part that falls outside these limits incurs a loss of fixed value.

Taguchi also distinguishes between off-line and on-line quality control methods.⁷⁹ Off-line quality control methods are technical aids for quality and cost control in the product and process design. In contrast, on-line quality control methods are technical aids for quality and cost control in manufacturing that involve diagnosis, prediction and correction (Figure II-9). It also can involve design of experiments. Off-line quality control methods are used to improve the product quality and manufacturability, and to reduce product development, manufacturing, and lifetime costs. In this context, the word quality has a very broad meaning which includes planning and quality improvement. Effective quality requires off-line quality control methods that focus on quality improvement rather than quality evaluation.

As with performance characteristics, all specifications of product and process design characteristics should be stated in terms of ideal nominal values and tolerances around those nominal values. It is a widespread practice in industry to state these specifications in terms of tolerance intervals only. This practice can mislead a manufacturer into producing products whose characteristics are barely inside the tolerance intervals.⁸⁰ Such products have poor quality and

⁷⁹Kackar, Raghu N., "Off-Line Quality Control, Parameter Design, and the Taguchi Method," Quality Control, Robust Design, and the Taguchi Method (Khosrow Dehnad, ed.), Pacific Grove, CA: Wadsworth & Brooks, 1989, pp. 51-76.

⁸⁰Ibid.

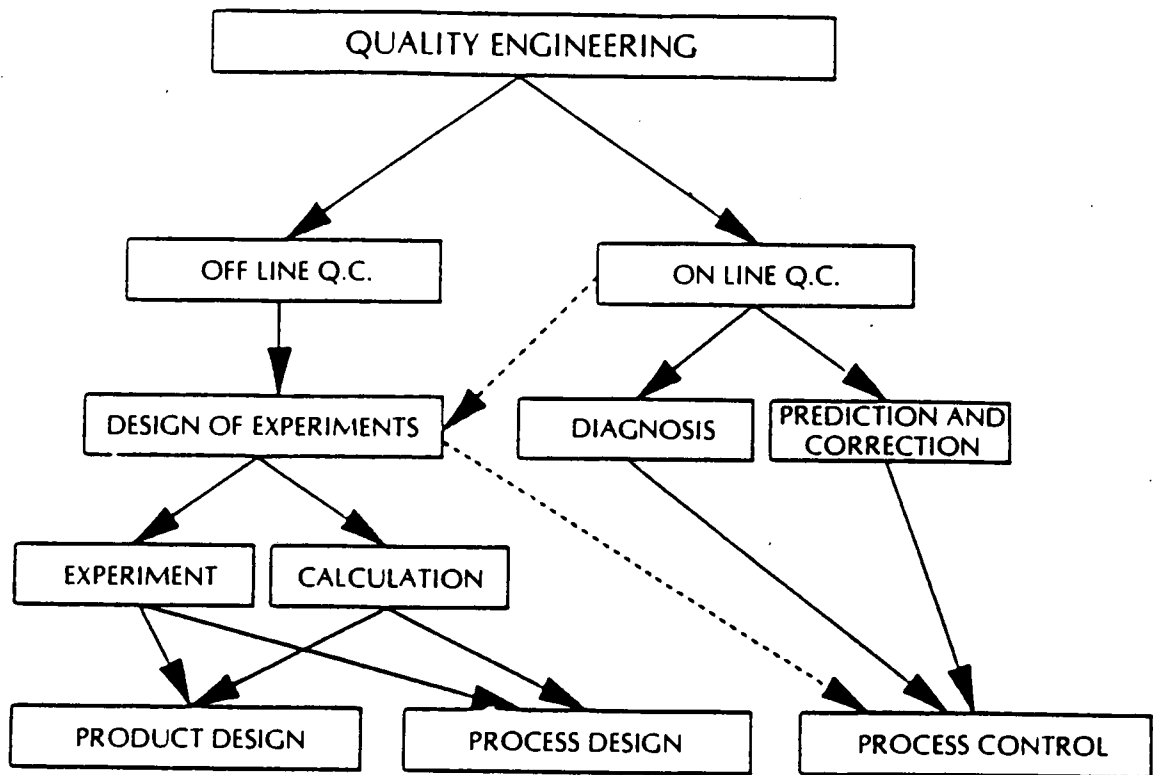


Figure II-9

An Overview of Taguchi's Philosophy of Quality Responsibility and Interaction

Source: Hamid Noori, "The Taguchi Methods: Achieving Design and Output Quality," The Academy of Management Executive, III, No. 4, 1989, p. 322.

reliability. Even if all the characteristics of a product are within their tolerance intervals, the product may not perform satisfactorily because of interactions among the product characteristics. A product performs best when all the characteristics of the product are at their ideal values.

An Approach to Effective Quality Control

In contrast to the current quality control paradigms, Taguchi has introduced a three-phase approach design of a product or process:

- o System design;
- o Parameter design; and
- o Tolerance design.⁸¹

System design is the process of applying scientific and engineering knowledge to produce a basic functional prototype design. The prototype model defines the initial settings of the product or process parameters. System design requires an understanding of both the customer's needs and the manufacturing environment. A product cannot satisfy the customer's needs unless it is designed to do so. Similarly, designing for manufacturability requires an understanding of the manufacturing environment.

⁸¹Ross, op. cit.

Parameter design is the process of identifying the settings of product or process parameters that reduce the sensitivity of engineering designs to the sources of variation. Adjustment of the mean value of a performance characteristic to its target value is usually a much easier engineering problem than the reduction of performance variation. Because parameter design reduces performance variation by reducing the influence of the sources of variation rather than by controlling them, it is a very cost-effective technique for improving engineering designs.

Tolerance design is the process of determining tolerances around the nominal settings identified by parameter design. It is a common practice in industry to assign tolerances by convention rather than scientifically.⁸² Tolerances that are too narrow increase the manufacturing cost and tolerances that are too wide increase performance variation. Therefore, tolerance design involves a trade off between the customer's loss due to performance variation and the increase in manufacturing cost.

Figure II-10 displays the basic steps of the Taguchi methods. Cost and consistency are the main issues in the Taguchi product and process development. In the system design phase, new concepts, ideas, or perhaps methods are generated with the objective of providing new or improved products/services to customers. The parameter design determines the product parameter values and the operating levels of process factors that improve the uniformity of a product at

⁸²Kackar, op. cit.

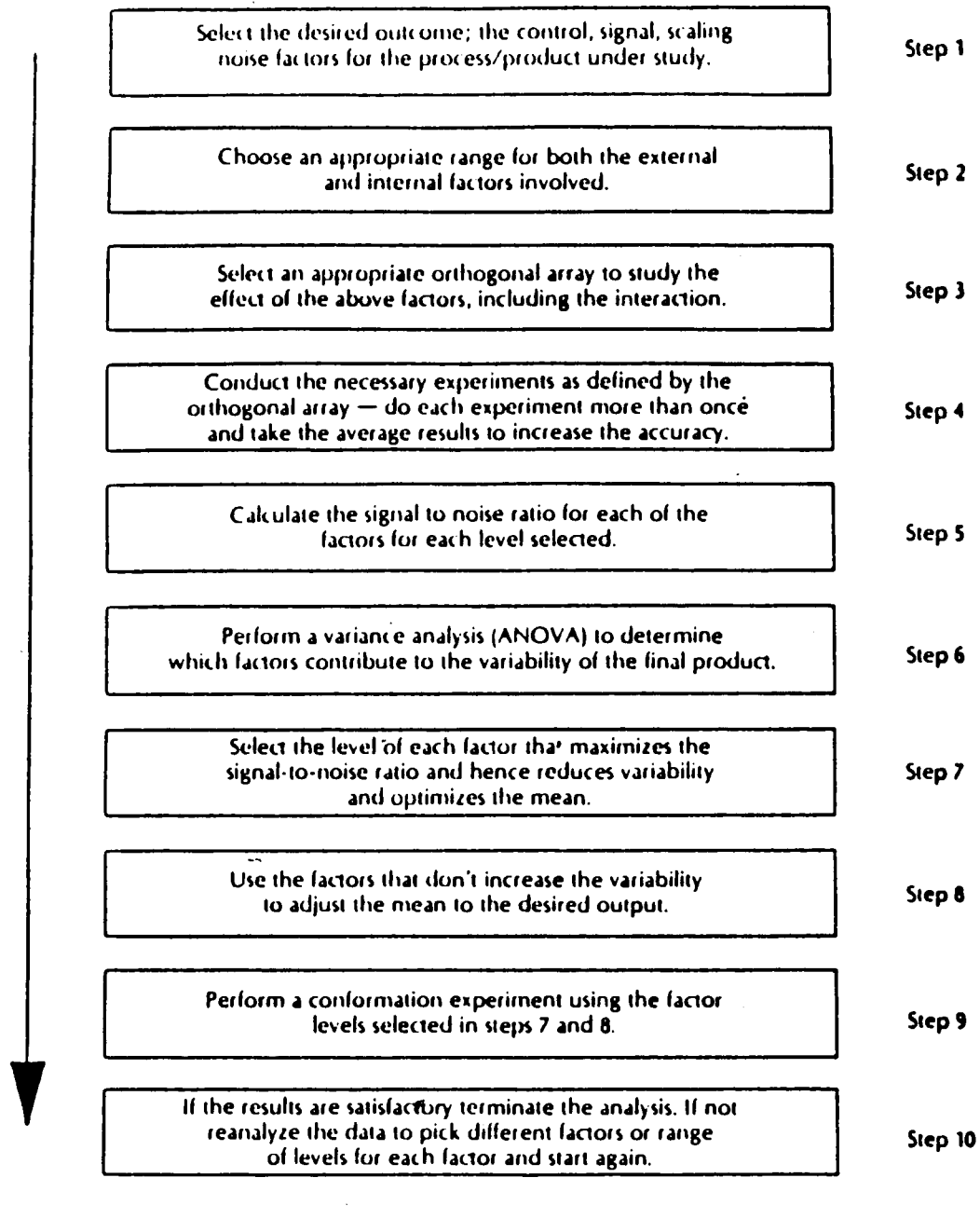


Figure II-10. The Basic Steps to Taguchi Methods

Source: Hamid Noori, "The Taguchi Methods: Achieving Design and Output Quality," The Academy of Management Executive, III, No. 4, 1989, p. 322.

no cost or even at a savings.⁸³ Finally, tolerance design improves quality further by tightening tolerances on products or process parameters to reduce the performance variation. The third step can only be done after parameter design.

Taguchi uses statistically planned experiments for at least three purposes including:

- o To identify the settings of design parameters that reduce cost without affecting quality;
- o To identify those design parameters that have a large influence on the mean value of the performance characteristic, but have no effect on its variation; and
- o To identify those design parameters that have no detectable influence on the performance characteristics.

Customer's Loss Due to Performance Variation

Variations from desired performance values cause loss of quality. Customers become dissatisfied and service costs increase for a direct loss. Indirect loss may result from loss of market share and from the unusual sales and marketing efforts needed to overcome uncompetitive quality.⁸⁴ To minimize loss,

⁸³Byrne, Diane M. and Shin Taguchi, "The Taguchi Approach to Parameter Design," Quality Progress, December 1987, pp. 19-26.

⁸⁴Barker, Thomas B., "Quality Engineering by Design: Taguchi's Philosophy," Quality Progress, December 1986, pp. 32-42.

customer service must be delivered at optimal levels and with minimal variation in its functional characteristics.

Two factors affect the process characteristics: controllable factors and noise (or uncontrollable) factors. Controllable factors are factors such as means of order placement, order cycle time, or order fill rate. Noise factors, on the other hand, are nuisance variables that are either difficult, impossible, or expensive to control. There are three types of noise factors:⁸⁵

- o **External** - Variables in the environment or conditions that disturb the functions of the product or process.
- o **Manufacturing imperfection** - Includes the variation in the product parameters from unit to unit even when they are built to the same specifications.
- o **Deterioration** - Changes that occur over the life of the process cycle such that it is no longer possible to achieve target functions.

⁸⁵Taguchi, Genichi, Introduction to Quality Engineering: Designing Quality into Products and Processes, Asian Productivity Organization (Detroit: American Supplier Institute, Inc.), 1989.

To overcome problems related to variability, design and production engineering departments use methods of off-line quality control, while production departments use methods of on-line quality control.

There are three types of quality characteristics:

- o **Measurable characteristics** which are amenable to measurement on a continuous scale.
- o **Attribute characteristics** which are not continuously scaled but can be classified on a discrete grading scale, They are often based on subjective judgments such as good, better, or best.
- o **Dynamic characteristics** which are functional characteristics of a system determined on the basis of input to the system and resulting output.

Each of these measurable characteristics can be classified into three types for which it is possible to develop a function to quantify the loss incurred by failure to achieve the desired quality:

- o **nominal-the-best** : a characteristic with a specific target value;
- o **smaller-the-better** : the ultimate target is zero;
- o **larger-the-better** : the target is infinity.

Identifying the target setting for a parameter requires specifying a criterion that is to be optimized. One such criterion is the expected value of monetary losses an arbitrary user of the product is likely to suffer at an arbitrary time during the product's life span due to performance variation. A measure of the degree of

the performance variation is the expected loss. The concept of expected loss makes the problem of reducing performance variation more concrete. It also provides a common basis for comparing variations in different performance characteristics.

The quality loss function as proposed by Taguchi directs attention on the center of the process and learning what it takes to produce products/services close to target.⁸⁶ It also describes customer sensitivity to deviations from the target. Taguchi's quadratic representation of the quality loss function is an approximation of a Taylor Series expansion around a target value, m (Figure II-11).

For "nominal-the-best" scenario, the quality loss function is given as:

$$L(y) = k (y - m)^2$$

where,

$L(y)$ = loss in dollars per unit product when the quality characteristic is equal to y

y = the value of the quality characteristic

m = the target value of y

k = a proportionality constant which depends on the financial importance of the quality characteristic.

⁸⁶Tribus, Myron and Geza Szonyi, "An Alternative View of the Taguchi Approach," Quality Progress, May 1989, pp. 46-52.

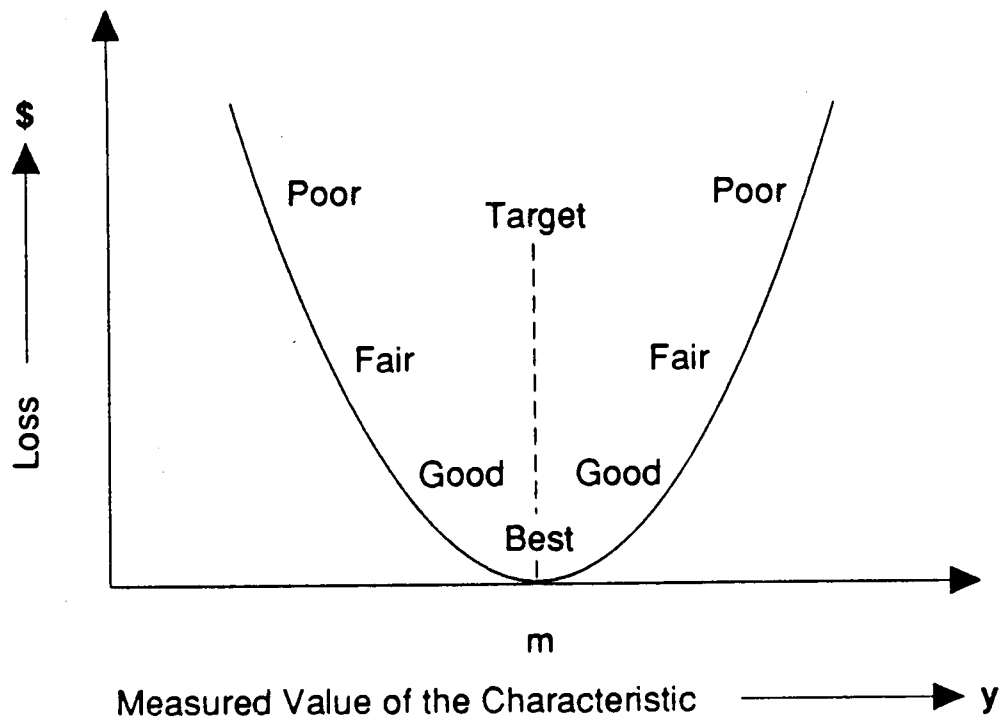


Figure II-11

Taguchi's Quadratic Representation of the Quality Loss Function

Source: American Supplier Institute, Detroit, Michigan, 1990.

The quality loss function, $L(y)$, has three necessary characteristics:

- o $L(y)$ is minimum at $y = m$;
- o $L(y)$ increases as y deviates from m . $L(y)$ increases slowly while in the neighborhood of m , and begins to increase more rapidly the further it deviates from m .
- o $L(y)$ is expressed in monetary units.

The loss function can also be determined for cases when the quality characteristic is a "smaller-the-better" scenario (Figure II-12). The formula is a little different, but the procedure is much the same as for the case of "nominal-the-best."

$$L(y) = ky^2$$
$$k = \frac{A_o}{y_o^2}$$

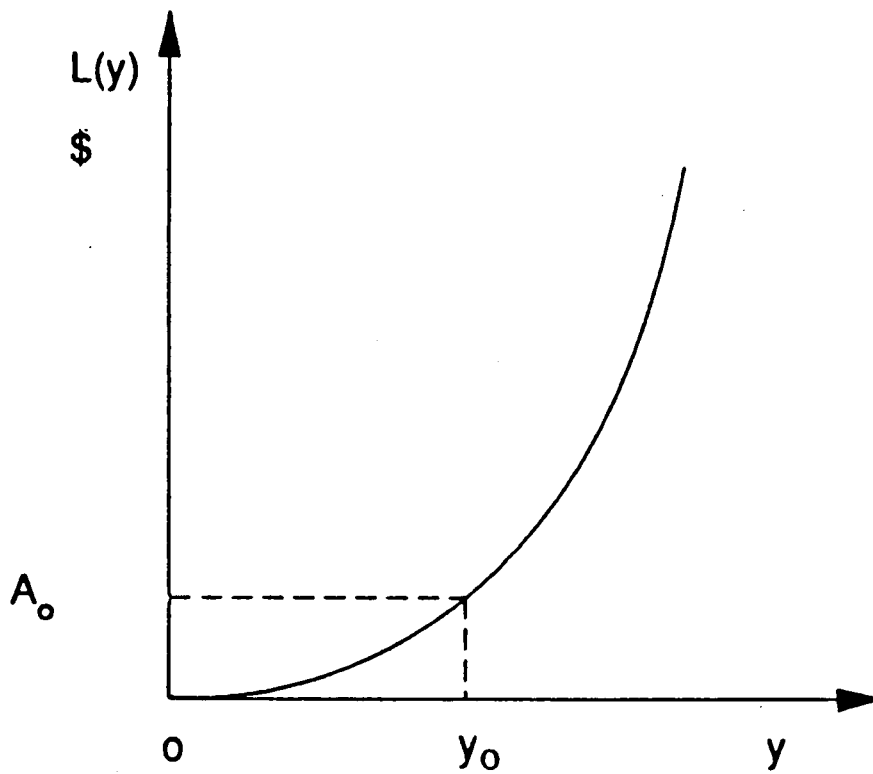


Figure II-12

Quality Loss Function for "Smaller-the-Better"

Source: American Supplier Institute, Detroit, Michigan, 1990.

The loss function for "larger-the-better" characteristic is given as:

$$L = \begin{cases} k \left(\frac{1}{y^2} \right), & k = A_0 y_0^2 \\ k(MSD), & MSD = \frac{1}{n} \sum_{i=1}^n \frac{1}{y_i^2} \\ & = \frac{1}{n} \left(\frac{1}{y_1^2} + \frac{1}{y_2^2} + \dots + \frac{1}{y_n^2} \right) \end{cases}$$

The representation of this loss function is shown in Figure II-13.

The concept of average loss due to performance variation can also be used to characterize process capability independently of the process specification limits. Process capability is often characterized by the "percentage nonconforming" which depends on the process specification limits. But process specification limits are only tentative cut-off points used for standardizing a manufacturing process.

As the process variability is reduced, the specification limits are often tightened. The average loss to performance variation provides a measure of process variation that is independent of the tentative specification limits.⁸⁷ The nonconformance rates can be reduced to parts per million levels only when the variation in the underlying performance characteristics is reduced continuously.

⁸⁷Kackar, Raghu N., "Taguchi's Quality Philosophy: Analysis and Commentary," Quality Progress, December 1986, pp. 21-29.

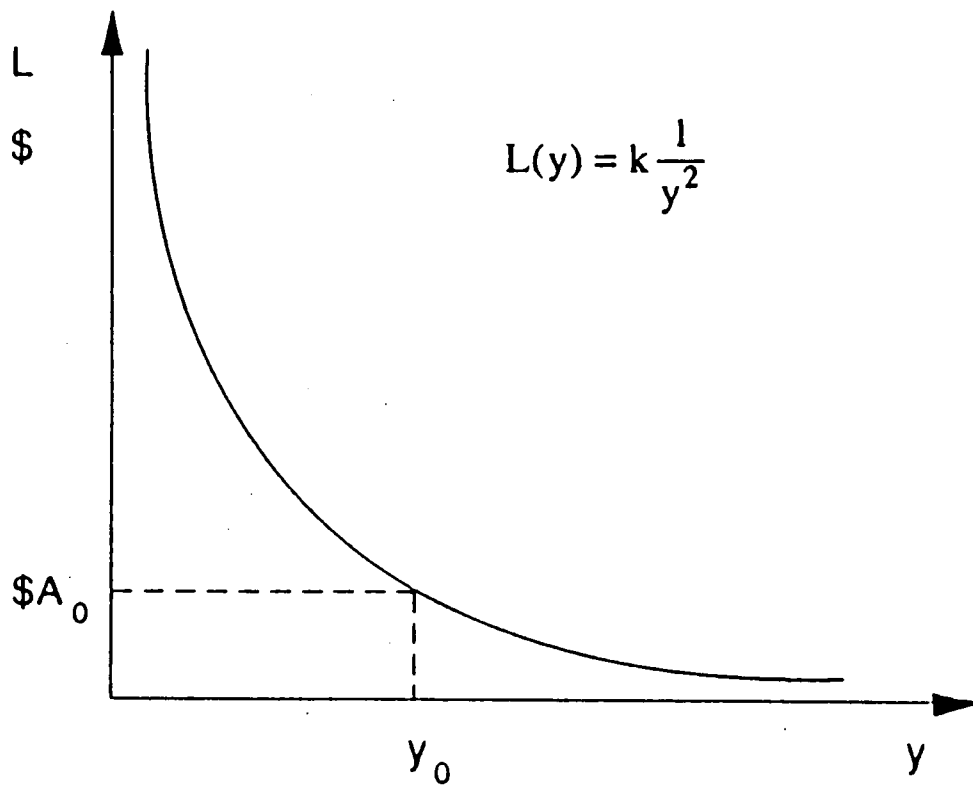


Figure II-13

Quality Loss Function for "Larger-the-Better"

Source: American Supplier Institute, Detroit, Michigan, 1990.

The concept of quadratic loss emphasizes the importance of continuously reducing performance variation.

Parameter Design Experiments

Taguchi-type parameter design experiments consist of two parts: a design parameter matrix and a noise factor matrix. The design parameter matrix specifies the test settings of design parameters. Its columns represent the design parameters and its rows represent different combinations of test settings. The noise factor matrix specifies the test levels of the noise factors. Its columns represent the noise factors and its rows designate different combinations of the noise levels. The complete experiment consists of a combination of the design parameter and the noise factor matrices (Figure II-14). Each test run of the design parameter matrix is crossed with all rows of the noise factor matrix, so that there are trials for each test run - one for each combination of noise levels in the noise factor matrix. The performance characteristic is evaluated for each of the trials in the test runs. Thus the variation in multiple values of the performance characteristic mimics the product or process performance variation at the given design parameter settings.

In the case of continuous performance characteristics as shown in Figure II-14, multiple observations from each test run of the design parameter matrix are used to compute a performance statistic. A performance statistic estimates the effect of noise factors. The computed values of a performance statistic are used

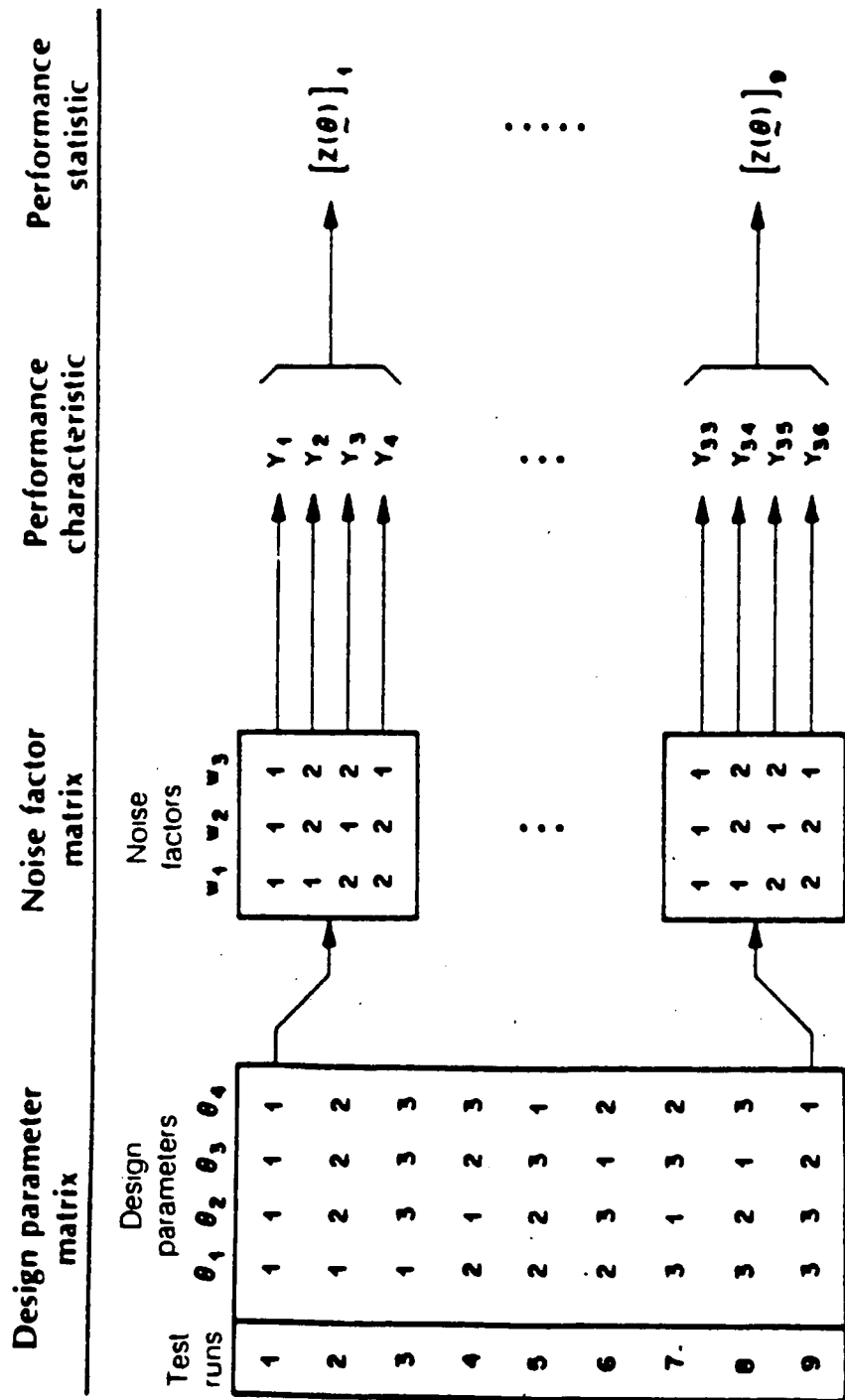


Figure II-14. Taguchi-Type Parameter Design Experiment

Source: Raghu N. Kacker, "Taguchi's Quality Philosophy: Analysis and Commentary," Quality Progress, December 1986, p. 27.

to predict better settings of the design parameters. The prediction is subsequently verified by a confirmation experiment. The initial design parameter settings are not changed unless the accuracy of prediction has been verified. Several iterations of such parameter design experiments may be required to identify the design parameter setting at which the effect of noise factors is sufficiently small.

Taguchi recommends the use of orthogonal arrays for constructing the design parameter and the noise factor matrices. All common factorial and fractional-factorial plans of experiments are orthogonal arrays. But not all orthogonal arrays are common fractional factorial plans.

Signal-to-Noise Ratios

Taguchi stresses the importance of studying the variation of response through the use of the signal-to-noise (S/N) ratio.^{88,89} In its simplest form, the S/N ratio is the ratio of the mean (signal) for the various factors to their standard deviation (noise). For continuous performance characteristics with fixed target, Taguchi has defined three S/N ratios depending upon the three forms of the loss function: the smaller the better, the larger the better, and a specific target value is best. The Taguchi S/N ratios can be written as follows:

⁸⁸Kackar, op. cit.

⁸⁹Ross, op. cit.

SMALLER THE BETTER

$$\text{MSD} = \frac{y_1^2 + y_2^2 + y_3^2 + \dots + y_n^2}{n}$$

$$S/N = -10 \log(\text{MSD})$$

$$= -10 \log \left[\frac{1}{n} \sum_{i=1}^n y_i^2 \right]$$

LARGER THE BETTER

$$\text{MSD} = \frac{1}{n} \sum_{i=1}^n \frac{1}{y_i^2}$$

$$S / N \text{ (dB)} = -10 \log (\text{MSD})$$

$$\text{MSD} = \frac{1}{n} \sum_{i=1}^n \frac{1}{y_i^2}$$

SPECIFIC TARGET VALUE IS BEST

$$\begin{aligned} S / N \text{ (dB)} &= 10 \log \left[\frac{\frac{1}{n} (\bar{S}_m - V_e)}{V_e} \right] \\ &= 10 \log \left[\frac{\bar{y}^2}{V_e} - \frac{1}{n} \right] \end{aligned}$$

$$S_m = \frac{T^2}{n}$$

$$V_e = \text{Sample Variance} = \sum_{i=1}^n \frac{(y_i - \bar{y})^2}{n-1}$$

$$T = \sum_{i=1}^n y_i$$

Factors that contribute to reduced variation (improved quality) can be quickly identified by looking at the amount of variation present for a service attribute. Taguchi recommends the use of the S/N ratio because it allows a measure of the sensitivity of an effect to change in specific factors.⁹⁰ Sensitivity can be expressed in terms of change in the mean or as changes in the standard deviation. The importance of S/N ratios lies in its ability to separate factors that affect the mean from others that affect the variability of a characteristic (attribute).

Factors which have a significant affect on the S/N ratio are known as control factors. Those which have no affect on the S/N ratio are identified as signal factors. In selecting the levels of factors which will lead to the least variability for a given customer service attribute, the logistics manager would seek

⁹⁰Burgman, Patrick M., "Design of Experiments - The Taguchi Way," Manufacturing Engineering, May 1985, pp. 44-47.

out conditions where S/N ratios are higher or sensitivity to variations in noise factors is low.⁹¹

However, there is some controversy surrounding the use of these ratios. According to Box it is better to study the mean (y) and the variance (s^2) separately rather than combine them into a single S/N ratio as Taguchi suggests.⁹² Pignatiello and Ramberg have also arrived at the same conclusion after thoroughly investigating a case study.⁹³ Ullman has also proposed a simple extension of the analysis of means to examine the dispersion effects and the interactive relationships of means and variation.⁹⁴

Traditional vs. Taguchi Design of Experiments

Experimental design techniques have not traditionally been used by American engineers in the area of quality. Yet, statistical experimental design was invented in the early 1920s by R. A. Fisher in England. Fisher's work on experimental method constituted a major step forward, particularly when this

⁹¹Byrne and Taguchi, op. cit.

⁹²Box, George E. P., "Research and Training for Quality Improvement," Proceedings of the American Statistical Association, Washington, D.C., August 6-10, 1989, pp. 462-470.

⁹³Pignatiello, Joseph J. and John S. Ramberg, "Discussion of Off-Line Quality Control, Parameter Design and the Taguchi Method," Journal of Quality Technology, October 1985, pp. 198-206.

⁹⁴Ullman, Neil R., "The Analysis of Means (ANOM) for Signal and Noise," Journal of Quality Technology, 21, No. 2, 1989, pp. 111-127.

method quickly produced relevant, practical findings in many important fields including medicine, education, and biology.⁹⁵

Due to lack of management understanding and support of this powerful tool, applications in the U. S. have been "patchy." In Japan, on the other hand, management requires that such methods be used to develop high-quality products and processes that will rarely go wrong.

Taguchi, in trying to improve the quality of the Japanese telephone communications after World War II, encountered difficulties in using Fisher's techniques.⁹⁶ Engineers quickly faced roadblocks with conventional experimental design because there exists no way to work with the large number of variables, interactions, and levels of variables present in an industrial setting. In addition, the practice of judging data significance by F-tests (for example) neglects a major premise of engineering knowledge: that effects fall along a continuum. Supporters of the Taguchi methods note that while traditional statistical principles are violated, the reproducibility of results gathered by the methods validates the approach.

A brief comparison of the Taguchi techniques and the traditional or standard analysis method is shown in Table II-4. It should be noted that implementation of the Taguchi methods require the appropriate use of statistical

⁹⁵Box, George E. P. and Soren Bisgaard, "The Scientific Context of Quality Improvement," Quality Progress, June 1987, pp. 54-61.

⁹⁶Burgman, op. cit.

Table II-4

Comparison of Taguchi Methods with Standard Statistical Design

TAGUCHI METHOD	"STANDARD" METHOD
1. S/N ratios	Appropriate transformations; analyze means and (log) standard deviation separately
2. Orthogonal arrays	Screening designs; factorial and fractional factorial designs
3. Linear graphs	Aliasing procedures and tables
4. Inner and outer arrays	Sensitivity analysis; variance component analysis; nested and split plots designs; variance component analysis
5. One-shot designs; pick-the-winner optimization	Sequential design strategy; response surface methods; computer methods
6. Two-stage procedure using signal and noise variables	Analyse location and spread separately; importance of interactions; residual analysis
7. Complex ANOVAs for analysis	Normal probability plotting; other graphical techniques; standard regression techniques
8. Outliers not considered in analysis	Residual plots and/or resistant data analysis procedures

Source: Berton Gunter, "A Perspective on the Taguchi Methods," Quality Progress, June 1987, p. 50.

design and analysis methods. A good deal of controversy centers on the meaning of "appropriate." Unfortunately, the Taguchi methods are nonstandard, and no scientific justification has yet been provided for their use.⁹⁷

Box points out that the Taguchi approach represents a significant advance in the application of experimental designs to the improvement of product and process quality.⁹⁸ However, he also points out several shortcomings to the Taguchi procedure including:

- o the Taguchi method does not exploit a sequential nature of investigation;
- o the designs advocated are rather limited and fail to deal adequately with interactions;
- o more efficient and simpler methods of analysis are available; and
- o the arguments for the universal use of the signal-to-noise ratio are unconvincing.

In carrying out his approach to product and process design, Taguchi recommends the blanket use of data collection plans. The Taguchi data collection

⁹⁷Gunter, Berton, "A Perspective of the Taguchi Methods," Quality Progress, June 1987, pp. 44-52.

⁹⁸Box, op. cit.

plans are not new. They are standard orthogonal array designs that have been discussed in the literature since the 1940s.⁹⁹

There is heavy confounding of main effects and two-factor interactions with some of the orthogonal arrays that Taguchi uses. If the arrays are used, the researcher needs to be aware of the alias structure (i.e. what effects are confounded) so that erroneous conclusions can be avoided. For example, if it is concluded that a certain main effect is statistically significant, it might be that a two-factor interaction with which it is confounded that is actually significant.¹⁰⁰

The alias structure of the orthogonal arrays have generally been ignored by Taguchi. Taguchi has advocated the use of these designs to allow the experimenter to investigate the possibility of quadratic effects. But as Box has pointed out, it is somewhat illogical to assume that there may be pure quadratic effects, and to ignore mixed quadratic (interaction) effects, especially when the response variable is to be maximized.

Hunter addresses the issue of Taguchi's experimental designs in substantial detail.¹⁰¹ He shows that the presence of interactions can seriously bias the estimates of the linear and quadratic coefficients in a model as well as the

⁹⁹Pignatiello, Joseph J., "An Overview of the Strategy and Tactics of Taguchi," IIE Transactions: Industrial Engineering Research and Development, 20, No. 3, 1988, pp. 249.

¹⁰⁰Ryan, Thomas P., "Taguchi's Approach to Experimental Design: Some Concerns," Quality Progress, May 1988, pp. 34-36.

¹⁰¹Hunter, J. Stuart, "Statistical Design Applied to Product Design," Journal of Quality Technology, October 1985, pp. 176-188.

estimate of error variance. However, the use of the Taguchi designs is not requisite for using the Taguchi strategy itself. Many other types of designs can be used, most of which need not be orthogonal.

Another point of controversy is that Taguchi does not recommend that the order in which the data is collected be randomized.¹⁰² Taguchi employs experimental methods to identify the settings of design parameters for which the effect of noise factors on the performance attribute is minimum. The settings are derived through systematic variation of parameters in the experiment with subsequent comparison of the effect of noise factors for each test run. If a time-trend effect is present, the lack of randomization presents problems.¹⁰³

Taguchi's rationale for not randomizing the order of the trial runs is to reduce the costs of changing the levels or versions of some of the factors in the experiment. Yet, Ross in his book on Taguchi techniques has a detailed discussion on three types of randomization that can be employed in the Taguchi-style design of experiments.¹⁰⁴ A more accurate assessment of Taguchi's viewpoint on randomization is that traditional practices of randomization should be adhered to if it does not unduly add to the time and expense of conducting the experiment. If the latter is true, and the experimenter believes that lack of randomization will not effect the results, then randomization of test runs is not advocated.

¹⁰²Pignatiello, op. cit.

¹⁰³Barker, op. cit., p. 38.

¹⁰⁴Ross, op. cit.

Resolution of Issues

The answer to these criticisms requires that the Taguchi philosophy be blended with a data analysis strategy in which the means and variance of the quality characteristic are both empirically modeled to a considerable greater degree than practiced by Taguchi. In this way the engineer and scientist can achieve the basic goal of the Taguchi method while addressing the stated criticisms.

One of the interesting aspects of the Taguchi method is that it has been quite successful, despite its shortcomings. For this reason, Pignatiello believes that any reasonable systematic experimentation can yield important information on how to design a new product or process, and on how to improve existing products and processes.¹⁰⁵ Furthermore, he states that the Taguchi strategy is a sound one. However, it is his belief that proper statistical design in experimentation will lead to greater benefits.

The quality engineering methods advocated by Taguchi have been readily accepted, while the statistical methods have been somewhat controversial.¹⁰⁶ However, if companies are to make great strides in quality improvement, they need powerful tools that are easy to use and understand. Taguchi's ideas can be combined with the best statistical techniques to produce an integrated methodology for designing, assessing, and improving the product or process.

¹⁰⁵Pignatiello, op. cit.

¹⁰⁶Ryan, op. cit., p. 34.

According to Sullivan, the ability to control performance variations allows companies to significantly shorten the product development cycle, improve quality, and reduce costs.¹⁰⁷ By focusing on methods to reduce the variability of output, and not just meeting specifications, continuous quality improvement is automatic.

There are now over 6,000 case studies from U. S. companies on the application of Taguchi methods. Yet, all of these measures of success deal with products. The quality of service, particularly in the area of logistics customer service, will profit from the application of the Taguchi methods and strategies. Companies that have implemented the Taguchi quality methods have reduced the need for statistical process control activities and changed the attention from quality control to cost reduction.¹⁰⁸

Implications for Customer Service Parameter Design

Improving the quality of customer service deals with statistical design and analysis methods. Taguchi advocates the use of multivariable statistical design methods as the way to study the simultaneous effects of many variables.¹⁰⁹ As previously discussed, the inability to measure more than one or two customer service attributes has impacted the capacity to evaluate responses of customers to varying service offerings. Because interactions are important to customer service

¹⁰⁷Sullivan, Lawrence P., "The Power of Taguchi Methods," Quality Progress, June 1987, pp. 76-79.

¹⁰⁸Ibid.

¹⁰⁹Gunter, op. cit.

programs, changing one variable at a time will probably result in higher costs and lower quality than if properly conducted statistically designed experimentation had been used.

The essence of parameter design is the utilization of nonlinear effects of product (or process) parameters on the performance characteristics to reduce the sensitivity of engineering designs to the sources of variation. Kackar maintains that because parameter design reduces performance variation, by reducing the influence of the sources of variation rather than by controlling them, it is a very cost effective technique for improving engineering design.¹¹⁰ This same concept can be applied to customer service design. Logistics managers are driven by economical considerations to provide customer service policies which are tolerant to performance variations. Customer service is a process for managing variety. It is specifically concerned with two distinct but inter-related problems: assessing customer demand and determining the appropriate supplier response.¹¹¹ By focusing on quality improvement and cost reduction in the design of the customer service process, it will be possible for the firm to increase customer value through the contribution of this effort.

¹¹⁰Kackar, op. cit., p. 21.

¹¹¹Schary, Philip B., "Customer Service as a System Process," Contemporary Issues in Marketing Channels, in Lusch, R. F., and Zinszer, P. H. (eds.), Norman, OK: University of Oklahoma, 1979.

4. CONCLUSION OF THE LITERATURE REVIEW

The review of the literature for this research combined concepts and examples from various disciplines in order to develop the idea of customer service measurement. While the field of logistics has developed a host of quality control models, this approach represents the "downstream" side of the quality process. It will be possible to increase the quality of the service provided, at no additional cost, by moving the quality focus in customer service "upstream" through the use of design of experiments.

The Taguchi strategy offers firms a means of achieving the dual objectives of quality improvement and cost reduction. Yet, few applications exist in the service area; none are known to exist for customer service. The traditional approach in this area has been to change one customer service attribute at a time. It has been shown in other applications that this will result in higher costs and lower quality than if properly conducted statistically designed experiments had been used.

Logistics managers have a key role in creating and sustaining customer value through quality service delivery. They are also driven by economic considerations to provide customer services which are sensitive to performance variations. Because customer service is multi-phenomenal, a comprehensive method is needed for analyzing the relationships of the various elements for the purpose of continuous quality improvement.

CHAPTER III. RESEARCH METHODOLOGY

The purpose of this chapter is to describe in detail the research objectives and methodologies which encompass the scope of the dissertation. As previously stated, the research effort is composed of two phases, each with distinct goals and techniques. The overall objective of the research is to develop a comprehensive method for designing, assessing, and improving the customer service process, from both a cost and customer service perspective.

The chapter is divided into five major sections. A statement and discussion of the research objectives are presented in the first section. Section 2 details research design for Phases 1 and 2, while Section 3 involves the development of the survey instrument (Phase 1) and the "artificial" experiment (Phase 2). The sampling plan and data gathering procedures for both phases are described in Section 4. The final section describes the plan for statistical analyses of the survey data collected during Phase 1 of the research. This section also includes a discussion of the techniques that are used to conduct the experiment in Phase 2.

1. STATEMENT AND DISCUSSION OF THE RESEARCH OBJECTIVES

The specific objectives of this dissertation are presented below along with discussions concerning their development. The objectives are a result of the research questions which form the basis for the study.

Phase 1 Research Objectives

A review of the pertinent customer service literature in Chapter II indicated that the customer service component of the marketing mix will become even more important to firms in the future. It has long been recognized that this activity creates customer value, and can strategically differentiate the product or service for many firms. Evidence suggests that many firms do not measure the cost effectiveness of service levels, and have no effective way of determining competitive service levels.¹ Schary in his research points out that differentiating service levels for various customer segments is very difficult due to the interaction of many variables on performance.² This confounding makes it hard to determine the effect of a particular service level.

¹LaLonde, Bernard J., Martha C. Cooper, and Thomas G. Noordewier, Customer Service: A Management Perspective, (Oak Brook, IL: Council of Logistics Management), 1988, p. 29.

²Schary, Philip B., "Management Control Over Customer Service," International Journal of Physical Distribution & Materials Management, 10, No. 4, 1980, pp. 147-159.

For this reason, it was necessary to determine which customer service factors are important, and how various levels of these factors are perceived in their role of creating value for the customer. Two research objectives were developed to satisfactorily address this component. First, relative preference rankings of the various customer service attributes were determined among multi-level alternatives. Second, an understanding was gained of how customers are willing to consider trade-offs among specified desirable alternatives.

To accomplish these objectives, a sequential methodology was used that can be readily transferred to other settings. A schematic of the design, which is taken from Sterling and Lambert, is shown in Figure III-1. The external audit represents the information that was obtained from a mail survey utilizing conjoint analysis. The internal audit examined existing customer service levels provided to customers of the consumer goods company. These levels then served as either the lowest attribute level for a customer service factor, or the center point, depending on the assessment by the logistics staff at the consumer goods company. Since the early 1970s, researchers and practitioners have embraced conjoint analysis as an effective technique for exploring individuals' preferences for multi-attribute products. By utilizing this technique for collecting and analyzing customer service data, it was possible to decompose the rankings into preference values for the attribute levels. Such an indirect method of determining preferences for the

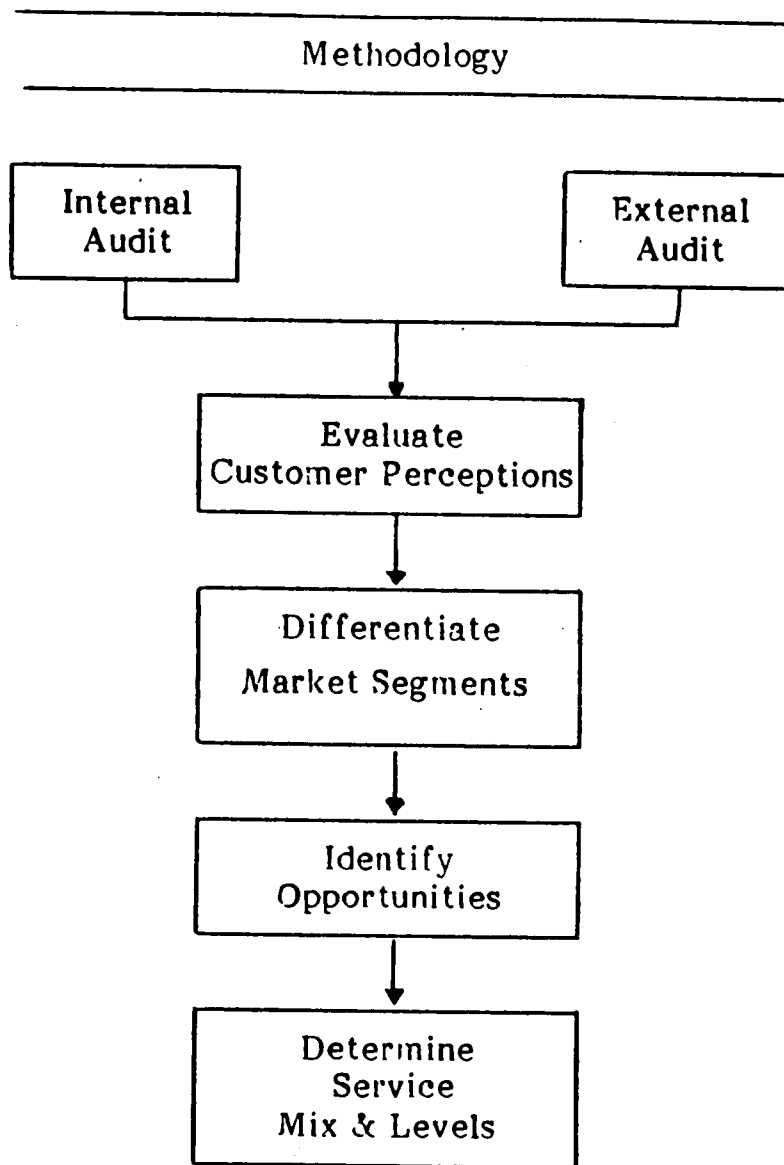


Figure III-1. Research Design Methodology

Source: Jay U. Sterling and Douglas M. Lambert, "Establishing Customer Service Strategies Within the Marketing Mix," Journal of Business Logistics, 8, No. 1, 1987, p. 10.

attributes is deemed superior to a self-explicated approach, which directly asks individuals about their preferences.³

Once these objectives were accomplished, it was possible to undertake the third objective of Phase 1 which was to build customer service profiles based on important attribute levels determined from the analysis. This task is shown as the last step on the methodology schematic (Figure III-1). The traditional approach in logistics has been to segment customers on the basis of product or geography. It was possible during this stage of the research to develop an alternative strategy to customer service segmentation which focuses on the preferences of different attributes. The importance and contribution of this type of approach has previously been discussed.

From a continuous quality perspective, it is not sufficient to simply calculate utility values to reflect how influential each customer service attribute level is in the respondent's evaluation. In today's dynamic environment the firm must constantly be thinking in terms of how to develop and deliver better customer service. Successful companies will adopt a total responsibility approach which fits logistics subsystems (such as customer service) into broader systems within the enterprise. In order to design and implement subsystems which optimize desirable quality features of results, it is necessary to have an understanding of the relationship of the customer service attributes.

³Safizadeh, M. Hossein, "The Internal Validity of the Trade-Off Method of Conjoint Analysis," Decision Sciences, Vol. 20, 1989, p. 451.

This understanding was gained by determining which attributes, and levels of these attributes, are significant with respect to customer requirements. In addition, some information was necessary as to what degree of variation each factor contributes to on-target customer service performance. However, this technique does not provide any information on the existence and significance of interactions between customer service attributes at the various levels. To accomplish this task, a designed experiment approach was taken in order to scientifically analyze factors which might affect on-target performance.

In summary, the following objectives were met for Phase 1 of the dissertation research:

- o Determination of relative preference rankings for specified customer service delivery attributes.
- o Understanding of the trade-offs that market segments are willing to make among various levels of customer service delivery attributes.
- o Segmentation of customers based on customer service delivery attributes.
- o Determination of statistical significance of attribute levels.

Phase 2 Research Objectives

Phase 2 of the research involves Taguchi parameter design for determining which customer service factors cause performance to deviate from its target value. The goal of parameter design is to identify values of the attributes so that the service exhibits a high level of performance and is minimally sensitive to certain

environmental factors. The parameter design examined the interactions between the customer service factors and specifically selected noise factors in order to achieve robustness. It was a search for parameter levels at which a characteristic is stable, despite external conditions.

If the causes of variation can be controlled or eliminated, then process variation can be reduced, and therefore, quality can be improved. However, in some cases it is neither desirable nor cost effective to try to control or eliminate all sources of variation. Instead, parameter design can be used to improve quality without controlling or eliminating causes of variation by choosing the proper level for control factors.

Because Phase 2 involved the construction of an "artificial" experiment, i.e. historical data will be used, it was not possible to run a confirmation experiment in the traditional sense. However, if management chooses to adjust customer service process variables on the basis of the analysis it will be possible to track the results to determine if they turn out as expected. If the objective of the experiment is not met, then further optimization is possible with confirmed factors. In summary, the objectives for Phase 2 of the dissertation involve the identification of customer service delivery attributes that:

- o improve the quality of the process;
- o effect the mean value of process performance, but have no impact on its variation; and
- o contribute no discernable influence on performance characteristics.

2. RESEARCH DESIGN

Research design is the plan, structure, and strategy of investigation conceived so as to obtain answers to research questions and to control variance.⁴ This section contains the plan for the overall scheme and program of research for the dissertation. It includes the selection, definition, and measurement of variables and their relation to accomplishing the research objectives.

A. DEVELOPMENT OF PHASE 1

Trade-Off Analysis of Customers' Values

Phase I of the research involves conjoint analysis to assess the utility of alternative levels of several customer service elements. The three components of the conjoint measurement are: 1) a technique of data collection requiring a respondent to consider "trade-offs" among desirable alternatives, 2) a computational method which derives "utilities" accounting as nearly as possible for each respondent's choice behavior, and 3) a simple market simulation model which attempts to determine those characteristics of a product (or process) which will maximize its share of preference within any particular competitive context.

⁴Kerlinger, Fred, Foundations of Behavioral Research (New York: Holt, Rinehart and Winston, Inc.), 1964, p. 275.

Although it requires only rank-order data, it produces measurements which are "stronger" than approaches based on simple rank order.

Because of the substantial amount of among-person (firm) variation in preferences, conjoint analysis is usually carried out at the individual level. Computation of the utility scales of each attribute (element), which determines how influential each is in the customers' evaluations, is carried out by various algorithms which have been developed for this purpose. The ranked data of a single respondent (or the composite rank of a group of respondents) are entered in the algorithm. The computer then searches for a set of scale values for each factor in the experimental design. The scale values for each level of each factor are chosen so that when they are added together, the total utility of each combination will correspond to the original ranks as closely as possible.

The model of preference formation underlying conjoint analysis assumes that the attributes studied are independent.⁵ This assumption creates two consequences. The first is that the attributes must be non-redundant. The utility for a collection of attributes is considered to be the product of the utilities of each of its attributes. If an attribute were represented twice, its utility would be its square rather than its first power.

The second ramification of the independence assumption involves interaction among variables. For example, the model might assume that

⁵Johnson, Richard M., "Trade-Off Analysis of Consumer Values," Journal of Marketing Research, Vol. XI, May 1974, p. 124.

preference of car color will be independent of factors such as size, price, and model type. However, due to "real world" correlations of some variables, preference models can sometimes produce unbelievable attribute combinations. If such interactions do exist in a specific set of data, they will be indicated by unfavorable values of tau and phi. Despite the potential problems due to environmentally correlated attributes, studies have found that this problem is much less serious in practice than in theory.⁶

The greatest strength of the procedure seems to be its ability to generate rather refined predictions from quite primitive data. This is a characteristic of all the nonmetric scaling methods. A second strength is its apparently wide applicability. Not only can the model provide predictions about levels of interest for new services, but it can also provide information about the trade-offs among the attributes. The procedure can easily be generalized to incorporate each respondent's perceptions of current services on such subjective attributes as "satisfaction."

Research on Customer Service Variables

The independent variables included in the conjoint analysis were determined by a variety of methods including: 1) previous published research on

⁶Moore, William L. and Morris B. Holbrook, "Conjoint Analysis on Objects with Environmentally Correlated Attributes: The Questionable Importance of Representative Design," Journal of Consumer Research, Vol. 16, March 1990, p. 491.

customer service process attributes, 2) previous customer satisfaction research at the consumer goods company, and 3) knowledge and experience of the corporate/plant logistics staff at the consumer goods company. Each of these sources did not receive equal weight in determining customer service attributes to be studied. Instead, each source of information was viewed from a design consideration with the objective of controlling extraneous variables.

In their study of the office systems and furniture industry, Sterling and Lambert identified sixteen variables that received the highest importance ratings from dealers, end users, and architectural and design firms.⁷ Of these, ten were physical distribution/customer service variables, two were price variables, one was a promotion variable, and three were product related. The rank order of customer service variables included:

- o ability of manufacturer to meet promised delivery date;
- o accuracy in filling orders;
- o advance notice on shipping delays;
- o order cycle consistency;
- o length of promised lead time for quick ship orders;
- o accuracy of manufacturer in forecasting estimated ship dates;
- o completeness of contract orders;
- o ability to expedite and/or provide rush service;

⁷Sterling, Jay U. and Douglas M. Lambert, "Establishing Customer Service Strategies Within the Marketing Mix," Journal of Business Logistics, 8, No. 1, pp. 1-30.

- o completeness of quick ship orders; and
- o action on customer service complaints.

The research obtained importance and performance evaluations for approximately 100 marketing service variables. Through established data reduction techniques, such as factor analysis, the study was able to identify all of the variables for which continued or improved service would or could lead to differential advantage.

In assessing the importance of customer service as a tool for differentiation in industrial markets, Kyj and Kyj found that different customer service packages are not only feasible, but highly desirable.⁸ Respondents were asked to rank each service attribute on a scale of 1 to 7, where 1 was "not very important," 4 "somewhat important," and 7 "very important" to the firm. The results for industrial products indicate that customer service attributes such as fast delivery, fill rate, speed in billing, personal response to complaints, and explanation of policies, are very important to customers. Interestingly, manufacturers also perceive these attributes to be significant in their service offering.

While some of these same attributes are important to food industry customers, other items such as quick recognition of debits/credits, advance notice of price change, advance information on shipping delays, and absorption of cost of

⁸Kyj, Larissa S. and Myroslaw J. Kyj, "Customer Service: Product Differentiation in International Markets," International Journal of Physical Distribution & Materials Management, 19, No. 1, 1989, p. 37.

items returned due to damage, recalls or errors, are also important. It should be noted that there were no significant differences in variability on the part of the manufacturers and customers. The data also provide considerable support that survey respondents either view customer service attributes as extremely important or of negligible importance. It seems reasonable to assume that customers will search for manufacturers that are capable of meeting their specific service needs.

As previously stated, the customer service variables to be included in the conjoint analysis were determined in part by the sponsoring firm. In their study of the office systems and furniture industry, Sterling and Lambert considered sponsoring firm to be the least desirable source of variable selection.⁹ Rather, they chose to expand and revise Levy's list of 71 variables used in his research study of the pharmaceutical industry (specifically prescription drugs). Yet, in later research, Sterling and Lambert state that analysis indicates that it is a mistake to use variables developed in past research because they may be applicable only to a specific industry or channel level.¹⁰ They also concluded the variables may not have been accurately constructed or defined, and that important/determinant variables may have been overlooked.

These findings were used as the supporting basis for utilizing several methods to determine customer service variables to be included in the conjoint

⁹Sterling, Jay U. and Douglas M. Lambert, "Customer Service Research: Past, Present, and Future," International Journal of Physical Distribution & Materials Management, 19, No. 2, 1989, p. 17.

¹⁰Ibid.

analysis. Given the considerable effort and quality of previous customer satisfaction research conducted at the corporate level of the consumer goods company, it was decided to utilize this knowledge for choice of variables and their levels. Because research, no matter how current, reflects past perception of performance, the logistics staff was asked to provide input concerning adjustments to specific attribute levels.

For each element chosen for the research study, the current performance level was determined and used as either the center point or first level of testing for that element. Three to four levels of each customer service element was determined to be sufficient for purposes of conjoint analysis. Factors were also chosen based on their relative importance to the consumer goods company, and their capability to make changes in the customer service process as might be indicated by the data analysis.

The factor levels are highly specific and non-subjective. A fractional factorial of the full-profile design was used. The pair-wise factorial design was not chosen because of its lack of realism from a "total package" consideration. Each respondent's comparisons will be presented in a different (random) order to avoid any effect which might influence evaluations. Random order of the attribute profiles will also produce more accurate parameter estimates, which is an important consideration for experimental design.

Definition and Measurement of Variables

In order to assign meaning to the concept of customer service within this study, the activities chosen for conjoint analysis were operationally defined for the survey respondent. While it was not possible to pre-test these definitions for clarity and conciseness, considerable detail was given to their development. Each respondent to the mail survey completed a prior telephone interview where the same activity terminology was used. The personal interaction provided clarity and conciseness of definition as needed. The development and consistent use of operational definitions was a joint effort of the researcher and the consumer goods company staff.

A questionnaire booklet was prepared to administer the survey. The following design considerations from Dillman were included:

- o no questions will be on the front page;
- o the questionnaire pages will be printed in a photographically reduced form; and
- o the questionnaire booklet will be reproduced on white paper at letter quality.¹¹

A cover letter was also included with each questionnaire to introduce the survey and hopefully motivate the respondent to participate in the research effort. In

¹¹Dillman, Don A., Mail and Telephone Surveys: The Total Design Method, New York: John Wiley & Sons, 1978.

addition, each respondent was notified of the forthcoming mail survey at the time of the telephone interview.

The various alternatives for defining a measurement scale for the dependent variable included:

NONMETRIC - paired comparisons and rank order;

METRIC - rating scales assuming approximately interval scale properties, or ratio scales obtained by constant-sum paired comparisons.

In comparing the metric with the nonmetric measurement scales, it should be noted that even though the dependent variable is nonmetric, the estimated parameters tend to satisfy close to interval-scaled properties. For purposes of this study, the nonmetric measurement scale was used. This approach has the following advantages:

- o ranked data are likely to be more reliable since it is easier for a respondent to express preference; and
- o data analysis based on a nonmetric dependent variable allows the part-worth functions to be combined in either an additive or multiplicative manner.¹²

B. DEVELOPMENT OF PHASE 2

Most engineers are familiar with setting up tests to model actual field conditions and the cause-effect relationship of design to performance. This

¹²Green, Paul and V. Srinivasan, "Conjoint Analysis in Consumer Research: Issues and Outlook," Journal of Consumer Research, Vol. 5, September 1978, p. 112.

experimentation, when used as a means of scientific investigation, allows the researcher to manipulate and control one or more independent variables and observe the dependent variable(s) for variation concomitant to the manipulation of the independent variable. To determine the "best" design of a product or process requires the use of a strategically designed experiment which exposes the product or process to varying environmental conditions.

The dissertation research, particularly Phase 2, is an attempt to apply the design of experiment approach to the customer service process. When the goal of a process is to achieve high stability and reliability, Taguchi has demonstrated that system/process design and parameter design are some of the most important steps in achieving the previously stated objective.¹³ If a process has a target value and attributes that can be used to correct deviations from it, the attributes can also be used as a means of quantitative control for consistent and reliable performance.

The ability of the logistics system to accommodate environmental factors, either internal or external to the firm, is critical to consistent performance. A change in any one of the dynamic components that influences the logistics system changes the manner in which the customer service/logistics system behaves with regard to "on-target" performance goals. The goal is even more complicated by the fact that the environmental factors are for the most part uncontrollable by the system itself. For this reason, a quantitative technique is needed for designing a

¹³Ross, Phillip J., Taguchi Techniques for Quality Engineering (New York: McGraw-Hill Book Company), 1988.

customer service process which can deliver consistent, desired functional performance, without controlling or eliminating certain causes of variation.

There is a multitude of environmental factors which cause variation in customer service performance. Germain's study of the firm's ability to adapt in response to environmental changes indicates that product introduction, global flexibility measure, and service level customization are important factors to the 360 executives which participated in the research.¹⁴

Following the Taguchi method of parameter design, customer service attributes were grouped in one of two ways: control factors or noise factors. Control factors are those which are set by the consumer goods company and cannot be directly changed by the customer. The intent of the experimentation is to determine which, if any, of the customer service delivery attributes are more robust against noise factors.

Noise factors are defined for this experiment as those activities that the logistics department has no direct control over but which vary with the customer's environment and usage. For example, this could involve new product introduction and/or product promotions. Parameter design was used to improve the customer service delivery process such that "poor quality" will not be passed downstream.

¹⁴Germain, Richard, "Output Standardisation and Logistical Strategy, Structure and Performance," International Journal of Physical Distribution & Materials Management, 19, No. 1, 1989, pp. 21-29.

The inference space for the Taguchi experiment used in Phase 2 is narrow due to the short period of time from which samples were drawn. The details of the experimental unit is discussed in Section 3, "Definition and Measurement of Variables." The amount of replication for the experiment was pre-planned and all repetitions are tested once a trial has been selected.

The experimental design for Phase 2 involves a fractional factorial using an orthogonal array. The selection of the orthogonal array depends upon the number of factors and interactions of interest, and the number of levels for the factors being studied. When the appropriate orthogonal array is selected the following inequality will be satisfied:

$$v_{LN} > v_{\text{REQUIRED FOR FACTORS AND INTERACTIONS}}$$

That is, the degrees of freedom in the experiment is greater than or equal to the sum of the degrees of freedom needed for factors and their interactions.

The major compromise of the fractional factorial is that some information may be lost because many interactions are confounded (mixed) with the main effects. This trade-off is made with reducing the number of tests which must be run in conducting the experiment. The orthogonal array is different from the classical fractional factorials in that it does not furnish the alias equation and the confounding scheme. Taguchi does not place much emphasis on the confounding

that exists in a low-resolution experiment.¹⁵ By choosing a higher-resolution orthogonal array it was possible to increase the clarity by which individual factors and interactions could be evaluated. Factors and interactions were assigned to columns of the array in a non-arbitrary method to avoid confounding when possible.

Definition and Measurement of Variables

The measured response variable for the experiment is the "perfect order score." This performance statistic is composed of four factors: on-time delivery, orders delivered complete, billed accurately, and percent of product ordered. Each of these categories are specified as being met (indicated by a "Y") or not met (indicated by an "N"). To derive the perfect order score, each of these performance designations were assigned a numerical value - 0 for non-conformance to customer requirements and 1 for meeting specifications. Therefore, the maximum perfect order score totaled four and the minimum obtainable score was zero. This method assumed an additive effect; future research effort will be devoted to ascertaining the validity of this assumption.

Five control factors were used for the inner array. Each of these customer service delivery attributes (or control factors) are tracked at the plant level of the consumer goods company. The factors and their levels (as applicable for qualitative variables) include:

¹⁵Ross, op. cit., p. 83.

1) delivery method

- o truckload
- o less-than-truckload
- o pool shipment

2) buyer delivery specification

- o date only
- o date and time
- o date range

3) warehouse arrival specification

- o pre-scheduled
- o open dock time

4) order lead time

5) order volume (cases)

The experiment was designed to be robust with respect to two environmental noises (or events) that have an acknowledged and undesirable influence on the performance of the customer service delivery process. These events are:

- o major brand introduction, and
- o major product promotion.

Customer activity from three major market segments - grocery, mass merchandiser, and drug - were randomly sampled for the above defined events. However, due to the time phasing of announcements concerning these events and the actual placement of orders resulting from the event, customer activity was delineated by a time measure (e.g. January/February 1991) for random sampling during the applicable event.

The parameter design of the customer service delivery process is crucial to improving the uniformity of performance. The objective is to make the performance less sensitive to causes of variation, with the aim of increasing the quality of service with little or no additional cost.

3. DEVELOPMENT OF THE SURVEY INSTRUMENT

This section discusses the development of the survey instrument that was used in the collection of data to satisfy the requirements of the research objectives for Phase 1. The Dillman "total design method" was used in implementation of the survey.¹⁶ Within these guidelines, a cover letter was included with the questionnaire. The cover letter served several basic purposes including: an

¹⁶Dillman, op. cit., pp. 160-169.

explanation of what the study was about, convincing the respondent that the study was useful, and promising confidentiality of individual responses.

Each questionnaire was stamped with an individual identification number so that follow-up mailings needed only to be sent to those not responding.

Return, postage-paid, envelopes were also included in the mailout package. Mail out dates were selected to closely follow the telephone interview portion of the customer satisfaction survey done at the corporate level.

A. PRETEST OF RESPONDENT VALIDITY

Pretesting of the customer satisfaction survey was conducted to identify any construction defects. For purposes of the dissertation, however, the pretest was used to determine whether or not the data required for the research could be supplied by the same respondents as to the overall corporate survey. A cross-section of a total of eighty accounts for the specific division was surveyed in the pretest stage. This cross-section included: the executive manager, the head of the buying committee, the buyer (or buyers), the head of the warehouse, and retail operations personnel. The questions were designed to determine the extent of the respondent's knowledge of logistics, and to determine how logistical concerns impact the buying decision. The following pretest survey items were used in this evaluation:

- o job performance criteria for the respondent;

- o respondent's relative influence on the buying process;
- o respondent's capability of identifying personnel in their warehouse facilities; and
- o respondent's view of logistics/transportation factors influence in the buying process.

B. CUSTOMER SERVICE DELIVERY MEASURES SURVEY

The survey contains three separate sections, each of which is discussed in relation to its content and contribution to the research.

Part I: Ranking of Customer Service Delivery Factors

Survey respondents were asked to rank seven features of service delivery in order of importance for various types of orders. The factors which were ranked from most important (1) to least important (7) include:

- o order status information,
- o damage control,
- o length of order cycle,
- o on-time delivery,
- o completeness of shipments,
- o unitized delivery, and
- o upcharge for special delivery options.

Each respondent was asked to designate the ranking for regular, promotional, and emergency orders. The purpose of this section of the survey was to determine which service factors are more highly valued by customers across different order types. This part of the survey is important because it gives management a method of prioritizing the use of resources among service components. Subsequent survey sections are used to determine the utility (trade-off) among levels of a specific attribute. As such, the data do not indicate which attribute will make it possible to derive the greatest benefit as defined by customer values.

Part II: Range of Delivery Service Performance

In the second part of the survey, respondents were asked to indicate the "most preferred" level of service and the "completely unacceptable" level of service for three delivery service features. This information was collected for two order types - emergency and promotional. Delivery service attributes were specified according to the population sampled, i.e. buyers were asked for information on delivery service features within their knowledge and job domain while warehouse/distribution managers were asked about delivery service features specific to their job performance. The service delivery features included in the survey are:

BUYER

- o length of order cycle
- o on-time requirement

- o completeness of shipments

WAREHOUSE/DISTRIBUTION

- o damage control (percent non-defective)
- o on-time requirement
- o methods of communication

The range between "most preferred" and "completely unacceptable" was used to determine what level of each customer service attribute is required to develop an effective service strategy. Furthermore, managerially useful market segments can be identified based on similar needs of customers.

Part III: Customer Service Delivery Profiles

After testing individual customer service delivery attributes, Part III of the survey involves the combination of attributes - each at specified levels - into a unique profile for preference ranking by the respondent. In addition to the ranking, each survey respondent was asked to rate the delivery service profile on a demarcated scale of "poor" to "excellent."

Different profiles were constructed for the buyer and the warehouse/distribution manager populations. Within each of these defined populations, unique attributes for emergency versus promotional orders were developed. For emergency orders, three service delivery attributes for each population were

tested. Each attribute was comprised of three levels. Promotional order profiles, for both the buyer and warehouse/distribution manager populations, were evaluated for four attributes, with each attribute tested at four levels. The factors tested include:

WAREHOUSE/DISTRIBUTION POPULATION

PROMOTIONAL ORDERS

- o on-time requirement
- o damage control (percent non-defective)
- o methods of communication

EMERGENCY ORDERS

- o methods of communication
- o unitized delivery
- o upcharge for delivery service

BUYER POPULATION

PROMOTIONAL ORDERS

- o order lead time
- o on-time requirement
- o completeness of shipments

EMERGENCY ORDERS

- o order lead time
- o completeness of shipments
- o upcharge for delivery service

A fractional factorial experiment was utilized for the design of Part III. Existing orthogonal arrays were used for testing the customer service delivery profiles. The arrays (Appendix A) were chosen based on their ability to analyze main effects and interactions to some extent. The objective was to assign factors and interactions in a non-arbitrary method to avoid possible confounding. The assignment of factors within the orthogonal array is presented in Appendix A.

4. SAMPLING PLAN AND DATA GATHERING PROCEDURES

Phase 1: Sampling Plan

The research for dissertation focused on a specific division of the consumer goods company. This division of the firm is composed of ten segments (or types of stores) including: 1) drug, 2) grocery, 3) health and beauty, 4) deep discount drug, 5) club, 6) convenient, 7) hypermarkets, 8) mass merchandisers, 9) toy, and 10) wholesalers. Phase 1 data collection represented only a portion of the current customer service research effort at the consumer goods company.

The consumer goods company has a significant customer base to support the necessary number of survey responses needed for the research. The customer base has a large degree of diversity which improves the generalizability of the results. The ten segments listed above provide an overall national survey of over 200 accounts. For each account, both the buyer and warehouse/distribution manager were surveyed. Due to the small number of customers for some segments it was decided to survey the complete population. Because certain other segments constitute a majority of accounts for the entire corporation, it was decided to do selective sampling rather than a purely random selection at the division level.

The selective sampling involved the top accounts based on volume of orders. By limiting the number of customers from the predominant market segments for the survey, it was possible to build groups proportionate to their population composition. This sampling plan introduces a great deal of bias in the sense that members of the population have no democracy in being selected. For this reason, the sample is not representative.

The intent of the sampling plan was to learn more about the smaller market segments, most of which are currently growing. Given the long history of customer service research in the grocery segments, it was felt that limited additional knowledge could be gained by focusing on these segments. Because their total customer size vastly outnumbers the other market segments, a random sample would have almost exclusively consisted of these accounts.

The lack of random assignment limits the inference that can be made about the characteristics or the relations between characteristics in the population.

While it is not possible to generalize to the population, the sampling plan allows for collection of information on specific customer stratifications.

Phase 1: Data Collection

The mail method of data collection was chosen for the administration of the survey. A postcard reminder was sent to non-respondents three weeks following the initial mailing of the questionnaire. Due to lack of nonresponse to this effort, and the relatively good survey response rate to that date, successive follow-up plan sequences were dropped.

In a survey of conjoint analysis research suppliers, Wittink and Cattin reported that the most often used means of data collection was personal interview (64 percent of respondents) for the period of 1981 through 1985.¹⁷ Other means included: computer-interactive method (12 percent), mail questionnaire (9 percent), telephone interview (8 percent), and combination (7 percent). While the use of mail questionnaires and telephone interviews was relatively infrequent, these means are particularly important if a probability sample is needed from a large geographic area such as with this research effort.

¹⁷Wittink, Dick R. and Philippe Cattin, "Commercial Use of Conjoint Analysis: An Update," Journal of Marketing, Vol. 53, July 1989, p. 92.

To avoid the disadvantage of a sampling unit being an organization, a specific individual in the company was targeted for receipt of the questionnaire. The appropriate respondent was designated by the consumer goods company. This individual was also pre-notified of the mail survey during the telephone interview portion of the customer satisfaction survey. Substitution of a specified respondent, by another company representative, will not be detrimental to the survey results. By asking for a respondent's position or title, it was possible to evaluate the appropriateness of a substitute respondent.

Data collection procedures in conjoint analysis have largely involved two basic methods:

- o the two-factor-at-a-time procedure, and
- o the full-profile approach.

Both approaches have certain inherent advantages. The pairwise approach (or trade-off analysis) is simple to apply and reduces information overload on the part of the respondent. The number of attributes to be studied is seemingly limited only by respondent endurance.¹⁸ The trade-off among pairs of attributes provides sufficient information for inference of attribute importance by simple

¹⁸Johnson, op. cit., p. 124.

tabulations of the data. In addition, the two-factor-at-a-time procedure lends itself easily to mail questionnaire form since no special props are needed.¹⁹

The full-profile approach requires fewer judgments to be made by the respondent, although each single judgment is more complex. The approach has the advantages of greater "realism" since respondents are choosing among concepts which are more elaborately specified. It also defines the levels of each of the factors by taking potential environmental correlations between factors into account. However, the full-profile approach may be affected by information overload which could lead to the simplification of the experimental task by the respondent. If this occurs, variation of perceived less important variables may be ignored or factor levels may be simplified.²⁰ Because of the information overload problem, the full-profile procedure is generally confined to five or six factors. If a large number of factors is used, the analyst should consider a fractional factorial design which requires fewer judgments to be made by the respondent.²¹

Recently, hybrid conjoint models have been introduced as one way to reduce the complexity of the data collection process. Although they were originally developed for the full-profile procedure, hybrid models can be adapted

¹⁹Green and Srinivasan, op. cit., p. 108.

²⁰Green, Paul E., "Hybrid Models for Conjoint Analysis: An Expository Review," Journal of Marketing Research, Vol. XXI, May 1984, p. 163.

²¹Green, Paul E. and Yoram Wind, "New Way to Measure Consumers' Judgments," Harvard Business Review, July-August 1975, p. 114.

to the tradeoff matrix approach. The central notion of hybrid modeling is to combine the simplicity of the self-explicated approach with the greater generality of conjoint models to develop multi-attribute utility functions that retain individual differences.²²

Hybrid conjoint modeling is characterized by the condition that three kinds of data are collected from each respondent:

- o attribute-level desirability values for the levels of each attribute separately;
- o attribute importance data; and
- o conjoint responses to a limited set (usually three to nine) of full profiles, drawn from a larger master design.

The main idea of hybrid modeling is to develop individual utility functions in which some aspects of the resulting utilities are measured at the individual level and other aspects at the total sample (or possibly sub-group) level. In general, the strategy of the approach is to obtain the most detailed (and individualized) utility function that can be supported by the data.

One of the options of the hybrid conjoint model is the enabling of respondents to indicate whether any level(s) within an attribute are "completely unacceptable." This implies that no matter how attractive an alternative might be

²²Green, op. cit., p. 156.

with other attributes, the respondent would reject the alternative if it contained any completely unacceptable attribute level. Once a respondent discards attribute levels as completely unacceptable, they are dropped from subsequent evaluations.

Phase 2: Sampling Plan

While Phase 1 focused its attention to data collection and analysis on a national level, Phase 2 concentrated on customers of the consumer goods company in the northeast sector of the U. S. Whereas the previous stage involved corporate staff interaction, the research effort for Phase 2 was assisted by the logistics module at the plant level. The narrower focus was necessary in order to gain an understanding of how environmental factors impact the logistics system's ability to meet customer requirements, and the implications this analysis has for logistics system's flexibility.

Two environmental changes are of interest to Phase 2 of this research: new product introduction and promotional programs. In discussions with the logistics staff at the plant, promotional programs and new product introductions were consistently ranked as the most difficult environmental changes to deal with in terms of on-target performance. The plant has a comprehensive customer service measurement system in place to track logistics' performance as viewed by the customer. By combining this data with information on lead times for incentive programs and new product introductions, it was possible to determine the mix of

customer service elements which are robust with respect to these external noise factors.

All customer activity (orders) are captured by the customer service measurement system at the plant. This information is used in the generation of reports for internal and external purposes. The size (number of data records) of the system made it easy to obtain the information needed for the experimental design. Shipment data from December 1990 through May 1991 were used to capture the two environmental noises (major brand introduction and product promotions) under study. Within this time frame, customer orders resulting from the two events were marked and copied to a separate data file. Customers were then stratified by size and type of account (e.g. large versus small, and grocery versus non-grocery). From these groups, random samples were taken for repetitions of the experimental design.

5. PLAN FOR STATISTICAL ANALYSES

Phase 1

Conjoint methodology is based on a decompositional approach in which respondents react to a set of profile descriptions. It is closely related to two developments in applied psychology - the modeling of clinical judgments and functional measurement. Both of these approaches utilize multiple regression as the main technique for parameter estimation of the models, as well as analysis of

variance (ANOVA) and full factorial designs. In functional measurement, the objective is both parameter estimation and predicted interaction effects. Users of conjoint analysis have generally emphasized predictive validity and regarded explanation largely as a secondary objective.²³

Since the data consist of only rank orders, the measure of fit must indicate the extent to which the products of the utilities have rank orders similar to the data. Three measures of fit are generally used: Kendall's tau, the coefficient of correlation, and the statistic phi.²⁴ The tau statistic is the difference between proportions of pairs in "right order" and "wrong order." A tau of 1.0 indicates a perfect rank order, while a tau of -1.0 indicates a perfect negative relationship, and a value of zero indicates an unrelated ordering.

The tau statistic is based on a count of numbers of errors without regard to their size. A second measure, phi, takes into account the sizes of the errors. For each pair of trade-off cells the ratio of the computed values denoted by the symbol "r", the quantity, given as $[r + (1/r) - 2]$, may be regarded as a measure of the distance of the ratio from one. This quantity is zero if the ratio is one and increases as the ratio becomes either larger or smaller than one. The statistic phi is defined by the expression:

²³Green and Srinivasan, op. cit., p. 104.

²⁴Johnson, op. cit., p. 123.

$$\phi = \frac{\sum [r + (1/r) - 2] \delta}{\sum [r + (1/r) - 2]}$$

$$\delta = \begin{cases} 1 & \text{if the computed difference is in} \\ & \text{the "wrong" direction.} \\ 0 & \text{otherwise.} \end{cases}$$

This index would have a value of zero if there were no errors of fit, and a value of one if the order of every pair of cells were incorrectly predicted. The most successful computing algorithm currently available uses a gradient technique to minimize phi.

Since conjoint measurement algorithms include a display of the best fitting monotone transform, this by-product can be used to select a specific functional form - logarithmic, square root, linear, etc. - prior to conducting the standard analysis of variance (ANOVA) tests. Each of the performance attributes were analyzed using SAS and a multidimensional statistics package. ANOVA analysis was used for testing differences among factor levels, and for determining the amount of variation due to each factor.

Customer service attribute ranking was analyzed using Thurstone CASE 5. Scale scores were computed from the ranked data, and a frequency matrix was developed to show the number of times one stimulus was preferred to another stimulus. Frequency analysis and other descriptive statistics were also used in an attempt to interpret the survey results. The specific objective for this part of the research was to determine which factors and levels give the best results for a customer service program.

The customer service attributes and levels were assessed from a qualitative perspective to see if any of the common factors influencing the results are at conflicting levels for the best results. If so, the impact of having these factors at the wrong levels or at some intermediate level as a compromise were also assessed. At this stage of the research, managerial insight was needed to gain an understanding of which variables offer the firm the best opportunity to improve performance. This is particularly important given that research has indicated that the most important variables do not necessarily lead to increased market share.²⁵

Phase 2

The following steps, which are essential for the Taguchi-type experimental design and interpretation, constituted the plan of analysis for Phase 2:

- STEP 1: Identify factors which are believed to influence the performance characteristics.
- STEP 2: Separate the factors into control and noise factors.
- STEP 3: Determine the number of levels and values for all factors.
- STEP 4: Identify control factors which may interact.
- STEP 5: Select the appropriate experimental design.

²⁵Sterling and Lambert, op. cit.

STEP 6: Assign factors and interactions to columns.

STEP 7: Conduct the experiment.

STEP 8: Analyze the data using the ranking method, ANOVA, S/N ratios, average graphs, and interaction graphs.

STEP 9: Interpret the results. Determine which factors are influential and which are not influential to the performance characteristic of interest.

STEP 10: Select optimum levels of the most influential control factors and predict expected results.

A statistical measure of performance called the signal-to-noise (S/N) ratio was be used in Phase 2 to evaluate the quality of the service. The S/N ratio measures the stability of performance of an output characteristic and the effect of noise factors on performance. Higher performance as measured by a high S/N ratio implies a smaller loss as measured by the corresponding Taguchi loss function. Like the loss function, the S/N ratio is an objective measure of quality that takes both the mean and variation into account.

When the ANOVA analysis on the conjoint data and the S/N analysis were completed, the customer service variables were classified in the following manner:

CLASS I: Factors which affect both average and variation.

CLASS II: Factors which affect variation only.

CLASS III: Factors which affect average only.

CLASS IV: Factors which affect neither average nor variation.

The parameter design strategy was used to select the proper levels of Class I and II to reduce variation, and to select Class III levels to adjust the average to target value. Class IV factors can then be set at the most economical levels since there is no effect on average or variation. Figure III-2 shows example plots for the four classes of factors. The fundamental parameter design approach is to move all but one customer design parameter to a region of low response slope to make those parameters insensitive to variation. The remaining factor(s) should be linear (adjustment) factors to obtain appropriate quality responses.

Taguchi S/N ratios were computed to identify control factors which effect performance variation (referred to as Class I or Class II factors). Then ANOVA results on the raw data were used to identify control factors which affect the average (Class III factors). The research objective in this stage was to select the proper levels of Class I and II factors to reduce variation and Class III factors to adjust the average to the target value. The identification of Class IV factors (those factors which affect neither average nor variation) was also important because they may be set at the most economical level.

In addition, regression analysis was used for exploring and approximating the functional relationship between customer service performance and the independent customer service variables. Interaction graphs and other forms of data presentation were utilized in the analysis of the Phase 2 experiment.

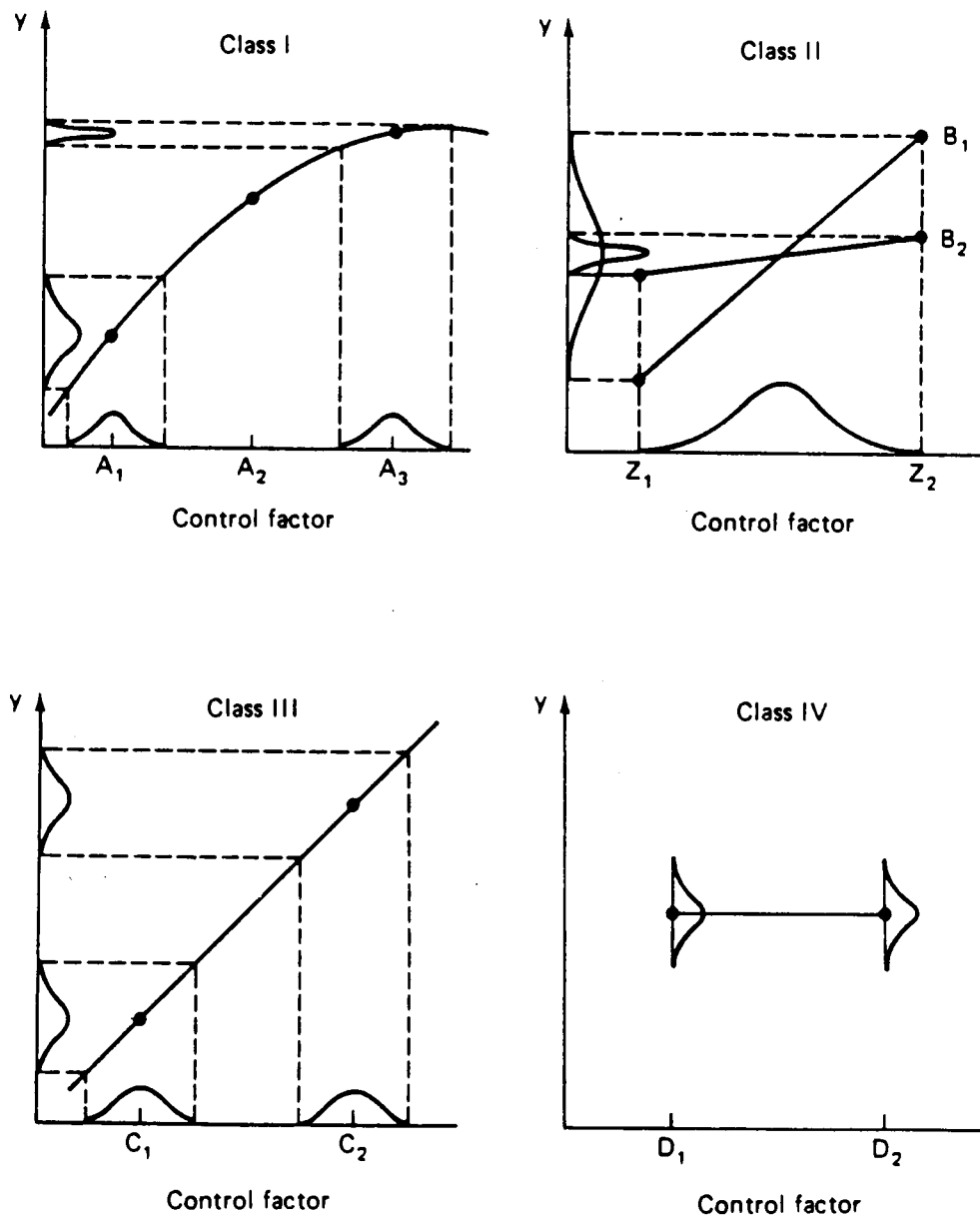


Figure III-2. Classes of Control Factors

Source: Philip J. Ross, Taguchi Techniques for Quality Engineering (New York: McGraw-Hill Book Company), 1988, p. 176.

Reliability and Validity Issues

The paired-comparison approach has an advantage over the full-profile method in that it results in higher reliability of the average rank order, and the ability to test for intransitivities in the respondent's expressed preferences.²⁶

The fractional factorial type design, on the other hand, is considerably easier to develop. If no attribute correlations are desired, it is likely to produce more accurate parameter estimates. It involves no limiting assumptions such as multivariate normality which needs to be assumed in the random sampling approach. Finally, if the relative importance of the attributes are to be obtained, the orthogonal design produces less ambiguous answers than the correlated factors approach.

Several methods can be used to test reliability at either the respondent level or at the estimated parameter level. One method (test-retest) involves repeated evaluations of subsets of the original set to obtain the reliability of a respondent's preferences. Instability occurs when there is a large number of order inversions between the original and retest rankings. However, these changes might also be the result of conscious changes in preferences. Conscious changes in preferences can occur when the time lapse between the test and retest is too

²⁶Green and Srinivasan, op. cit., p. 112.

great. Wilson experienced this problem when only four weeks had elapsed between his test/retest rankings.²⁷

The question of test/retest for determining reliability of respondents' preferences was considered to be of less importance to this research effort than other reliability issues such as minimization of error variance. Several factors contributed to the lack of primary emphasis on reliability testing of preferences including:

- o Customers are frequently asked to participate in surveys on a continual basis by this consumer goods company and others.
- o Competitive pressures are such that customer preferences vary over time as market conditions and offerings change.
- o The survey was designed to include a means of checking for inconsistencies in a respondent's preferences. (Section 3 - Development of the Survey Instrument)

A second method of reliability testing focuses on four sources of error: inaccuracies in the input data, variability in the set of constructed stimuli, errors in the estimation procedure, and time-related variables. In addition to this rigorous test, consistency and accuracy can be tested at an aggregate level by comparing the conjoint analysis results with available data from other sources. Consistency

²⁷Wilson, Minor Keith, A Multidimensional Scaling Analysis of Customer Service: An Evaluation of Manufacturers by Their Distributors, unpublished doctoral dissertation, Indiana University, 1974.

checks were conducted to determine whether the estimated parameters made sense and if the signs agree with a priori expectations.

Four methods were available for improving the predictive accuracy of conjoint analysis. First, by reducing the number of estimated parameters, the remaining ones will be estimated more reliably.²⁸ The second method utilizes reduction of allowable relations among parameters to increase reliability of estimated partworths. Third, an increase in accuracy can be obtained by utilizing additional information in the form of self-explicated importance weights for each respondent. Hagerty proposed a fourth method for improving the predictive power of conjoint analysis by grouping respondents with similar preferences using Q-type factor analysis.

For purposes of this analysis, the first method - reducing the estimated parameters - was used. This approach is consistent with other design criteria specified for the research, and is sensitive to the respondent's limited time and willingness to participate in a survey. Previous research done by the consumer goods company provided an excellent base for selection of a "meaningful" and concise set of variables for parameter estimation.

Predicted rank orders derived from the first set of preference data can be compared to actual rank orders using the tau statistic to determine the correlation between the two. This measure of cross validation tests the goodness of the

²⁸Hagerty, Michael R., "Improving the Predictive Power of Conjoint Analysis: The Use of Factor Analysis and Cluster Analysis," Journal of Marketing Research, Vol. XXII, May 1985, pp. 168-184.

model and also takes the predictive ability of the model into account. Internal validity can also be obtained in terms of the correlation between the actual versus estimated values of the dependent variable.

Neither of these methods, however, tests the external validity of the results. External validity can be tested by presenting respondents to the survey concept statements describing the customer service programs and asking them to rank these concepts in order of their preferences. Utilities calculated for the attributes were used to predict the rank order of preferences for the concepts to determine their correlation. This test also provided an overprediction/underprediction measure for the concept.

6. SUMMARY

This chapter has discussed the methodological approach and research design used to conduct this study. Lessons learned from numerous previous developments of customer service studies, as documented in the literature review, are incorporated into the research design as appropriate for each phase of the research. The methodology for Phase 1 was a previously used approach in customer service attribute analysis. However, when this stage was combined with Phase 2 the analysis became much more powerful in the understanding it provided of the relationship between the various customer service elements. This type of

approach represented a new and innovative way to measure and evaluate customer service performance within the logistics function.

The current growing interest in the Taguchi strategy has focused mainly on improving production processes. Although there are a few existing applications of this methodology in the service area, none of these have been made available for public edification. The research for Phase 2, in and of itself, represented a novel approach to measuring customer service performance in the context of uncontrollable variations in the external environment. Because customer service is a multi-dimensional phenomenon, which often spans an array of several functional areas, a comprehensive method is needed to analyze the elements from a total responsibility viewpoint.

CHAPTER IV

RESEARCH FINDINGS AND ANALYSIS

This chapter is comprised of four sections. The first section discusses the results of the pre-test of respondent validity (phase one) and its impact on data analysis. Section 2 examines the response rate on the survey instrument (also Phase 1) and its implications for analysis and interpretation. The third section presents and discusses the research findings for Phase 1 and 2 of the dissertation. In the final section, an attempt is made to integrate the two research phases for a comprehensive method of designing, assessing and improving the customer service delivery process.

Definition of the population to be studied has direct impact on research findings and analysis. Because the dissertation research was a smaller, more specific component of the corporate effort for the consumer goods firm, particular detail was needed at the design level to determine the members of the population to be studied. It was hypothesized that the five category respondents to the corporate research effort would not be appropriate to the dissertation study. A pretest for respondent validity was conducted to ascertain which categories of respondents would be most meaningful to the research.

1. PRETEST OF RESPONDENT VALIDITY

This section discusses the results of the pretest of respondent validity which was conducted prior to the survey administration of Phase 1. The purpose of this procedure was to determine whether or not the data required for the research could be supplied by the same respondents as to the overall corporate survey.

Job Performance Criteria

The key steps in the buying process executed to make product addition/deletion decisions include:

- o review of the item form,
- o estimation of volume and profit potential for the new item,
- o decision by a committee or individual, and
- o execution of the decision.

Because a significant majority of buying organizations are centralized, the decision to adopt a new product or delete an old product is made by a single buyer.

Within a decentralized structure, however, the pretest results indicated that only a small percentage (16%) of firms rely on a single buyer to make product decisions.

These findings would seem to suggest that there is an important reason to identify participants in the account decision making process and determine their relative influence. Furthermore, in order to understand the behavior of each participant

or influencer in the buying process, it is necessary to assess factors that motivate behavior.

Senior management. The motivating factors and job performance for this group focused on four strategic areas: volume growth, internal cost reductions, planned acquisitions, and store consolidations. Senior management's involvement with the customer service delivery process was not directly surveyed. However, because this group does not have any relative influence on the buying process it is believed that no information was lost due to non-direct pretest questions.

Buyer/merchandiser. Even before the pretest results, it was believed that this group is key to the buying process. The purpose of the pretest decisions was to confirm/disconfirm this hypothesis and to determine the extent to which logistics/transportation factors influence the buying process. An evaluation of job performance criteria provides a good basis for measuring this type of influencer. Figure IV-1 indicates that four of eight criteria are logistics/transportation driven. Given the prominence of the minimization of out of stocks, it is believed that the buyer/merchandiser will be responsive to systems which affect this factor.

Warehouse/logistics. Three basic components of any customer delivery program were also identified by this group as being key job performance criteria. Figure IV-2 shows that on-time delivery, completeness of deliveries, and damage free are important measures of effectiveness for the warehouse/logistics manager.

Retail operations personnel. The members of this group are very volume sensitive. Sales revenue and sales revenue growth are the most significant job

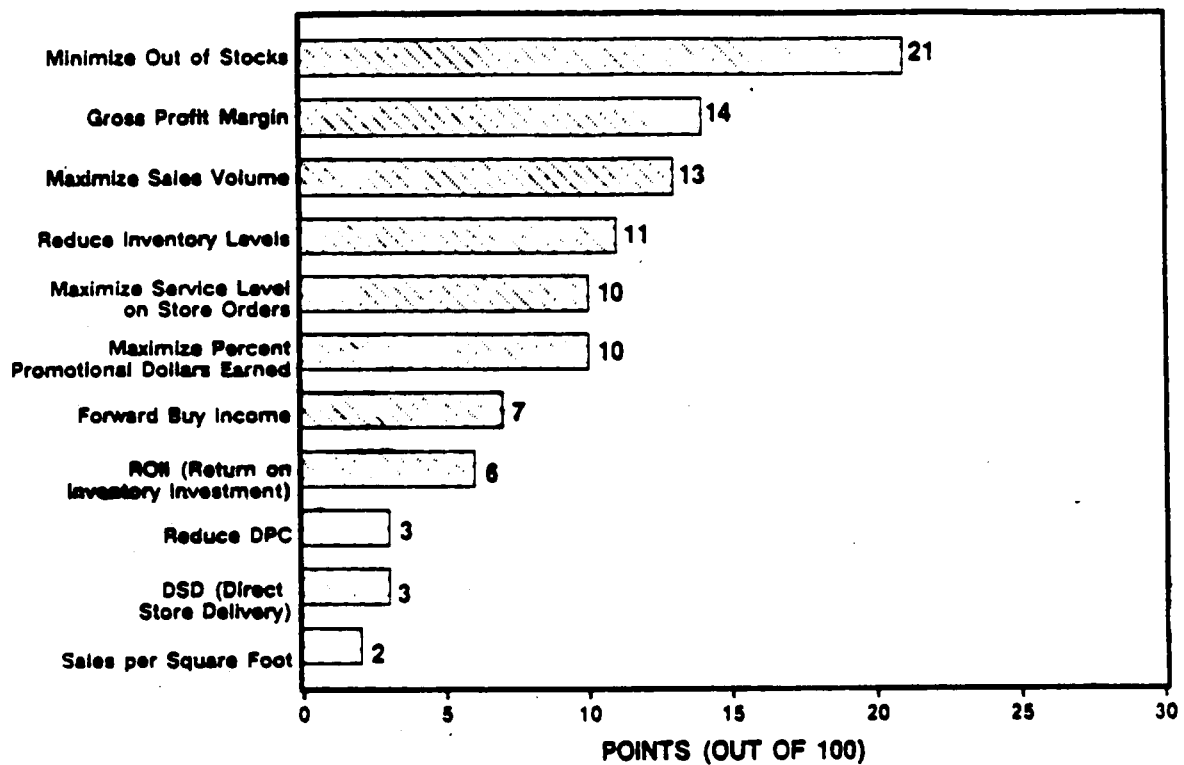


Figure IV-1

Job Performance Criteria - Buyer/Merchandiser

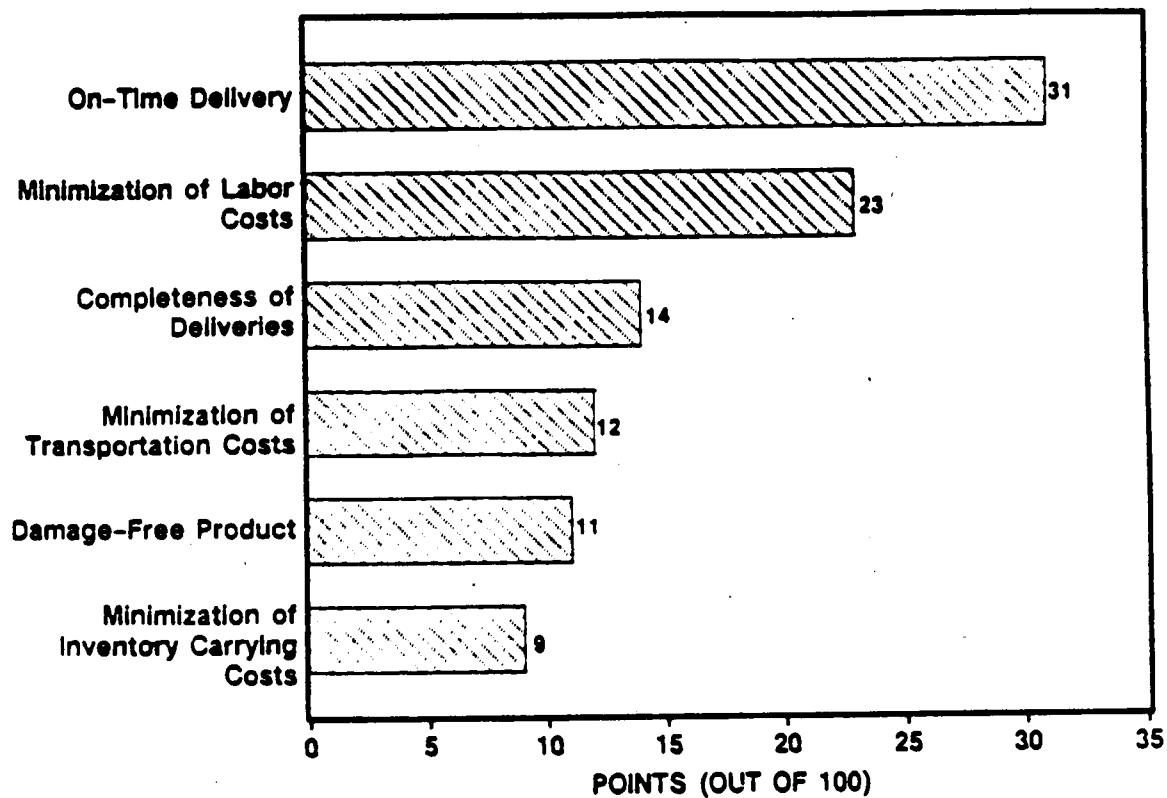


Figure IV-2

Job Performance Criteria - Warehouse/Logistics Manager

performance criteria. Indeed of the total criteria reported by this segment, none were related to the logistics/transportation function. There seemed to be no awareness of customer service delivery and its influence in the buying process.

Relative Influence on the Buying Process

Across all steps of the buying process, the warehouse/logistics manager has the least amount of influence. Table IV-1 shows that the buyer/merchandiser is the dominant functional influencer. However, the relative influence of the participant varies by step, type of account, and market segment. Interestingly, the general influence pattern does not vary by step, except for step four, where retail operations perceive they have a greater influence (Table IV-1). The warehouse and logistics function has an insignificant influence on new product adoption decisions at all process steps.

Warehouse/Logistics Factors Influence

The warehouse/logistics function has a strong influence in creating customer value. The buyers' attributes of value by rank order indicate that the top five are:

- o on-time delivery of regular shipments,
- o complete shipments,
- o order status communication,
- o on-time delivery of promotional orders, and

Table IV-1
Decision Influence Matrix
(percent of influence)

Function	Steps			
	Review of item data form	Volume and profit potential	Decision by committee or individual	Execution of decision
Senior management	10	0	10	0
Buyer	30	50	30	10
Merchandising	55	50	55	0
Distribution/ logistics	0	0	0	0
Warehousing	5	0	5	0
Store operations	0	0	0	90
TOTAL	100	100	100	100

NOTE: Percentages were derived based on the summation of point assignment of 100 points per respondent.

- o responsiveness to emergency orders.

As determined by factor analysis, these attributes in total define the customer service benefit. They account for a 0.33 change in quality rating per one point increase in benefit rating as calculated by the regression coefficient (Figure IV-3). In addition, customer service and promotion flexibility are key drivers of the buyers' quality perception. Figure IV-4 shows that there is a significant penalty for customer service at a performance level of less than "very good." The largest improvement in overall quality perception can be achieved through superior performance in this area versus promotion flexibility, cost control reductions, and sales autonomy.

Warehouse Facilities

The rank order of warehouse attributes of value are classified into five groups: delivery, damage elimination/packaging, dock handling, unitization, and cube efficiency. Unitization and cube efficiency benefits are not statistically significant drivers of quality. However, as Figure IV-5 indicates, the delivery service benefit is almost three and one-half times more important than either damage elimination or dock handling benefits. There is also a significant penalty for delivery service and damage elimination at a perceived level of less than "good" (Figure IV-6). It is possible to realize an extreme improvement in overall quality perception through leveraging manufacturer's ability to provide very good to excellent delivery service.

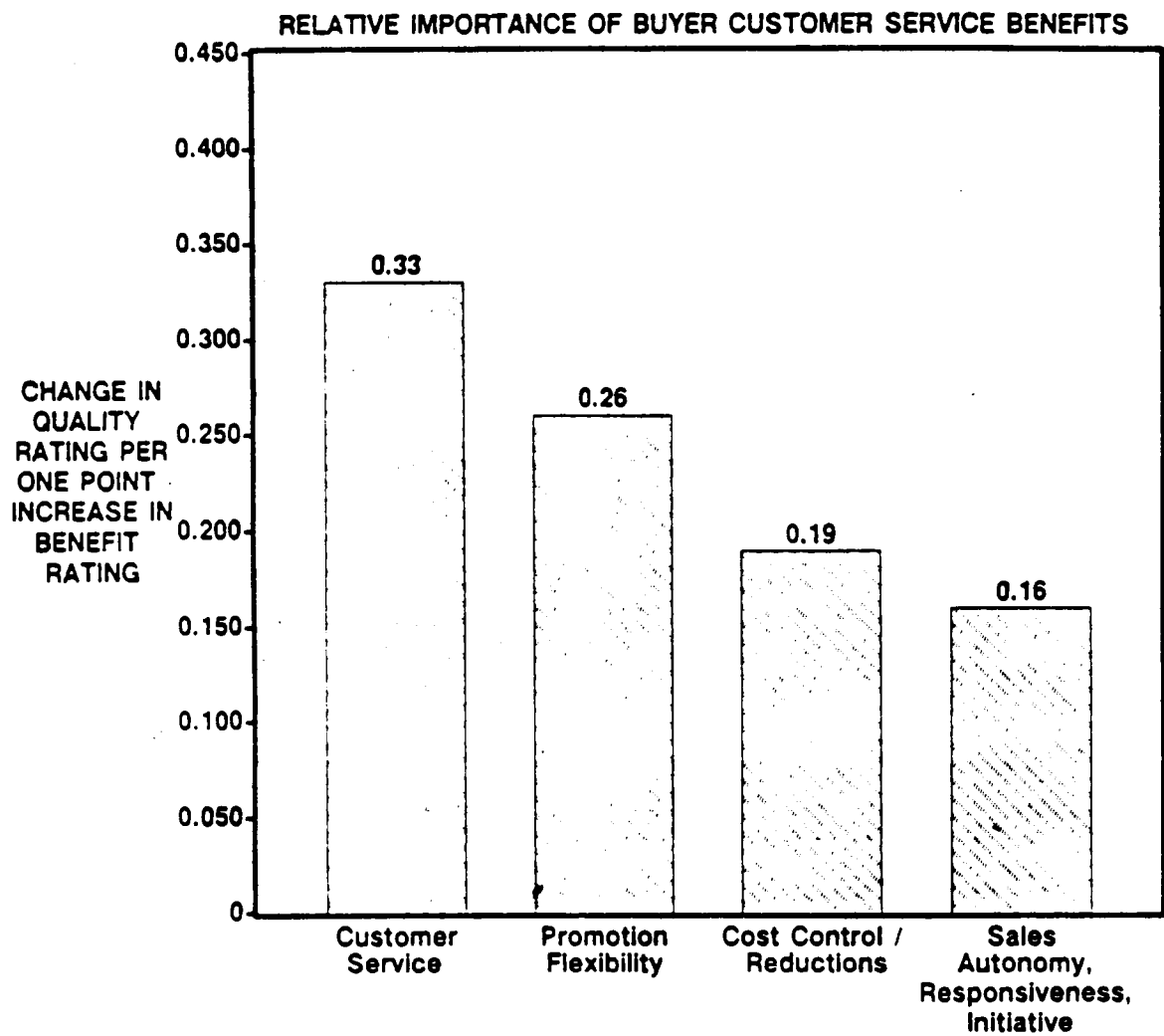


Figure IV-3. Relative Ranking of Customer Benefits
BUYERS

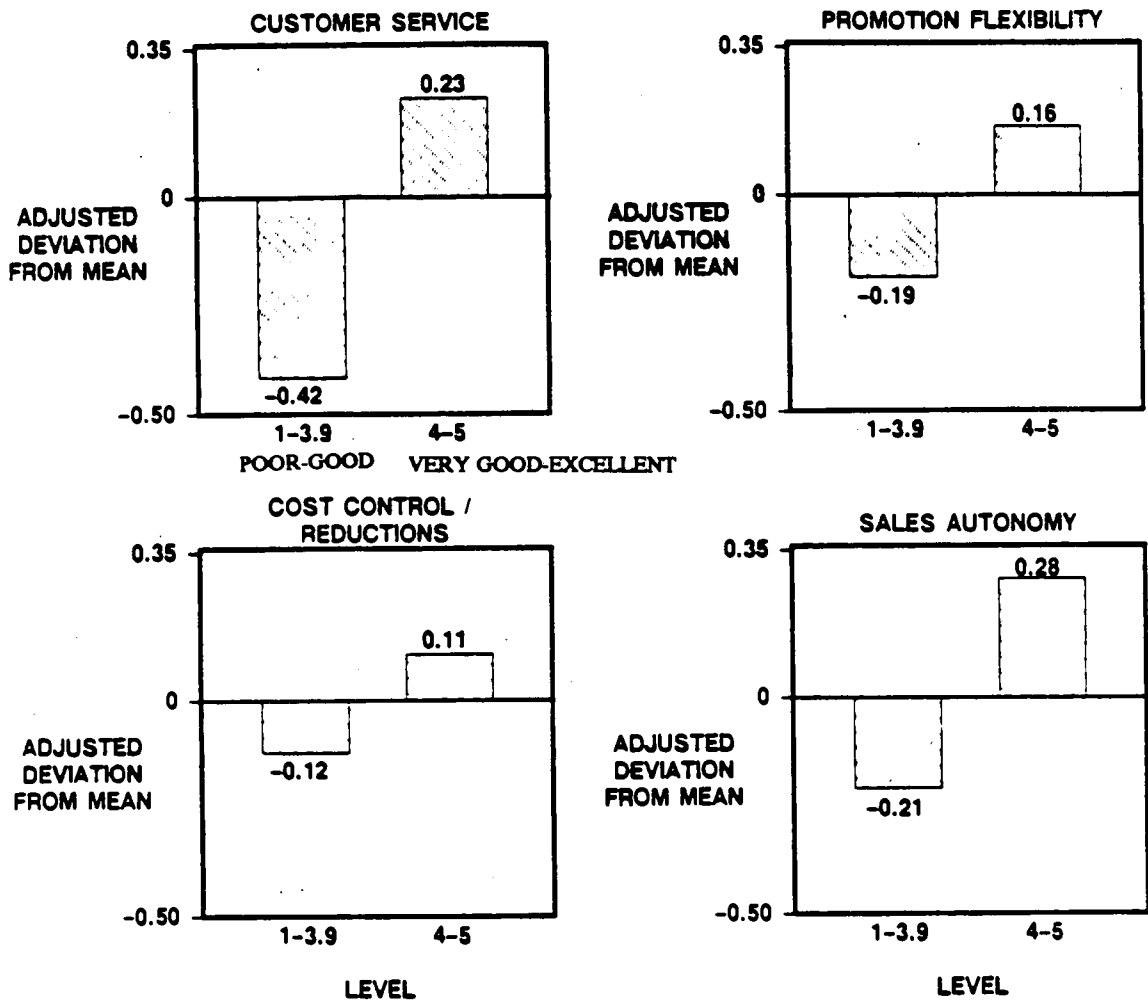


Figure IV-4

Effect of Benefit Level on Buyers' Quality Perception

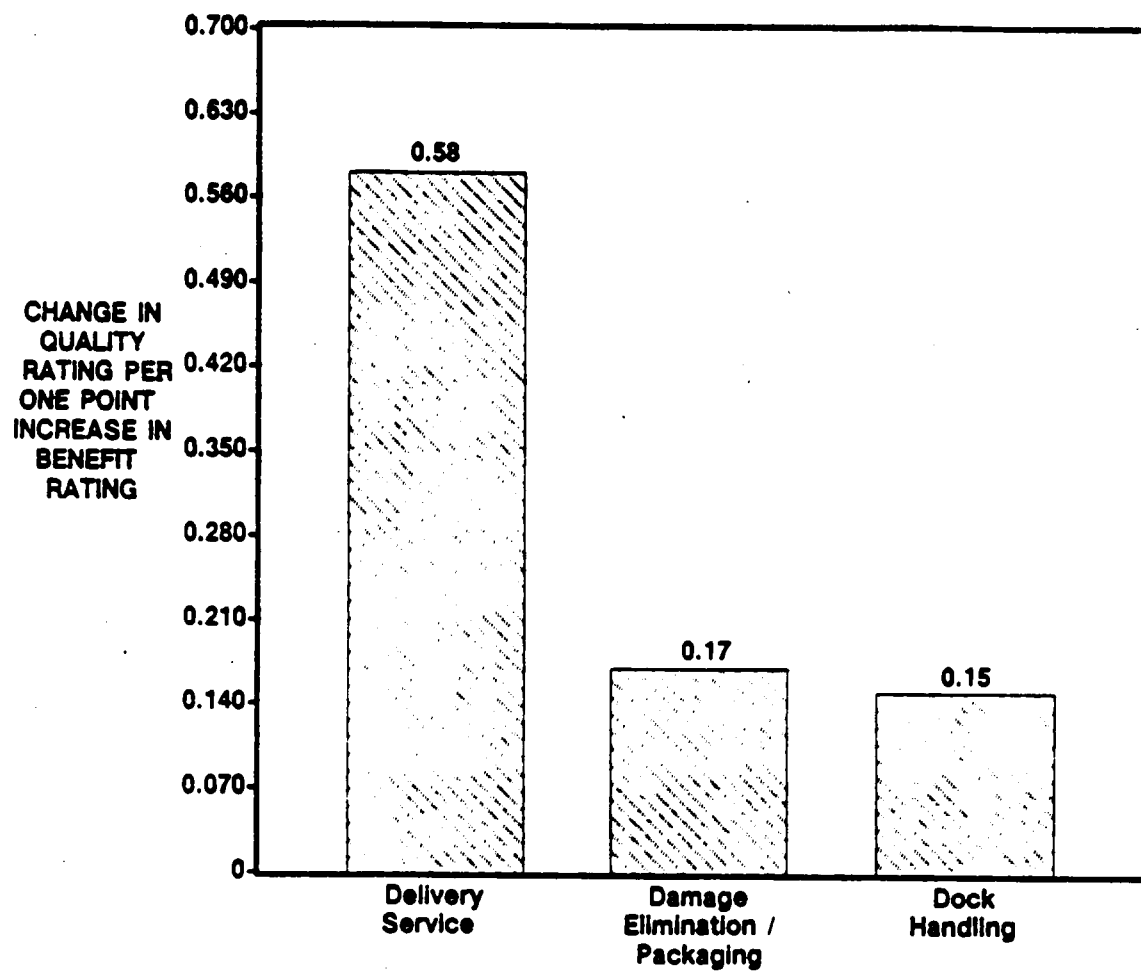


Figure IV-5
Relative Importance of Warehouse Customer Service Benefits

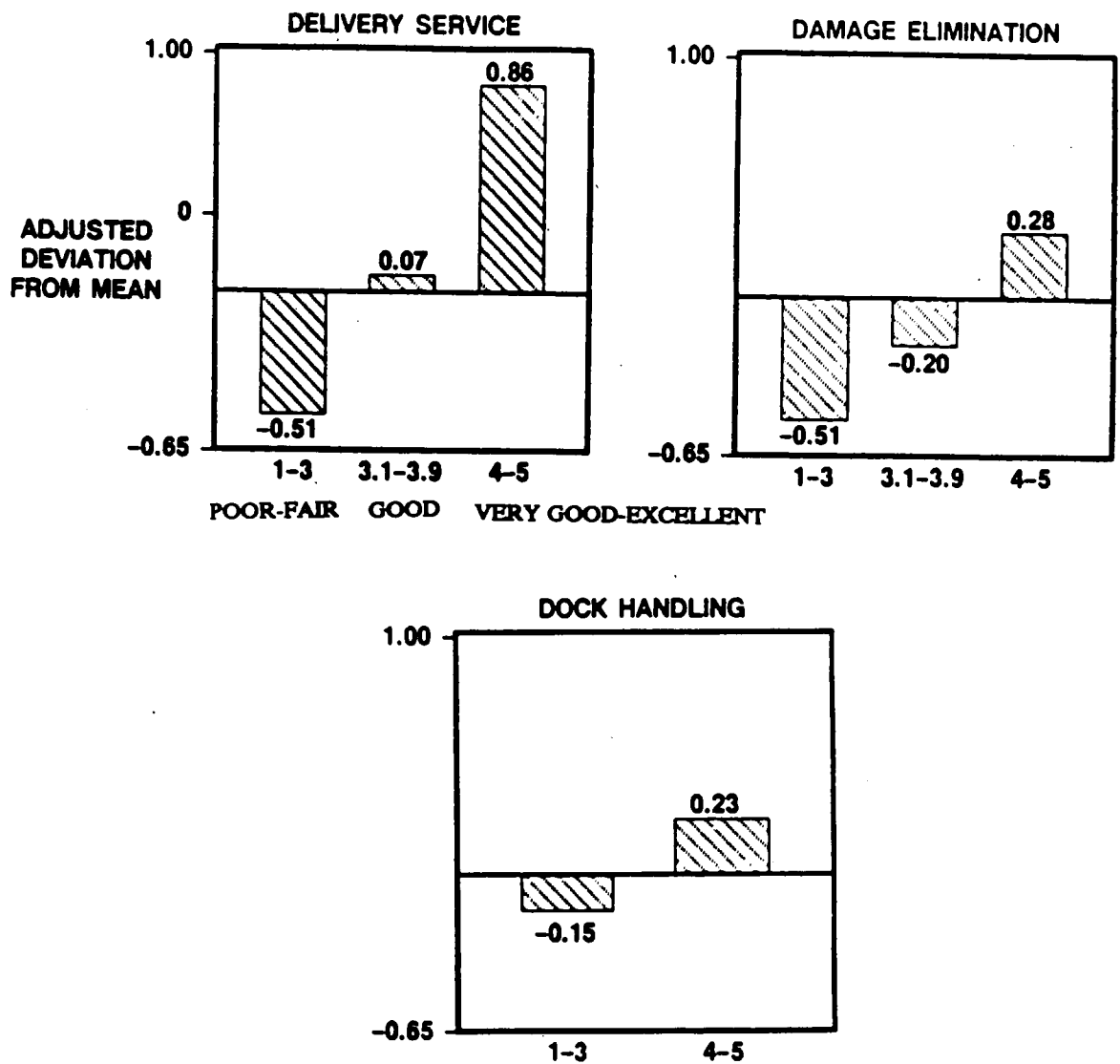


Figure IV-6

Effect of Benefit Level on Warehouse Managers' Quality Perception

Relative Influence of Logistics/Transportation

While buyers are able to ascertain the value of customer service attributes (e.g. on-time delivery, completeness of shipments, damage-free product), they do not perceive the importance of these factors as they relate to the logistics/transportation function and their relative influence in the buying process. Table IV-2 indicates that the majority of buyers either don't know how logistics/transportation influences buying decisions or they believe the influence is not very important to creating customer value.

These results are very similar to previous research findings which suggested that within a particular organization the logistics/transportation functional area does not participate in the buying process. Interestingly, however, this group is most critical to the delivery of customer value as defined by the pretest survey results. In an effort to understand the needs of both buyers and warehouse/distribution managers as they relate to the buying process it was determined that the dissertation research should focus on both groups. The remaining pretest respondent groups - executive manager and retail operations personnel - do not contribute to the understanding of customer service delivery quality. Therefore, they were not included in the survey population for dissertation study of customer service delivery measures.

Table IV-2

Extent of Logistics/Transportation Influence on the Buying Process

Evaluation of influence	Percentage of respondents
Extremely important	4.2
Very important	4.2
Somewhat important	20.8
Not very important	29.2
Not at all important	16.6
Don't know importance	25.0
TOTAL	<u>100.0</u>

2. SURVEY RESPONSE AND ITS IMPLICATIONS ON THE DATA ANALYSIS

This section discusses the response rate to the survey instrument for Phase 1, possible explanations for the level of responses received, and the implications of the response rate on the data analysis.

Response Rate

At the completion of each telephone interview for the Customer Satisfaction Survey at the corporate level, respondents were asked to participate in a mail survey portion of the research. The response rate to the corporate survey instrument for both buyers and warehouse managers was quite high (58.8 percent and 78.0 percent, respectively). As Table IV-3 and Table IV-4 indicate, the majority of the respondents are from the grocery market segment. There does not appear to be any significant differences between the response rates for the buyer and warehouse groups except for the hi-lo segment which had 30 percent more respondents for the warehouse portion of the telephone interviews. Regional response rates for the buyer and warehouse groups show no differences by functional area (Table IV-5). Given the market area for the consumer goods company, the response rates are indicative of this spread.

Both respondents and non-respondents to the telephone interview were included in the mail survey portion of the dissertation research. Because the warehouse managers were the first group to participate in the telephone interview,

Table IV-3

Buyer Respondents by Channel Type
CUSTOMER SATISFACTION SURVEY

Channnel	Percent of respondents
Hi-lo	28.5
EDLP	9.2
Wholesaler	24.6
Mass merchandiser	9.2
Convenience	2.3
Variety	1.5
Drug	16.2
Club	1.5
Toy	1.5
Deep discount drug	5.4
Percent of total sample - 58.8	

Table IV-4
Warehouse Respondents by Channel Type
CUSTOMER SATISFACTION SURVEY

Channnel	Percent of respondents
Hi-lo	40.7
EDLP	9.0
Wholesaler	24.8
Mass merchandiser	4.1
Convenience	2.1
Variety	0.7
Drug	11.0
Club	2.1
Toy	1.4
Deep discount drug	4.1
Percent of total sample -	78.0

Table IV-5

Regional Response Rates for Buyers and Warehouse Managers

Region	Percent of respondents	
	BUYERS	WAREHOUSE
Southeast	18.5	18.4
East	23.1	27.0
Central	33.8	29.1
West	24.6	25.5
TOTAL	100.0	100.0

this group was also first to receive the questionnaire. The mailing of 186 surveys to the warehouse managers was completed during the week of June 3, 1991. Of this number, thirty-eight surveys were received within three weeks.

A follow-up postcard was sent to those individuals who had not yet responded. For the warehouse sample, this effort resulted in the return of four more questionnaires. All of these were received within a week of the postcard mailing.

Surveys were mailed to buyers during the week of June 24, 1991, following the completion of their telephone interviews. A total of 221 questionnaires were mailed in packages which also contained self-addressed, postage return envelopes. At the end of three weeks, forty-four surveys had been returned. Following the same plan as for the warehouse managers, the buyers who had not responded were sent a postcard follow-up. The postcard mailing generated no additional responses for the buyer sample.

In total, eighty-six usable surveys were received for an overall response rate of 21.1 percent. However, when the respondents to the mailed survey were compared to the telephone survey respondents, less than 5 percent of the telephone non-respondents participated in the mail survey. If the corporate response totals, adjusted for telephone non-respondents, are used for buyers and warehouse managers to compute an adjusted response rate for the dissertation survey the overall success rate rises to 29.5 percent. This translated to a 27.6

percent response rate the warehouse group and a 31.5 percent response rate for buyers.

The analysis of survey respondents by channel type indicated that some sixty percent of the top 100 shipment accounts are captured in the research findings (Table IV-6). When this is further examined at the segment level, the data show that the majority of the large accounts participated in the survey. A review of completed surveys also indicated that certain segments identified as having future growth potential were represented. The response by type of channel has direct implications for findings of managerial significance.

The survey response rate by type of channel for the Customer Service Delivery Measures Survey indicates that some differences exist between the mail method of obtaining information and the telephone interviews. For example, no buyers responded to the mail questionnaire from the convenience, variety, and deep discount drug market segments (Table IV-7). Due to the small total population for these groups (3, 1, and 5, respectively), this result was not unexpected or unanticipated. The warehouse respondents by channel type (or market segment) are similar for both methods of survey. As Table IV-8 shows, only one segment (toy) did not participate in the mail survey. Once again, given that the total population for this customer group is two, the resulting non-response is not surprising. This segment, while growing in volume, currently does not constitute a large dollar share of the total customer base.

Table IV-6

Characteristics of Survey Respondents by Channel Type

Channel	Percent of top 100 shipments	Percent of segment top 100 shipments
Hi-lo	18.2	60
EDLP	7.6	42
Wholesaler	18.0	57
Mass merchandiser	10.5	84
Convenience	0.2	100
Variety	*	50
Drug	3.1	85
Club	2.0	55
Toy	*	100
Deep discount drug	0.3	100
Total percent of top 100	60.0	

*Less than 0.05 percent.

Table IV-7

Buyer Respondents by Channel Type
CUSTOMER SERVICE DELIVERY MEASURES SURVEY

Channnel	Percent of respondents
Hi-lo	34.1
EDLP	7.3
Wholesaler	24.4
Mass merchandiser	4.9
Convenience	-
Variety	-
Drug	24.4
Club	2.4
Toy	2.4
Deep discount drug	-
TOTAL	100.0

Table IV-8
Warehouse Respondents by Channel Type
CUSTOMER SERVICE DELIVERY MEASURES SURVEY

Channnel	Percent of respondents
Hi-lo	38.1
EDLP	9.5
Wholesaler	21.4
Mass merchandiser	4.8
Convenience	4.8
Variety	4.8
Drug	9.5
Club	2.4
Toy	-
Deep discount drug	4.8
TOTAL	100.0

Although response rates have been reported which range from below 20 percent to 100 percent, there is no reliable evidence which identifies the factors responsible for this enormous variation.¹ One of the limitations of the mail survey method is that a response rate of 30 percent or more is not common.²

The response rates experienced in this research is somewhat typical of those reported in the logistics literature. Three major logistics publications - International Journal of Physical Distribution & Materials Management (IJPDM&MM), the Journal of Business Logistics (JBL), and the Transportation Journal (TJ) - have been used in the past as sources for understanding response rates for mail surveys in logistics research.³ During the time frame 1985-1986, nineteen articles in these journals used mail surveys. The following response rates were found:

IJPDM&MM	-	26.0 %
JBL	-	33.8 %
TJ	-	14.6 %

¹Kanuk, Leslie and Conrad Berenson, "Mail Surveys and Response Rates: A Literature Review," Journal of Marketing Research, Vol. XII, November 1975, p. 451.

²Erdoes, Paul L., Professional Mail Surveys (New York: McGraw-Hill), 1970.

³Novack, Robert A., Logistics Control: An Approach to Quality, unpublished doctoral dissertation, University of Tennessee, 1987, p. 104.

Of these research endeavors, eight adjusted the original sample size downward. Without the downward adjustment, there is a small (1.5 percent) decline in response rate. However, because response rates can be manipulated and because they are hard to compare to one another, no judgment can be made concerning their significance in these studies.

Even the overall response rate for the Customer Service Delivery Measures Survey was acceptable, the number of responses by type of market segment made it necessary to combine categories. For purposes of statistical analysis, only grocery and non-grocery channel differentiation will be used. This modification will permit valid statistical tests and some degree of inference.

Response Rate Analysis

Researchers have long recognized the advantages of mail questionnaire surveys because they are relatively low in cost, geographically flexible, and can reach a wide sample simultaneously without possible distortions of time lag. The major disadvantages, however, are believed to be their low response rates, with attendant problems of response bias and non-response bias.⁴ A separate effort was undertaken to understand the lower-than-expected response rate. Of the 321 total non-respondents remaining after the postcard follow-up, 125 (38.9 percent) were called to determine the reasons for non-response. The refusals can be classified under the following categories:

⁴Erdos and Morgan, op. cit.

- o no time,
- o send a sales representative instead,
- o nothing to say,
- o company policy requires monetary compensation to participate, and
- o don't participate in mail surveys.

The majority of respondents expressed a concern for the time they spend participating in surveys. While this factor can be influenced by length of survey, evidence gives very little support to this view.⁵ Given the length of the research survey (three pages), it was believed that "no time" reflected the respondents' unwillingness to participate in surveys of any and all lengths.

Non-response is important in any type of research because it is not the loss in sample number that is serious, but the likelihood that the non-respondents differ significantly from the respondents such that estimates based on the latter are biased.⁶ If the respondents randomly complete or fail to complete and return the questionnaire, there will not be response bias.⁷ However, this cannot be known until the respondents are compared to the non-respondents. Based on the

⁵Kanuk and Berenson, op. cit., p. 443.

⁶Moser, Sir Claude and G. Kalton, Survey Methods in Social Investigation (New York: Basic Books), 1974, p. 167.

⁷Alreck, Pamela L. and Robert B. Settle, The Survey Research Handbook (Homewood, IL: Richard D. Irwin), 1985, p. 45.

38.9 percent sample of non-respondents, Table IV-9 indicates that the refusals vary somewhat from the respondents for several channels. Further examination of the respondents versus non-respondents for these channels indicated no significant difference in the groups by account size (volume or revenue).

To conclude, the relatively low response rate was a result of many factors. There is no systematic body of knowledge, nor conceptual framework, which relates specific techniques or research design to questionnaire response behavior except in some intuitive sense. Few findings are related to scientific theory. Due to the nature of this research, the response rate (calculated using the total sample with telephone non-respondents) of 21.1 percent is normal and acceptable, albeit disappointing.

3. RESEARCH FINDINGS AND ANALYSIS

This section presents and discusses the findings of the data analysis based on the research questions presented in Chapter 1. Each phase of the research will be examined in a separate section, addressing the general and specific research objectives and questions.

Table IV-9

Survey Refusals by Channel Type
CUSTOMER SATISFACTION SURVEY

Channnel	Percentage
Hi-lo	45.5
EDLP	9.8
Wholesaler	17.9
Mass merchandiser	5.7
Convenience	0.8
Variety	2.4
Drug	12.2
Club	4.9
Toy	-
Deep discount drug	0.8
TOTAL	100.0

Phase 1

Objective 1. To determine the utility scales (relative preference rankings) of various customer service attributes among multi-level attributes.

Hybrid conjoint modeling is characterized by the condition that three kinds of data are collected from each respondent:

- 1) attribute-level desirability values for the levels of each attribute separately,
- 2) attribute importance data, and
- 3) conjoint responses to a limited set of full profiles.

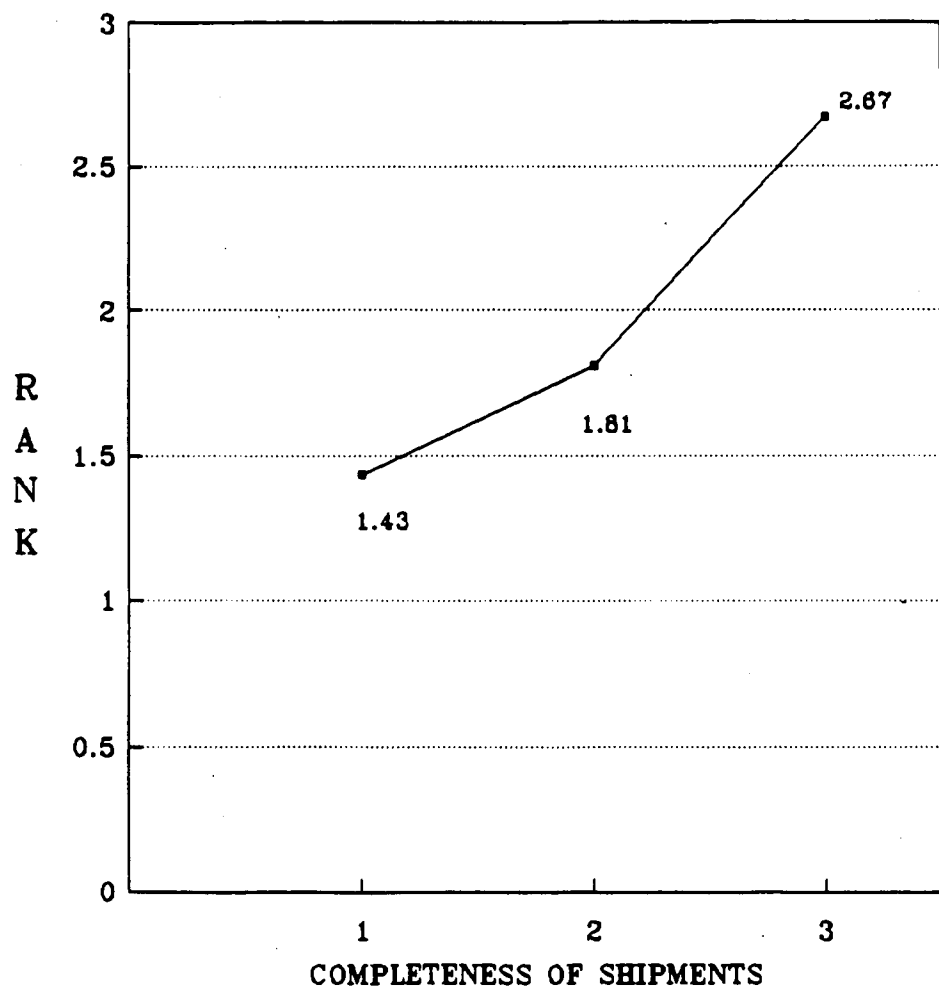
The simplest hybrid model involves the least squares approximation and was used for this analysis. The utility function was developed at the individual level and was summed to produce a group level. The scaling of the utility function was expressed in two forms: metric and semimetric. Importance weights for attributes were reported via ratings (metric), while the self-explicated desirability scores for levels of each attribute were given as dummy variables that reflect categorical responses of most preferred and unacceptable (semimetric).

In order to determine what level of each customer service element was required to develop an effective service strategy, two separate models were utilized. One (RANK) attempts to predict the customer service delivery profile

ranking (1 to 3 for emergency orders and 1 to 4 for promotional orders) by order type and market segment, while the other model (RATE) uses the rating of the delivery service package (on a scale of 1 to 10) for the dependent variable. The following analysis was conducted and the results of each are discussed.

Emergency Orders - Buyers

The model for emergency orders, with the dependent variable RATE, does not provide any evidence that it is useful in predicting values for specific settings of the customer service delivery attributes ($F=1.52$, $p=0.169$). The associated R-square of 0.44 further implies that it is not possible to make inferences about the utility of the model. However, when RANK is used as the dependent variable, the F-test indicates that the model is useful for prediction purposes ($F=2.82$, $p=0.010$). Although the R-square is acceptable at 0.59, a large amount of variation in ranking of attribute levels is not accounted for by the model. The F-value for testing individual service delivery attributes indicates that completeness of shipments is the only significant contributor ($F=5.24$) with an associated probability of 0.012. Figure IV-7 shows that 96-100 percent completeness of shipments is the most desirable. The greatest utility can be gained by moving from 84-89 percent complete to 90-95 percent (2.67 to 1.81, respectively).



1 = 96 - 100% complete
2 = 90 - 95% complete
3 = 84 - 89% complete

Figure IV-7

Attribute Level Preference
BUYERS - Emergency Orders

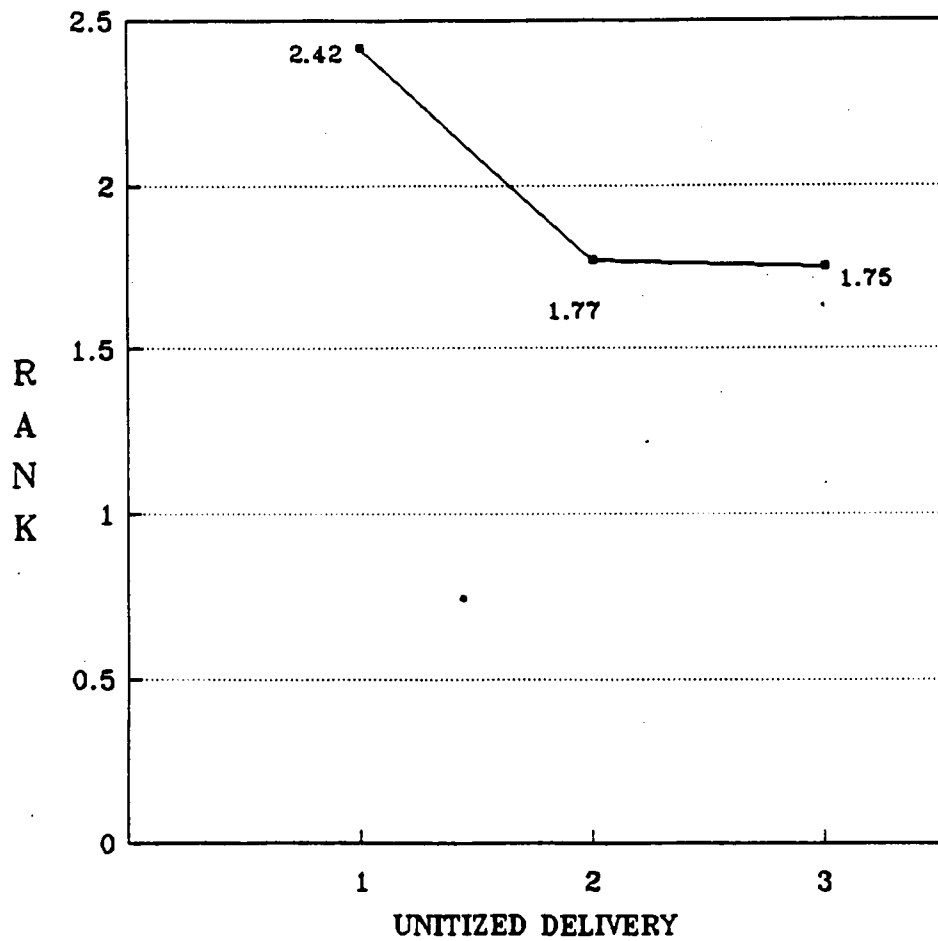
Emergency Orders - Warehouse

Both dependent variables, RANK and RATE, are useful for predicting values for specific settings of the customer service delivery attributes. The pertinent statistics for each of these models is shown below:

<u>Dependent variable</u>	<u>F-value</u>	<u>Pr > F</u>	<u>R-Square</u>
RANK	2.15	0.053	0.52
RATE	2.10	0.059	0.51

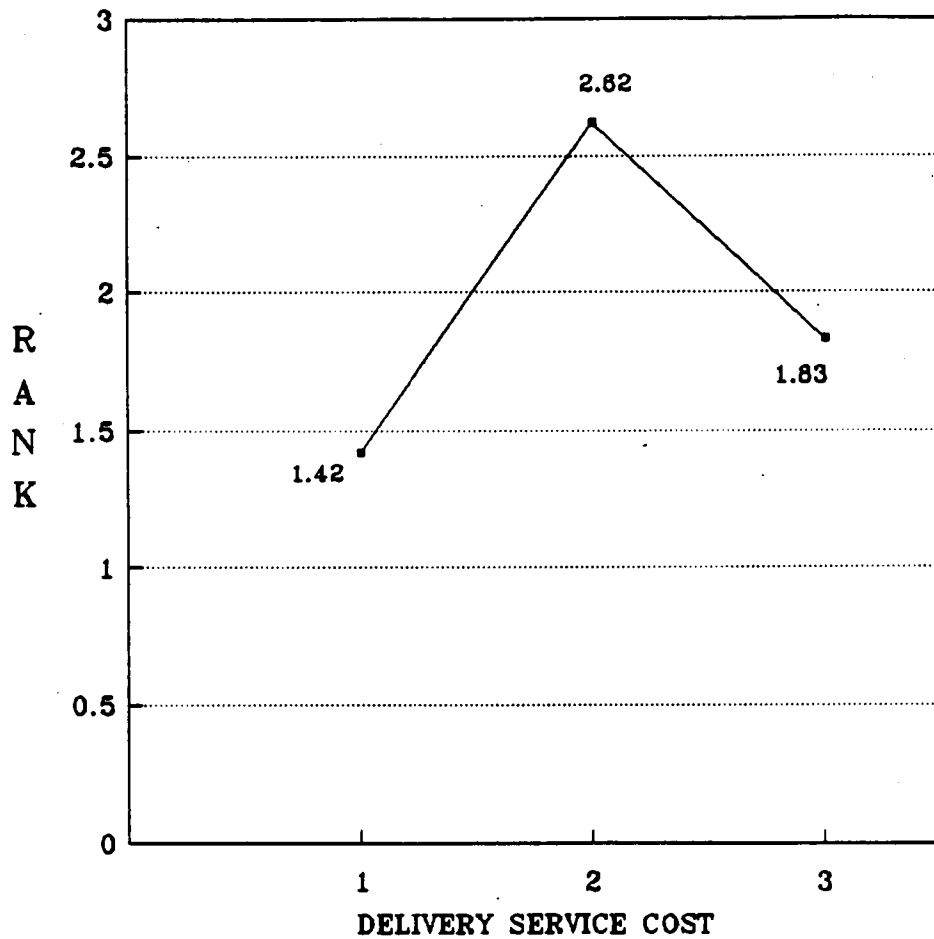
The RANK model indicates that unitized delivery ($p=0.043$) and delivery service cost ($p=0.006$) account for significant amounts of variation in predicting the rank of an individual profile. As presented in Figure IV-8, shrink wrap is the preferred method of packaging (mean utility = 1.75). However, slip sheets are more desirable than pallets (1.77 versus 2.42). Delivery service options for emergency orders is sensitive to any increases in price, with customer preference clearly shown for no change in price (Figure IV-9).

Preference ratings (RATE model) are also related to the attribute unitized delivery ($p=0.048$). The results are consistent with the RANK model in that pallets are the least preferred (mean utility = 4.75), and shrink wrap and slip sheet packaging are the most desirable (7.38 and 6.83, respectively). The RATE model indicates that the interaction of order status communication and delivery service cost contribute information to the prediction of the dependent variable



1 = pallet
2 = slip sheet packaging
3 = shrink wrap packaging

Figure IV-8
Attribute Level Preference
WAREHOUSE MANAGERS - Emergency Orders



1 = no change in price
2 = increase in price
3 = shared cost - special delivery opts

Figure IV-9

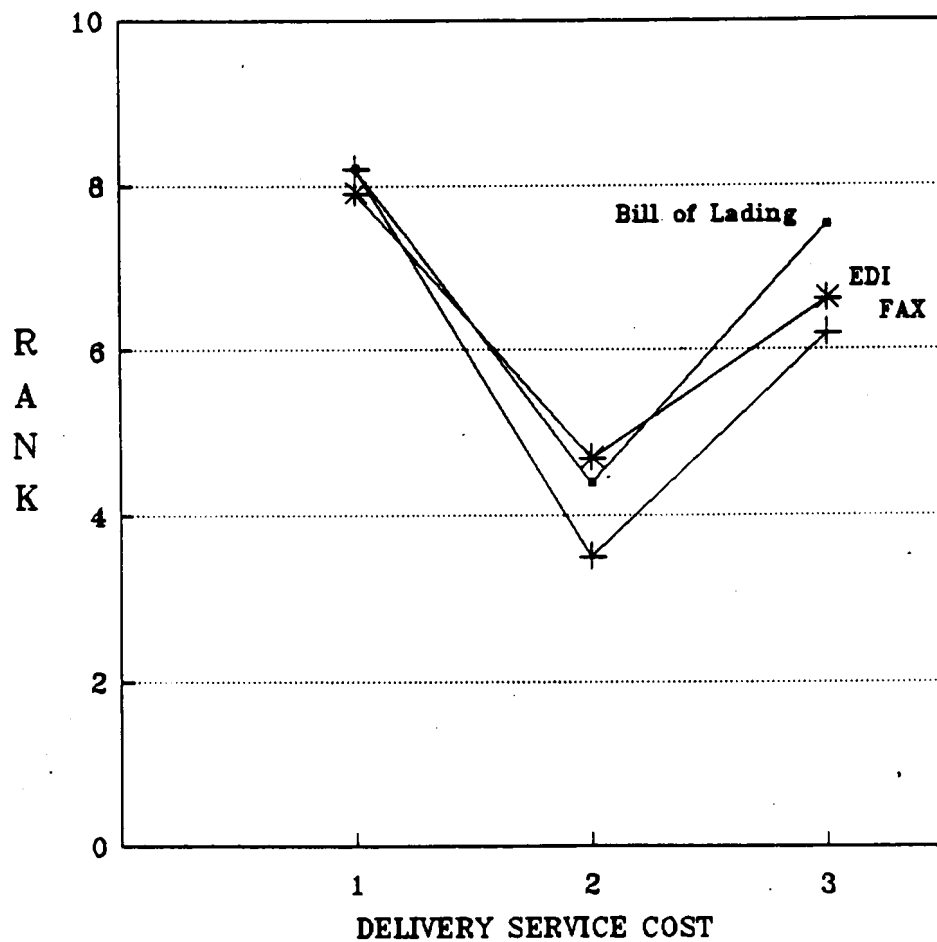
Attribute Level Preference
WAREHOUSE MANAGERS - Emergency Orders

($p=0.036$). Figure IV-10 shows that customers do not want any increase in price associated with order status communication. While the bill of lading is the preferred method of communication (mean preference = 8.92), the other two methods (FAX and electronic communication) are also clearly valued (7.86 and 8.20, respectively).

Promotional Orders - Buyers

The dependent variable, RANK, can be used to predict values of customer service delivery attributes for promotional orders ($F\text{-value}=2.31$, $p=0.034$). The R-square for this model is 0.60, and two attributes and their interaction are significant contributors of variation - order cycle length ($p=0.056$) and on-time requirement ($p=0.029$). Figure IV-11 indicates that 3 to 5 days is the most preferred length of order cycle, while 7 to 10 days is the least preferred. Clearly the greatest utility for the firm is to move to a shorter order lead time. The average utility rank for the on-time requirement indicates that the categories are not well defined (Figure IV-12). This is demonstrated by the fact that ± 1 hour on-time requirement has the highest rank but yet its score is 2. The low preference ratings for all the categories indicates a dissatisfaction with the choices. Further analysis of the survey data (Research Objective 3) expands this topic.

The on-time requirement/order cycle length interaction ($p=0.071$) indicates that as the order cycle length increases, customers view the on-time requirement more critically. For example, a 2-day order cycle will accept an on-time variance



1 = no change in price
 2 = increase in price
 3 = shared cost - special delivery opts

Figure IV-10

Attribute Level Interaction
 WAREHOUSE MANAGERS - Emergency Orders

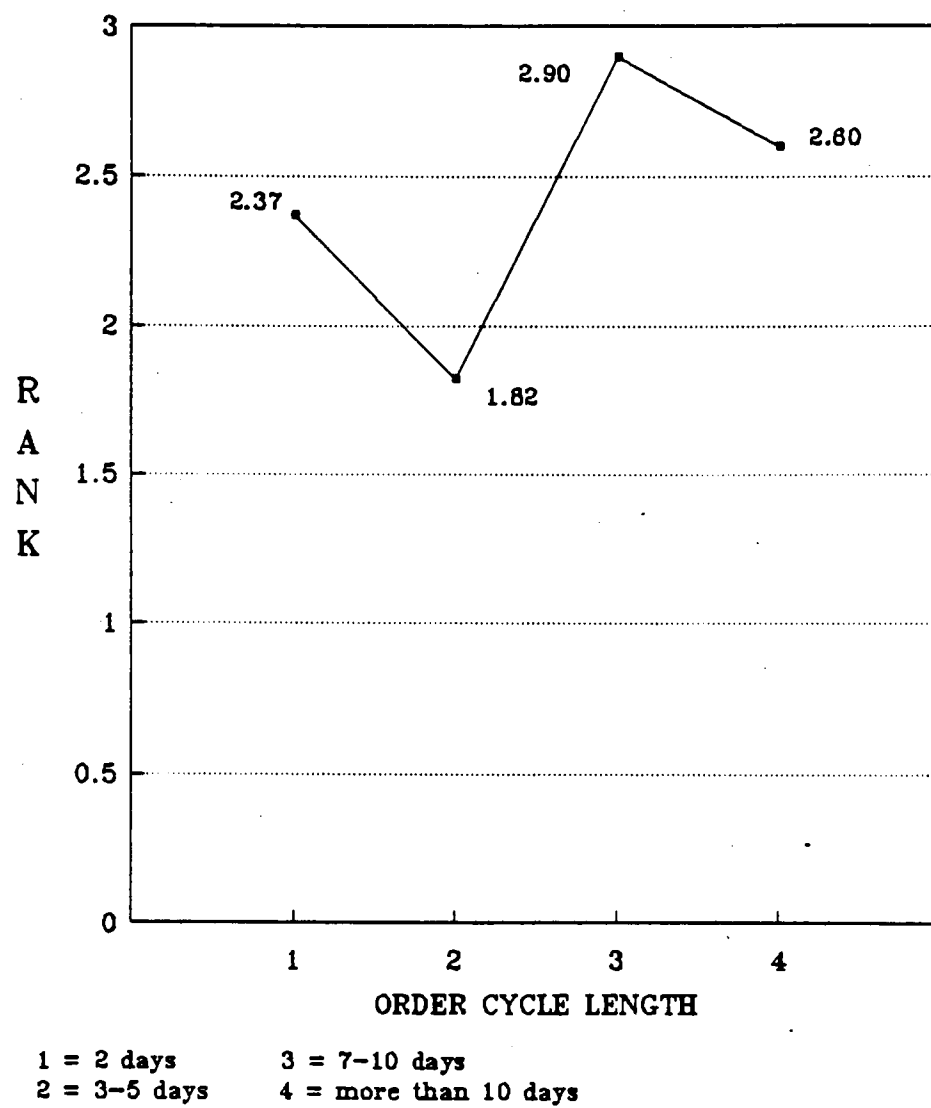


Figure IV-11

Attribute Level Preference
BUYER - Promotional Orders

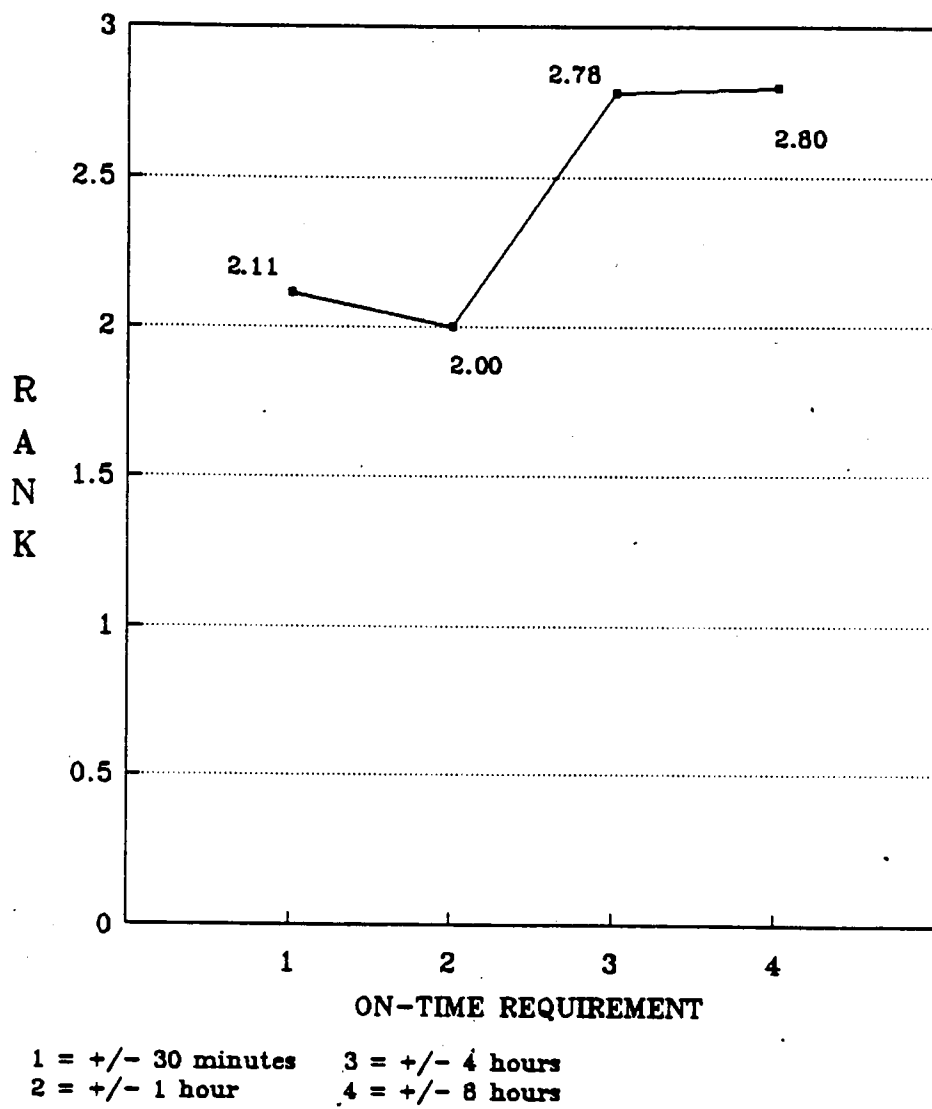


Figure IV-12

Attribute Level Preference
BUYER - Promotional Orders

of +/- 8 hours while a 3 to 5 day order cycle customer does not find this variance acceptable (average utility = 2.5 versus 2.0). Due to previously discussed problems with the levels of the on-time attribute, further analysis or plots were not developed.

The customer service delivery attributes, order cycle length and on-time requirement, are also significant for the RATE model ($p=0.019$ and $p=0.034$, respectively). In addition, the model produces similar test statistics to the RANK model for both the F-test and R-square ($F=2.36$, $p=0.031$, and $R\text{-square}=0.61$). The 3 to 5 day order cycle length has the highest preference rating among the choices, and the on-time requirement of preference is +/- 1 hour. There were no significant interactions for this model.

Promotional Orders - Warehouse

Neither model, RANK nor RATE, provided any evidence that they were useful in predicting values for specific settings of the customer service delivery attributes. The F-value and associated probabilities for each model is:

<u>Dependent variable</u>	<u>F-value</u>	<u>Pr > F</u>
RANK	1.61	0.109
RATE	1.30	0.241

No further analysis was conducted for these models.

Desirability Scores - Warehouse

When average scores are computed and used for determining and measuring customer requirements, a significant amount of information is lost. Instead the range can be used to effectively demonstrate the degree of service responsiveness needed by the organization. To derive these types of desirability scores, respondents were asked to designate both the preferred and unacceptable level of service across the various attributes. The following tabular results represent the summation across individuals for that attribute; accompanying graphs report the percentage of respondents for each category (level) of service for either the acceptable or unacceptable demarcation.

The comparison of preferred and unacceptable customer service levels for promotional and emergency orders indicates that specifications do not vary significantly by market segment (Table IV-10). For example, grocery customers prefer orders to be delivered on the "exact" time for both promotional and emergency orders. The range of acceptability for on-time extends to +/- 2 to 3 hours for both the grocery and the non-grocery segment. The range for measuring the conformance to specifications is reported at a minimum of +/- 15 minutes to the extent of +/- 4 hours. This large time span indicates a "window" of conformance.

The data presented in Figure IV-13 show that the "target" on-time delivery is exact time, and more than seventy percent of the customers prefer the on-time delivery to be 30 minutes or less either early or late. Warehouse managers seem

Table IV-10

Comparison of On-Time Requirements by Market
Segment and Order Type

WAREHOUSE

	Grocery	Non-grocery
PROMOTIONAL ORDERS		
Preferred range		
Minimum	exact time	exact time
Maximum	+/- 2 hours	+/- 2 hours
Unacceptable range		
Minimum	+/- 15 minutes	+/- 15 minutes
Maximum	+/- 4 hours	+/- 4 hours
EMERGENCY ORDERS		
Preferred range		
Minimum	exact time	exact time
Maximum	+/- 3 hours	+/- 2 hours
Unacceptable range		
Minimum	+/- 15 minutes	+/- 30 minutes
Maximum	+/- 4 hours	+/- 4 hours

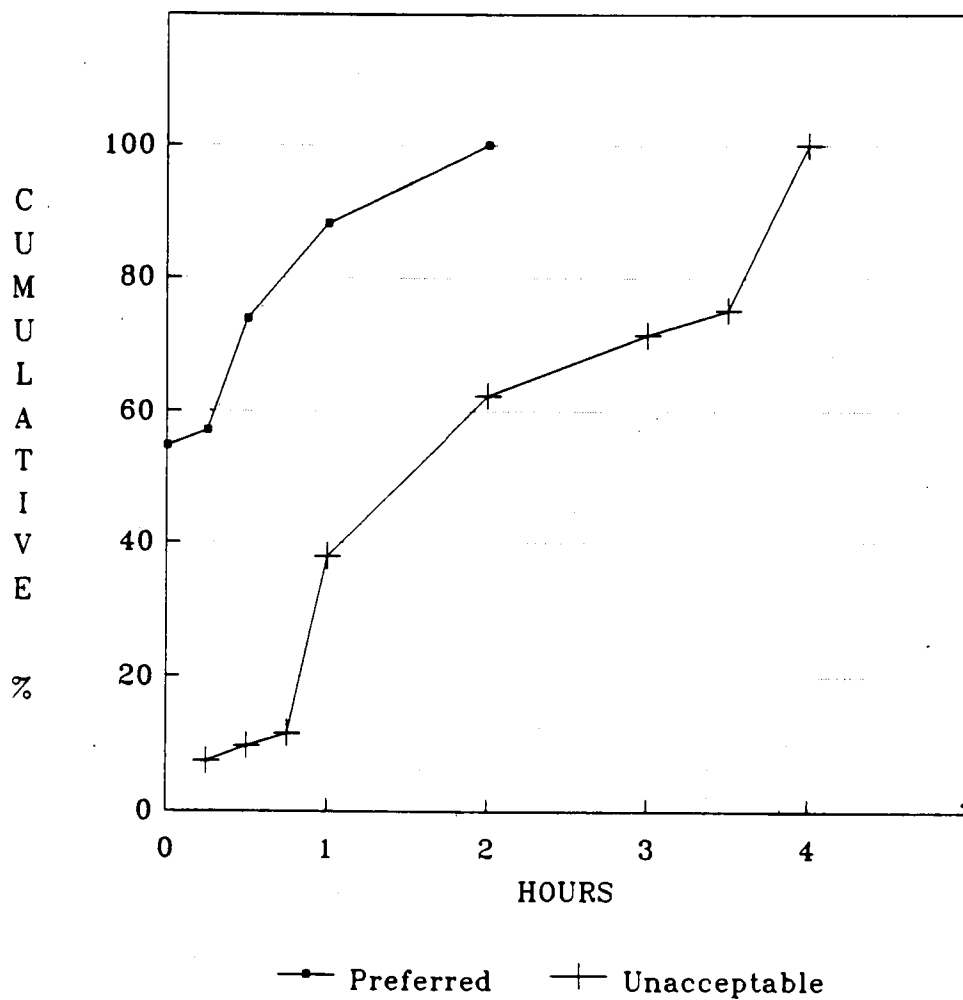


Figure IV-13

On-Time Delivery Specifications
Promotional Orders - WAREHOUSE

to be less sensitive to on-time delivery of emergency orders as evidenced by the proportion of respondents (7 percent) that indicated +/- 2 hours or more is acceptable (Figure IV-14). Further research is necessary to determine why the difference between type of order exists.

The non-grocery market segment for promotional orders requires tighter damage control than the grocery segment - 99 percent non-damaged versus 97 percent, respectively (Table IV-11). No variance in preference is indicated for any segmentation of emergency orders. The industry standard is clearly designated at 10 percent or more damage being unacceptable. Over sixty percent of all customers want "zero defects" (Figure IV-15 and Figure IV-16). The critical value appears to be 95 percent undamaged; less than 20 percent of the customers are satisfied beyond this level. Appendix B contains detailed frequency analysis for each of the above customer service delivery attributes.

Desirability Scores - Buyers

Preferred and unacceptable measures were collected for three attributes - completeness of shipments, length of order cycle, and on-time requirement - for the buyer sample. The data indicate (Table IV-12) that no significant variance occurs between market segments for a given order type. For example, both grocery and non-grocery customers prefer shipments to be 95 percent or more complete for promotional orders. Any order less than 80 percent complete is

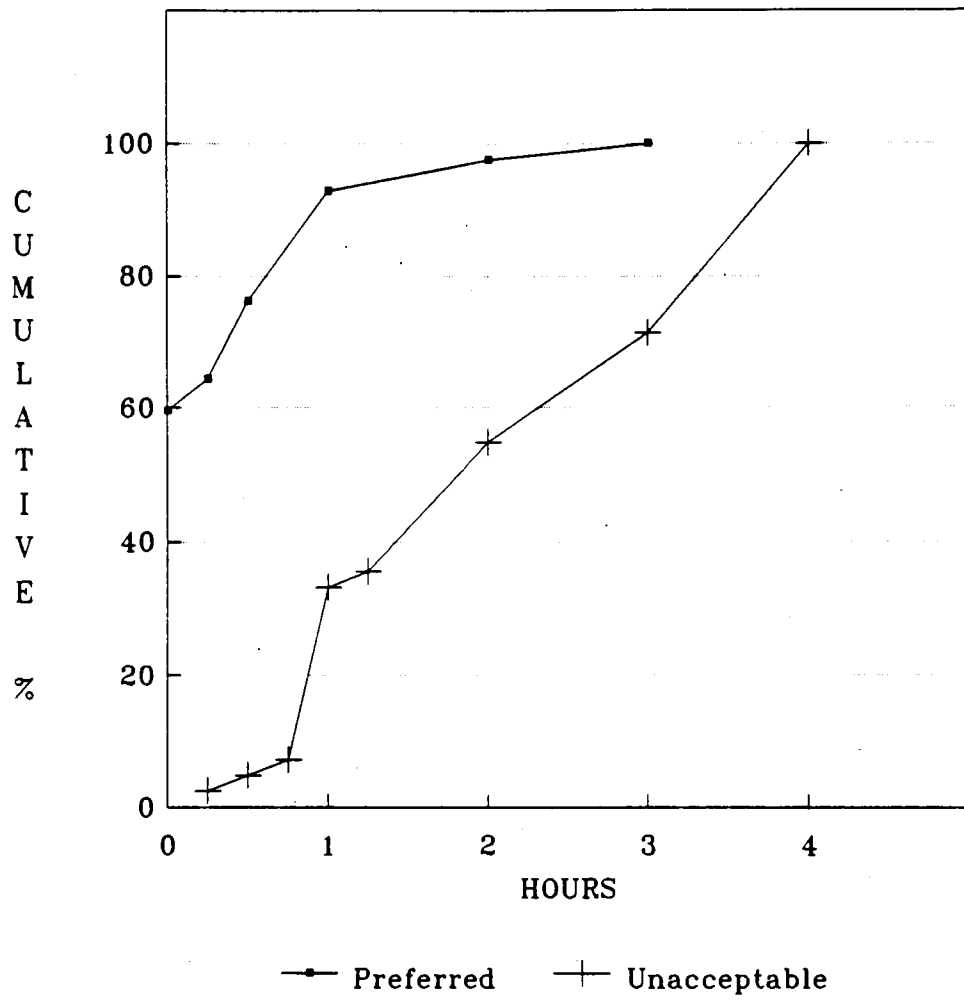


Figure IV-14

On-Time Delivery Specifications
Emergency Orders - WAREHOUSE

Table IV-11

Comparison of Damage Requirements by Market
Segment and Order Type

WAREHOUSE

	Grocery	Non-grocery
PROMOTIONAL ORDERS		
Preferred range		
Minimum	97	99
Maximum	100	100
Unacceptable range		
Minimum	0	0
Maximum	10	10
EMERGENCY ORDERS		
Preferred range		
Minimum	97	97
Maximum	100	100
Unacceptable range		
Minimum	0	0
Maximum	10	10

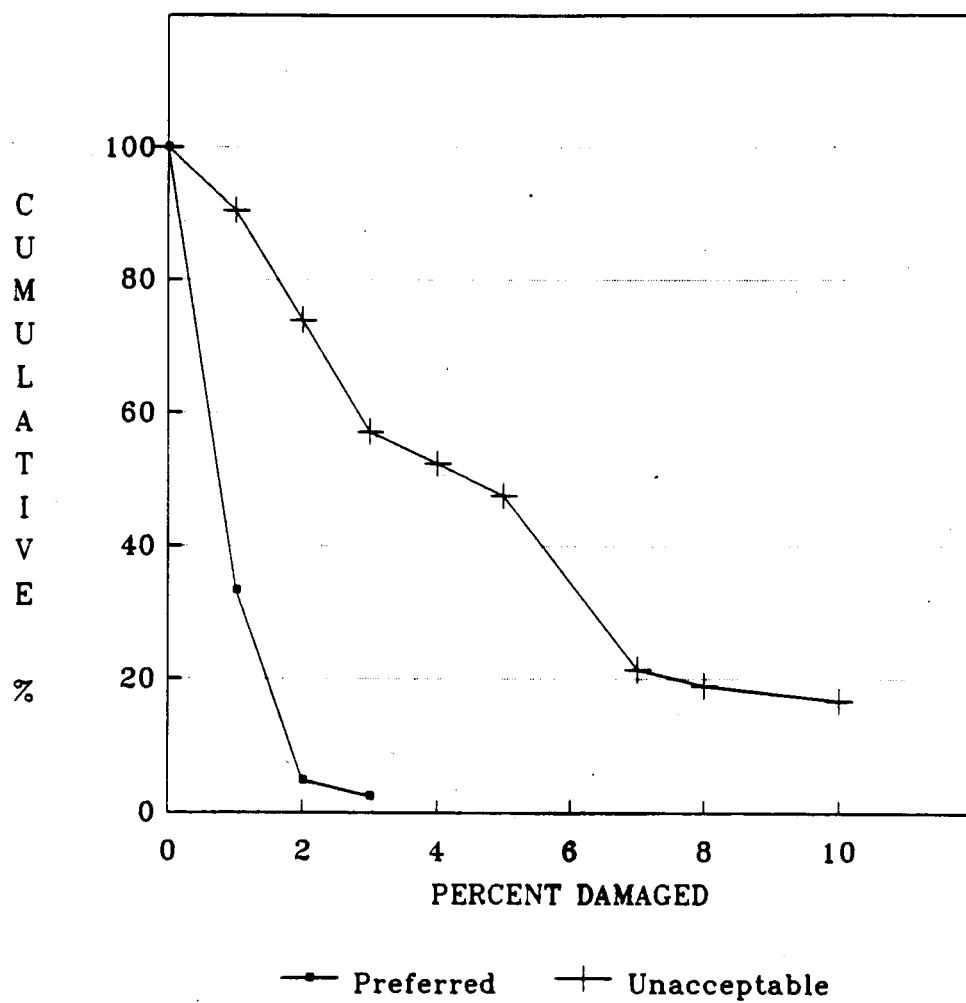


Figure IV-15

Damage Control Specifications
Promotional Orders - WAREHOUSE

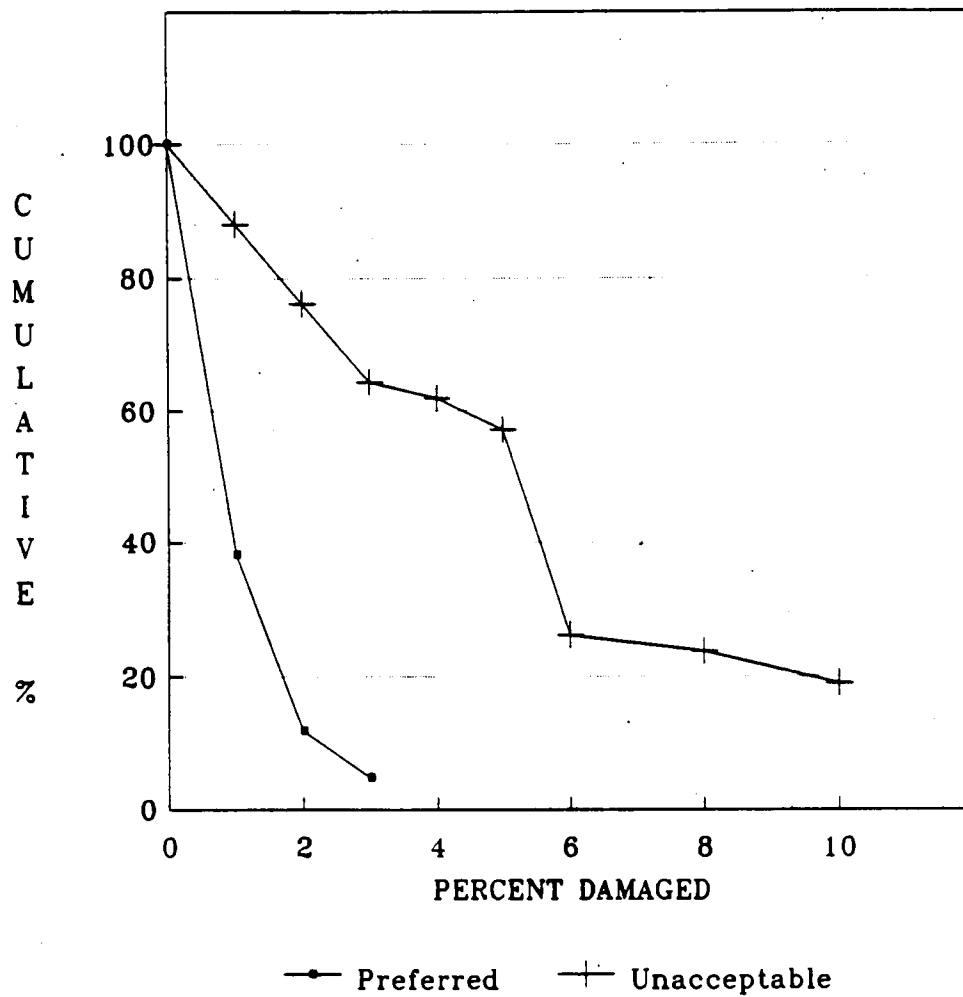


Figure IV-16
Damage Control Specifications
Emergency Orders - WAREHOUSE

Table IV-12

Comparison of Completeness of Shipments by Market
Segment and Order Type
(percent complete)

BUYER

	Grocery	Non-grocery
PROMOTIONAL ORDERS		
Preferred range		
Minimum	96	95
Maximum	100	100
Unacceptable range		
Minimum	80	80
Maximum	98	98
EMERGENCY ORDERS		
Preferred range		
Minimum	90	90
Maximum	100	100
Unacceptable range		
Minimum	80	80
Maximum	100	100

unacceptable, and even for some customers anything below 98 percent is unacceptable.

Emergency orders are less accepting of lack of completeness than promotional orders. This can be seen by the end points of the preferred and unacceptable ranges which are both 100 percent. However, the preferred range is smaller for promotional orders than emergency orders. Much of this can be explained by the fact that customers spend a considerable amount of time and resources planning and implementing a promotional effort. Therefore, a smaller range of acceptability exists (maximum preferred = 100 percent, minimum preferred = 96 percent) for this type of order. Eighty percent or less completeness of shipment is not acceptable irregardless of order type or market segment.

The sensitivity to completeness of shipments by order type is also shown in Figure IV-17 and Figure IV-18. Buyers expect that promotional orders will be 95 percent complete. This represents a 5 percent increase in requirement versus the preferred completeness for emergency orders. However, the largest proportion of buyers also require 100 percent completeness of shipments for emergency orders.

The preferred order cycle for promotional and emergency orders is less than 2 days (or 48 hours) for both the grocery and non-grocery market segments (Table IV-13). The defined end point for the emergency order cycle is considerably shorter than the promotional order cycle (3 days versus more than 10 days). It is therefore extremely interesting to note that the preferred order cycles

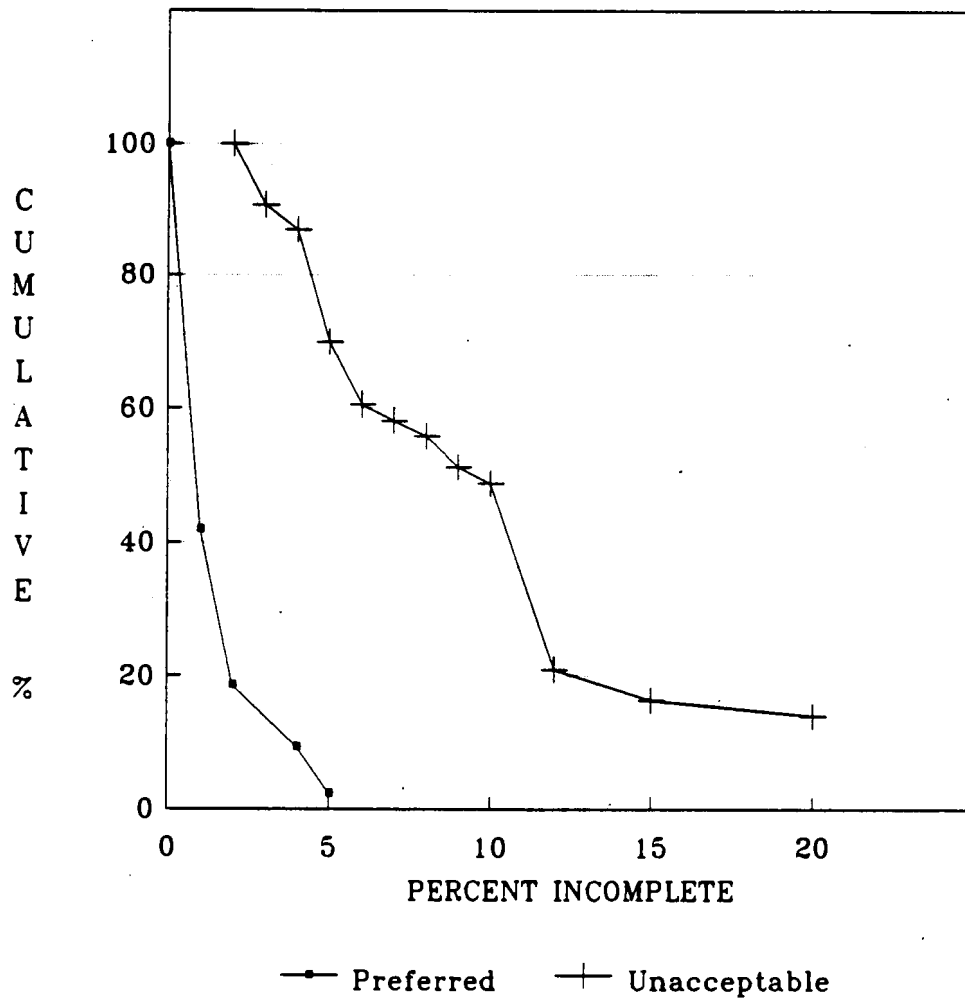


Figure IV-17

Completeness of Shipments
Promotional Orders - BUYER

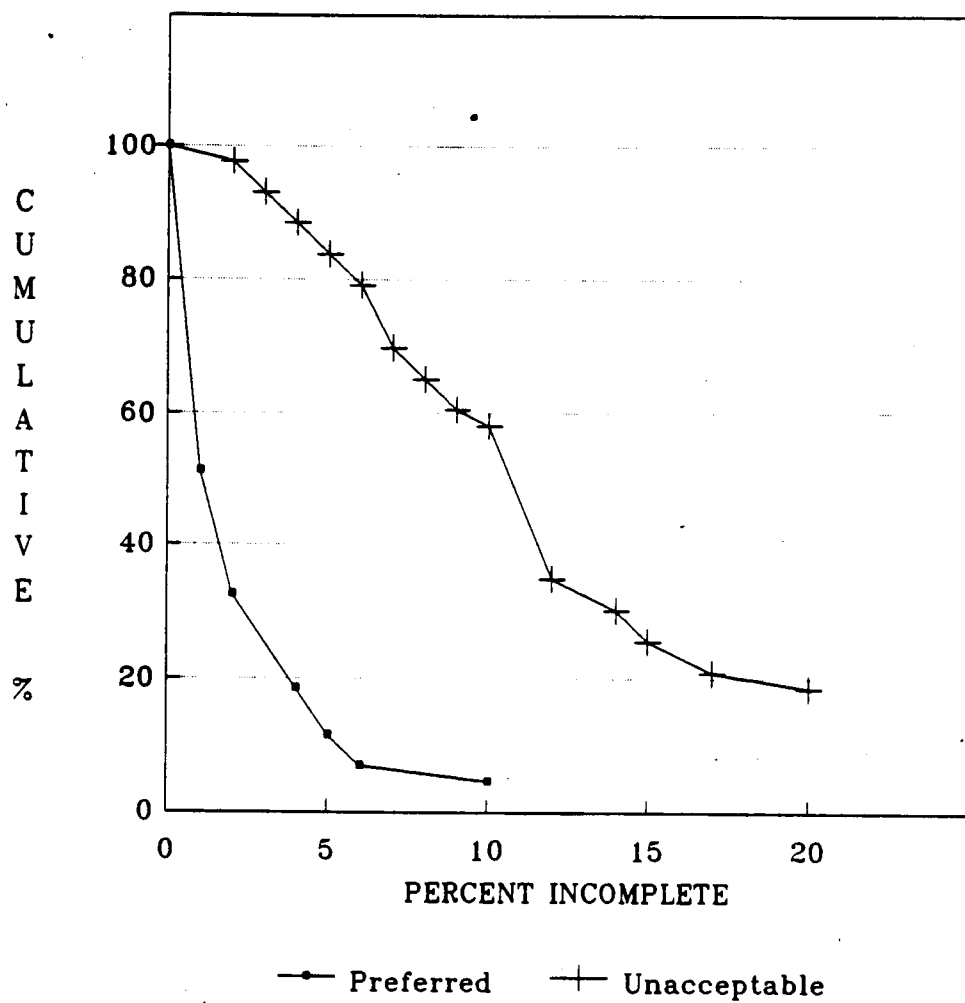


Figure IV-18
Completeness of Shipments
Emergency Orders - BUYER

Table IV-13

Comparison of Length of Order Cycle by Market
Segment and Order Type

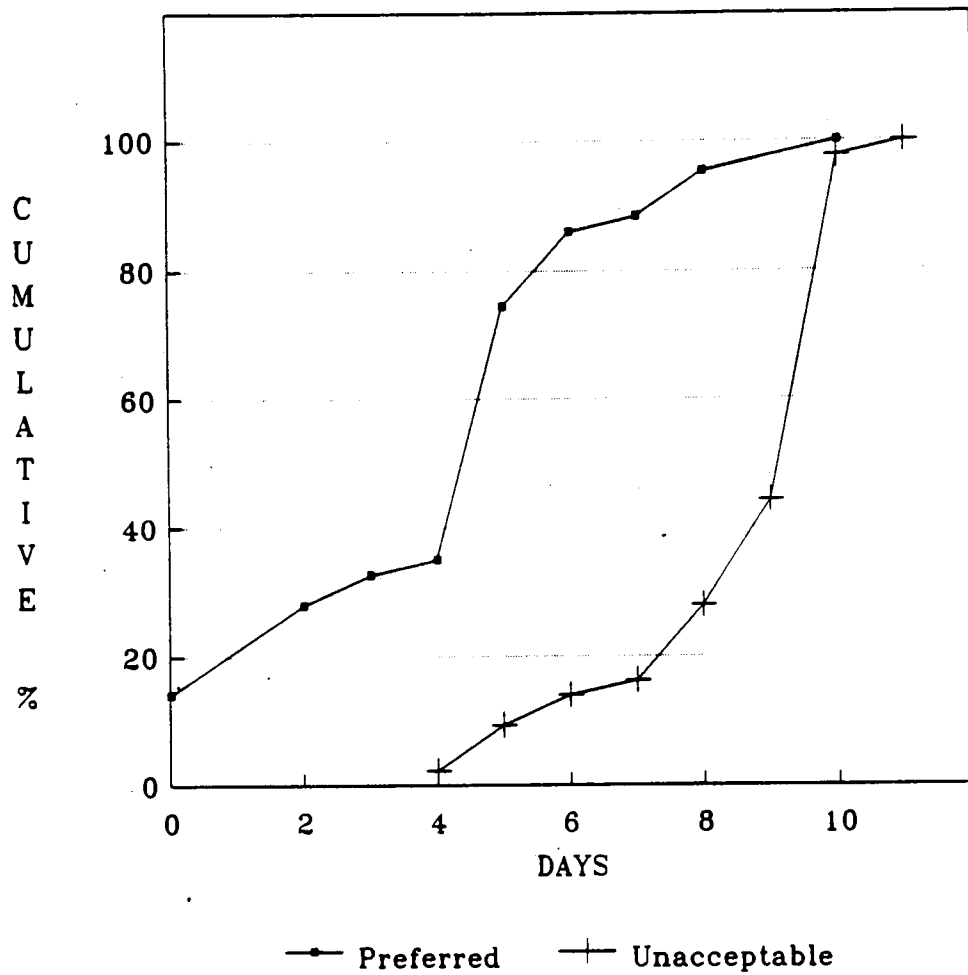
BUYER

	Grocery	Non-grocery
PROMOTIONAL ORDERS		
Preferred range		
Minimum	less than 2 days	less than 2 days
Maximum	10 days	10 days
Unacceptable range		
Minimum	4 days	5 days
Maximum	10 days	more than 10 days
EMERGENCY ORDERS		
Preferred range		
Minimum	less than 48 hrs	less than 48 hrs
Maximum	2 days	2.5 days
Unacceptable range		
Minimum	48 hrs	48 hrs
Maximum	3 days	3 days

for both are the same. The differences in order cycle by market segment and order type occurs in the unacceptable scores. Promotional orders are more tolerant of longer order cycles than emergency orders - 10 days as compared to 2-3 days.

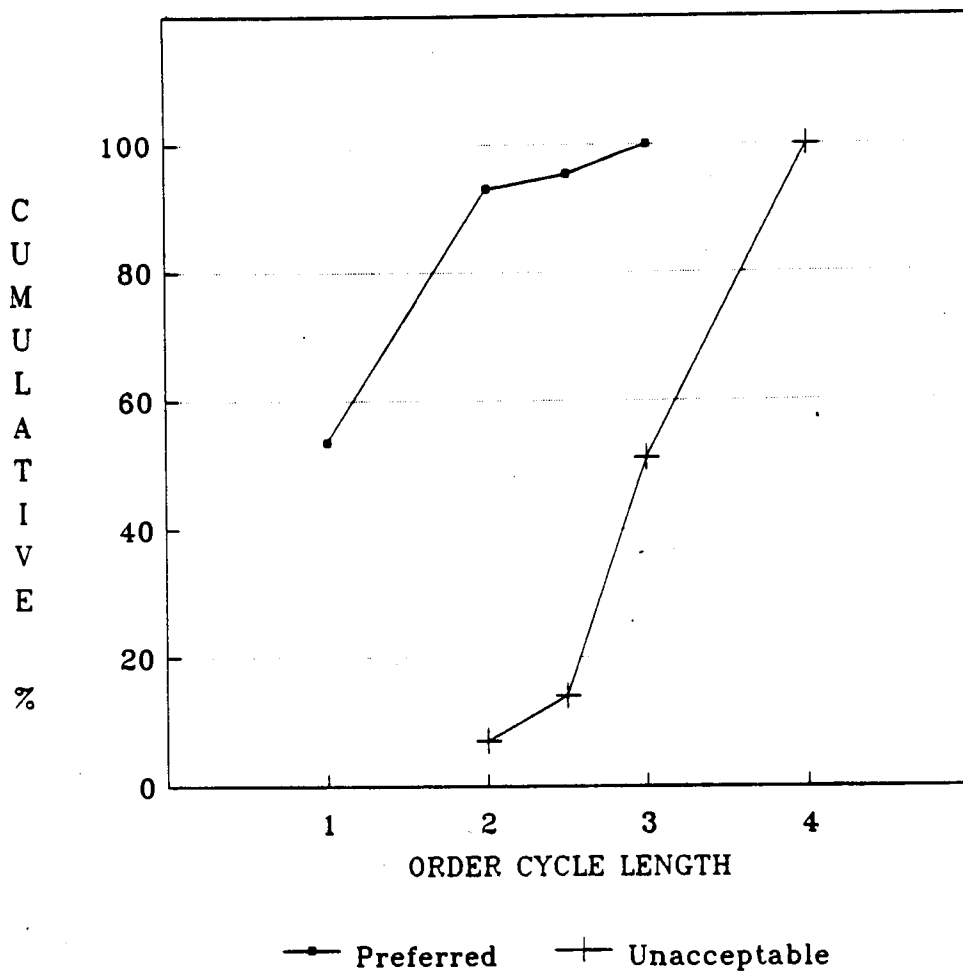
The preferred order cycle length for the majority of buyers for promotional orders is 5 days (39.5 percent of the sample). The greatest benefit (utility) to the firm can be gained by moving from a 5-day order cycle to a 4-day order cycle (Figure IV-19). For emergency orders, however, the largest benefit is gained by moving from a 48-hour order cycle to less than 48 hours (Figure IV-20). Ninety-three percent of all buyers prefer that the lead time for emergency orders be less than 48 hours. The sensitivity to order cycle length is also reflected by the fact that more than half of the buyers find 2 1/2 days an unacceptable order lead time.

Desirability scores for the on-time requirement confirmed an earlier hypothesis that delivery "windows" (defined by any tolerance greater than +/- 15 minutes) are being replaced by "on-target" requirements. In fact, data presented in Table IV-14 indicate that some emergency orders have no tolerance associated with the on-time specification. This is particularly true for the grocery segment. Promotional orders in general appear to have a larger window of acceptance for on-time delivery; in most cases this is +/- 8 hours. Figure IV-21 shows that the largest gain in utility can be gotten by keeping the maximum on-time variance at +/- 4 hours versus +/- 5 hours for promotional orders. Conversely, the maximum



0 = LESS THAN 2 DAYS
11 = MORE THAN 10 DAYS

Figure IV-19
Order Cycle Length Specifications
Promotional Orders - BUYER



1 = < 48 HOURS 3 = 72 HOURS
2 = 48 HOURS 4 = > 72 HOURS

Figure IV-20

Order Cycle Length Specifications
Emergency Orders - BUYER

Table IV-14

Comparison of On-Time Requirements by Market
Segment and Order Type

BUYER

	Grocery	Non-grocery
PROMOTIONAL ORDERS		
Preferred range		
Minimum	exact time	exact time
Maximum	+/- 8 hours	+/- 4 hours
Unacceptable range		
Minimum	+/- 30 minutes	+/- 1 hour
Maximum	+/- 8 hours	+/- 8 hours
EMERGENCY ORDERS		
Preferred range		
Minimum	exact time	exact time
Maximum	+/- 4 hours	+/- 2 hours
Unacceptable range		
Minimum	exact time	+/- 15 minutes
Maximum	+/- 4 hours	+/- 4 hours

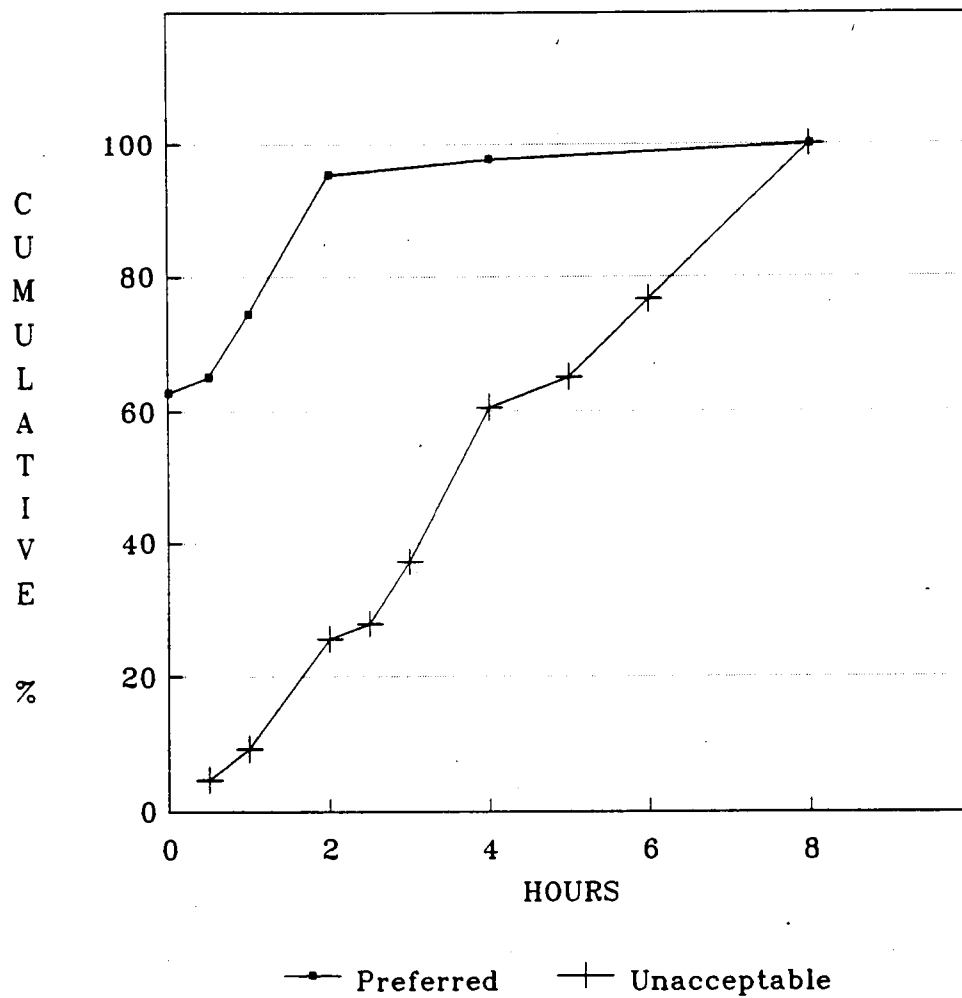


Figure IV-21

On-Time Delivery Specifications
Promotional Orders - BUYER

preferred benefit is gained by moving from an on-time delivery window of +/- 30 minutes to a target of exact time. The on-time specification preferred by approximately 50 percent of the buyers for emergency orders is exact time (Figure IV-22). In addition, with this on-target requirement is a smaller range of acceptable deviation in that some 65 percent of the buyers find 3 1/2 hours or less unacceptable.

Objective 2. To gain an understanding of the trade-offs that various customer groups (market segments) are willing to make among specified attributes.

Using Thurstone's law of comparative judgment, it was possible to develop a model that led to the construction of a uni-dimensional stimulus scale using the attribute data collected in Phase 1. Thurstone assumes that discriminant differences are normally distributed, i.e. the scale difference between the modal discriminial processes for any two stimuli represents the degree of separation assumed to be present on the individual's psychological scale. Through Phase 1 of the Customer Service Delivery Measures Survey, data were collected and assimilated concerning the proportion of times an attribute j is preferred to attribute k . The task necessary to achieve the research objective was to infer scale values from the frequency data developed on each attribute across all individuals.

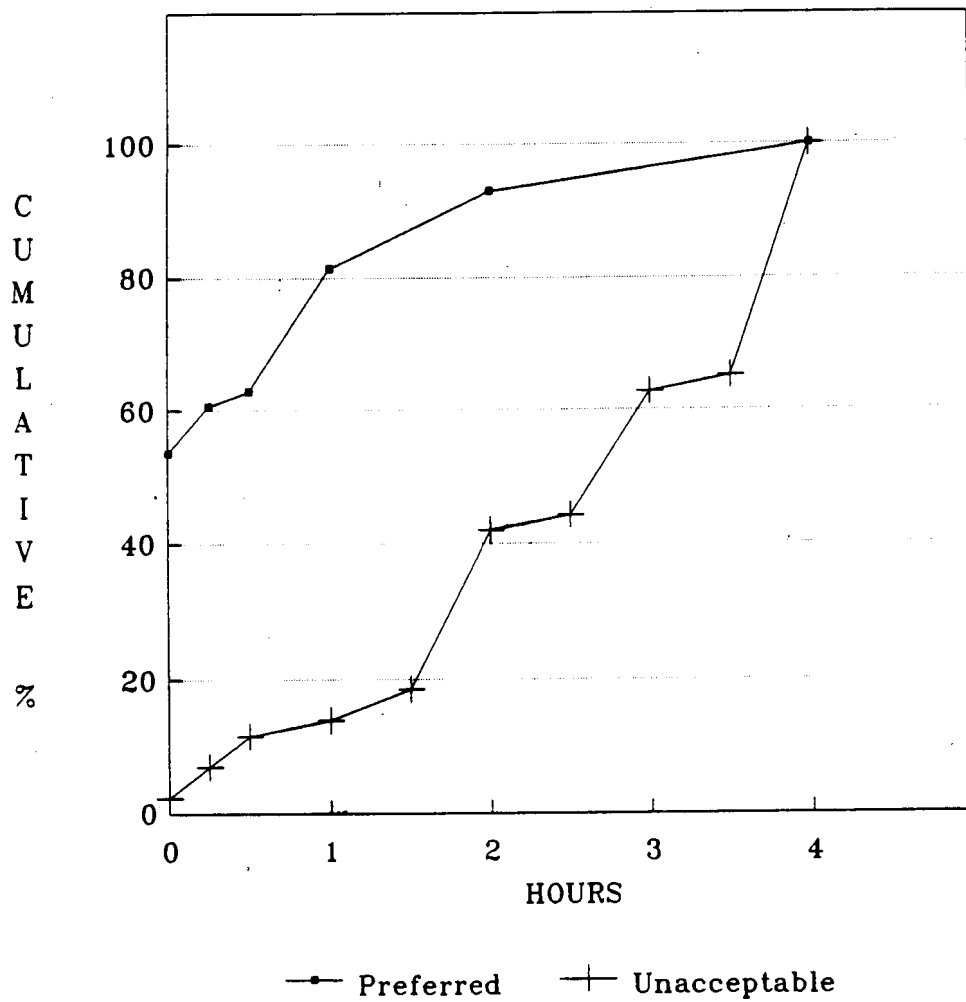


Figure IV-22
On-Time Delivery Specifications
Emergency Orders - BUYER

Assuming that the discriminial dispersions are equal and that correlation between the discriminial processes on the same set of judgments is equal or zero, Thurston's CASE V can be stated as:

$$R_j - R_k = Z_{jk}\sqrt{2}$$

where,

$R_j - R_k$ = a linear distance on the subject's psychological scale between attribute j and attribute k ,

Z_{jk} = standard (unit normal) variate associated with the observed proportion in which attribute j is preferred to attribute k .

It is also possible to "test" the law by computing predicted proportions and comparing these to observed proportions. The chi-square test is used to determine if the model represents a satisfactory description of the data. Because the ranking of parameters represents a one-way classification, in using the chi-square table only k , the number of categories, is pertinent rather than sample size n .

Warehouse Managers

The comparison of attribute rank by order type indicates a great deal of agreement concerning the importance of customer service delivery features (Table IV-15). Regular and promotional orders are identical with respect to attribute

Table IV-15

Comparison of Attribute Rank by Order Type

WAREHOUSE

Attribute	Regular orders	Promotional orders	Emergency orders
Length of order cycle	1*	1*	1*
On-time delivery	2	2*	2*
Completeness of shipments	3	3	3
Order status information	4	4	6
Damage control	5	5	4*
Upcharge for special delivery options	6	6	5
Unitized delivery	7	7	7

*Statistically significant for $\alpha = 0.05$.

rank; emergency orders, however, are more sensitive to damage control and upcharge for special delivery options. Given the speed in which emergency orders are processed and delivered, order status information does not rank high in importance.

This data, however, does not indicate if any significant differences exist between the attributes for their ranking. In order to determine this, proportional preferences between the various attributes were calculated. The preference difference between any two attributes is calculated as a ratio of the frequency of choice matrix. The frequency matrix can also be used to derive the percentage contribution to quality perception. As the data show, length of order cycle is the critical attribute for warehouse regular orders (Table IV-16). The largest proportional difference in preference among customer service delivery attributes as defined by warehouse managers occurs between length of order cycle and on-time delivery.

Table IV-17 shows that 80 percent of the customers rated length of order cycle more important than on-time delivery, or conversely, that only 20 percent of the warehouse managers perceive on-time delivery to be more important than length of order cycle. The proportional preference for on-time delivery to completeness of shipments is 0.43, i.e. forty-three percent of the respondents report that on-time delivery is more important than completeness of shipments. Comparing length of order cycle to completeness of shipments, 60 percent of the warehouse managers ranked length of order cycle as more important.

Table IV-16
Contribution and Difference Among Attributes for
Regular Orders

WAREHOUSE

Attribute	Frequency matrix	Percentage contribution to quality perception	Difference in preference (ratio)
Length of order cycle	202.0	19.6	1.9
On-time delivery	173.0	16.8	1.2
Completeness of shipments	154.0	14.9	0.9
Order status information	138.5	13.4	0.3
Upcharge for special delivery options	134.0	13.0	0.7
Damage control	124.5	12.0	1.3
Unitized delivery	103.0	10.0	

Table IV-17

Attribute Proportional Preference for Regular Orders

WAREHOUSE

Attribute	4	7	5	6	3	2	1
4	-	0.57	0.62	0.62	0.64	0.80	0.80
7	0.43	-	0.49	0.45	0.62	0.80	0.80
5	0.38	0.51	-	0.54	0.57	0.60	0.70
6	0.38	0.55	0.46	-	0.52	0.60	0.70
3	0.36	0.38	0.43	0.48	-	0.60	0.60
2	0.21	0.24	0.36	0.38	0.43	-	0.80
1	0.19	0.21	0.33	0.33	0.38	0.20	-

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized delivery
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

To derive scale values for each of the customer service delivery attributes, Z-values related to reference proportions were calculated. If the proportion is less than 0.5, the Z-value carries a negative sign. Conversely, if the proportion is greater than 0.5, the Z-value carries a positive sign. The Z-values in this context are merely taken from a standard unit normal curve and are associated with a given proportion of a total area under the curve. The Z-value tables for the various groupings (warehouse versus buyer, by order type and market segment) are presented in Appendix C.

Scale values are obtained by means of the following relationship:

let R_j = scale value of stimulus j

R_k = scale value of any other stimulus k

then by definition:

$$R_j - R_k = Z_{jk} \sqrt{2}$$

$$nR_j - R_k = \sqrt{2} \sum Z_{jk} \quad (\text{sum over all stimuli})$$

$$R_k = 0 \quad (\text{set mean of all stimuli arbitrarily at zero, since only interval scale is assumed})$$

then:

$$nR_j = \sqrt{2} \sum Z_{jk}$$

$$R_j = \frac{\sqrt{2}}{n} \sum Z_{jk}$$

By substituting the Z-value score in the previous equation, it is possible to get scale values for each of the attributes. These values are plotted and presented in Figure IV-23. This presentation of the data represents another way in which the proportional difference in rank (preference) can be shown. The scale has an arbitrary zero point and is unique only up to a positive linear transformation. The scale values and their associated predicted values (identified as the factor prime) are presented in Appendix C. The purpose of this "test" is to determine if the predicted and observed proportions are in accord with each other.

Another method for determining if the model represents a satisfactory description of the data is the chi-square test. As Table IV-18 indicates, the model is able to predict proportions for scores related to regular orders for warehouse managers. The selected critical value of alpha has been chosen to be 0.05; at this level of significance, the model fits the data. This value will be used for all subsequent analysis to determine "goodness of fit."

The least significant difference method was used to judge the contrasts of scores. As shown in Table IV-18, only one attribute - length of order cycle - is significantly different from the other attributes in terms of importance. For regular orders, warehouse managers do not distinguish a difference in importance in the following "groupings" of attributes:

- o on-time delivery/completeness of shipments;

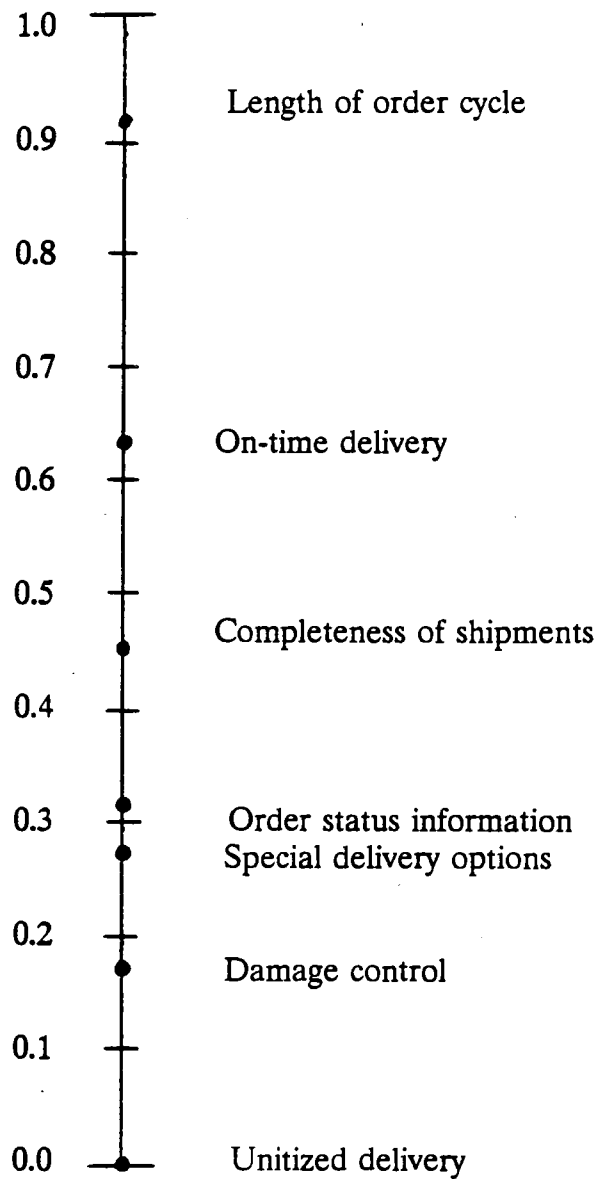


Figure IV-23
Derived Internal Scale of Preference for Regular Orders

WAREHOUSE

Table IV-18

Methods for Judging Contrasts of Scores for Regular Orders

WAREHOUSE

Chi-Square Goodness of Fit Test

$$\chi^2 = 11.6816$$

$$Z\text{-value} = -0.5516$$

$$\chi^2 = 12.59$$

$$p = 0.291$$

H_0 : Observed frequencies are consistent with those expected under application of the model.

Evaluation : Do not reject the null hypothesis; output is in agreement with the actual frequencies.

Least Significant Difference Method

critical difference = 22.5, giving the ordering:

<u>Attribute</u>						
4	7	5	6	3	2	1

Any attribute whose scores are not underlined by the same line may be considered distinguishably different.

- o completeness of shipments/upcharge for special delivery options/
damage control;
- o upcharge for special delivery options/unitized delivery/
damage control; and
- o damage control/unitized delivery.

While warehouse managers placed significantly more emphasis on length of order cycle for regular orders than promotional orders (202 versus 199 frequency count), this attribute accounted for a larger contribution to the quality perception for promotional orders (Table IV-19). Restated, approximately 30 percent of the customers view these attributes as being more important than length of order cycle. These findings were similar to the warehouse managers (Table IV-17).

As Table IV-20 indicates, the proportional preference for length of order cycle over on-time delivery, completeness of shipments, and order status information, is the same. However, as the derived interval scale indicates, both length of order cycle and on-time delivery are distinguishably different attributes in terms of their importance for promotional orders (Figure IV-24). This graph also shows that the remaining attributes - order status information, completeness of shipments, damage control, upcharge for special delivery options, and unitized delivery - are not statistically different as indicated by the closer grouping of preference scores.

This result is confirmed by the least significant difference test (Table IV-21) which shows that the following attributes are not distinguishable:

Table IV-19
Contribution and Difference Among Attributes for
Promotional Orders

WAREHOUSE

Attribute	Frequency matrix	Percentage contribution to quality perception	Difference in preference (ratio)
Length of order cycle	199.0	20.3	1.2
On-time delivery	171.0	17.4	1.2
Completeness of shipments	114.0	14.4	1.0
Order status information	140.5	14.3	1.1
Damage control	126.5	12.9	1.2
Upcharge for special delivery options	110.0	11.2	1.2
Unitized delivery	92.0	9.3	

Table IV-20

Attribute Proportional Preference for Promotional Orders

WAREHOUSE

Attribute	4	5	7	6	3	2	1
4	-	0.52	0.70	0.70	0.65	0.80	0.90
5	0.47	-	0.60	0.57	0.62	0.70	0.80
7	0.30	0.40	-	0.51	0.60	0.80	0.80
6	0.30	0.42	0.49	-	0.47	0.60	0.70
3	0.35	0.37	0.40	0.52	-	0.60	0.70
2	0.22	0.27	0.25	0.37	0.35	-	0.70
1	0.15	0.25	0.22	0.37	0.32	0.30	-

1 = Length of order cycle

2 = On-time delivery

3 = Completeness of shipments

4 = Unitized delivery

5 = Upcharge for special delivery options

6 = Order status information

7 = Damage control

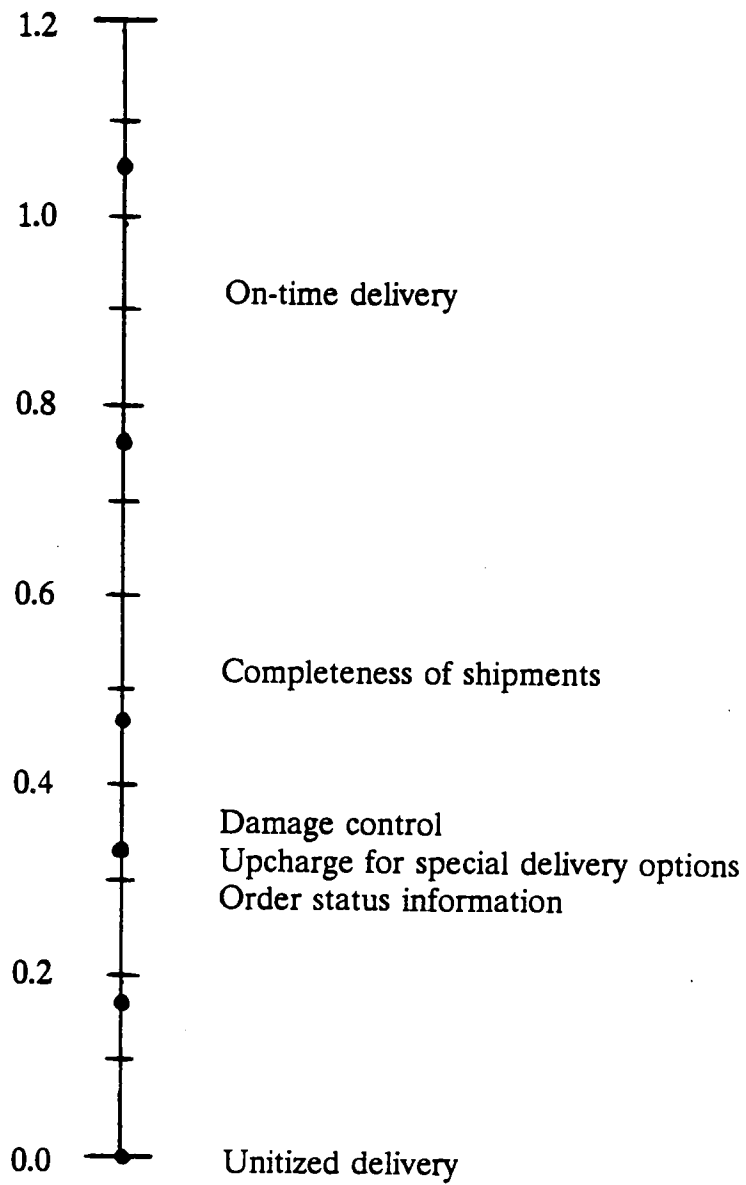


Figure IV-24
Derived Internal Scale of Preference for Promotional Orders

WAREHOUSE

Table IV-21

Methods for Judging Contrasts of Scores for Promotional Orders

WAREHOUSE

Chi-Square Goodness of Fit Test

$$\chi^2 = 9.3277$$

$$Z\text{-value} = -1.0660$$

$$\chi^2 = 12.59$$

$$p = 0.142$$

H_0 : Observed frequencies are consistent with those expected under application of the model.

Evaluation : The model does represent a satisfactory description of the data.

Least Significant Difference Method

critical difference = 21.97, giving the ordering:

<u>Attribute</u>						
4	5	7	6	3	2	1

Any attribute whose scores are not underlined by the same line may be considered distinguishably different.

- o completeness of shipments/order status information/
damage control;
- o damage control/upcharge for special delivery options; and
- o upcharge for special delivery options/unitized delivery.

Just as with regular orders, the chi-square goodness of fit test indicates that the predicted proportions of the model are consistent with observed frequencies (Table IV-21).

Length of order cycle is extremely important for emergency orders. In addition to its major contribution to quality perception (Table IV-22), length of order cycle accounts for a consistent proportional preference (80 percent) when compared to the all the other customer service delivery attributes except for unitized delivery (Table IV-23). The criticality of length of order cycle can be evaluated by reviewing the proportional preferences for promotional orders where 70 percent was the reported statistic for three of the seven attributes.

Irregardless of order type, unitized delivery ranked lowest in terms of importance. As Figure IV-25 indicates (as well as the previous two interval scales of preference), the scale value for unitized delivery is zero. Furthermore, the graphical representation of scale values for emergency orders shows that damage control, upcharge for special delivery options, and order status information are almost of equal importance to the warehouse manager.

In addition, the plot suggests that length of order cycle, on-time delivery, and unitized delivery are distinguishably different from the other customer service

Table IV-22
Contribution and Difference Among Attributes for
Emergency Orders

WAREHOUSE

Attribute	Frequency matrix	Percentage contribution to quality perception	Difference in preference (ratio)
Length of order cycle	209.5	21.9	1.2
On-time delivery	173.5	16.8	1.3
Completeness of shipments	137.5	14.4	1.1
Damage control	123.0	12.9	1.1
Upcharge for special delivery options	114.5	12.0	1.0
Order status information	111.0	11.6	1.3
Unitized delivery	103.0	10.0	

Table IV-23

Attribute Proportional Preference for Emergency Orders

WAREHOUSE

Attribute	4	6	5	7	3	2	1
4	-	0.62	0.62	0.64	0.67	0.80	0.90
6	0.38	-	0.51	0.60	0.64	0.70	0.80
5	0.38	0.49	-	0.56	0.62	0.70	0.80
7	0.36	0.40	0.44	-	0.62	0.70	0.80
3	0.33	0.36	0.38	0.38	-	0.70	0.80
2	0.15	0.28	0.26	0.26	0.28	-	0.80
1	0.10	0.21	0.23	0.21	0.21	0.20	-

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized delivery
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

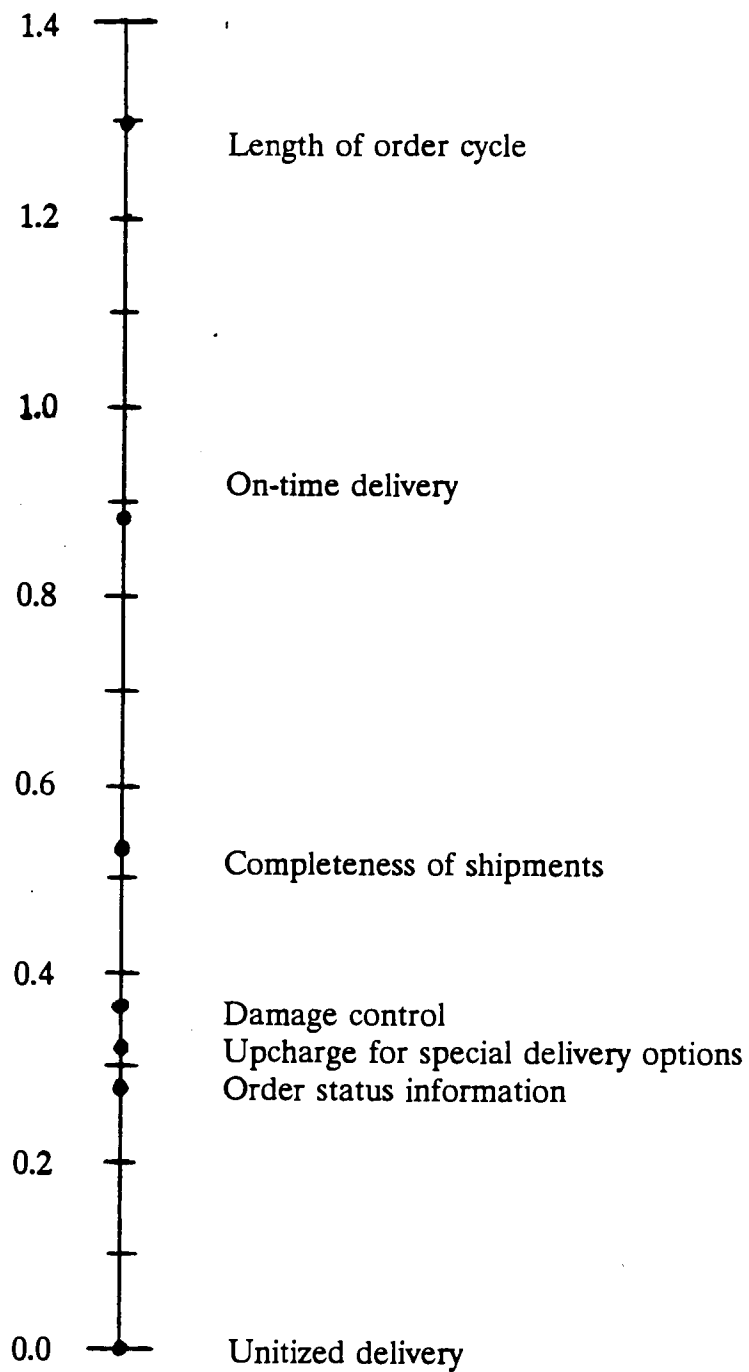


Figure IV-25
Derived Internal Scale of Preference for Emergency Orders

WAREHOUSE

delivery attributes. This hypothesis is confirmed by the least significant difference method for judging contrasts of scores (Table IV-24). Because the measure of variation between the predicted and actual frequencies is low, the fit of the model is good. The model's output appears to be statistically in agreement with the actual frequencies.

Buyers

The comparison of attribute rank by order type indicates that very little difference is present (Table IV-25). Except for the position of damage control and upcharge for special delivery options, these rankings are also very similar to warehouse managers (Table IV-15). The percentage contribution to quality perception is heavily weighted by three factors - length of order cycle, on-time delivery, and completeness of shipments. For regular orders, these factors account for almost 60 percent of the total importance scoring (Table IV-26). The proportional preference between length of order cycle, on-time delivery, and completeness of shipment is not as large as indicated by warehouse managers for regular orders (Table IV-27 and Table IV-17). The proportional preferences between these three factors (0.70 and 0.50, respectively) as ranked by buyers is shown in Figure IV-26; the scaling indicates that the interval preference between length of order cycle, on-time delivery, and completeness of shipments is approximately equal. This is also indicated by the proportional preferences of 0.70 and 0.50, respectively, for the three attributes (Table IV-27).

Table IV-24

Methods for Judging Contrasts of Scores for Emergency Orders

WAREHOUSE

Chi-Square Goodness of Fit Test

$$\chi^2 = 11.4509$$

$$Z\text{-value} = -0.5996$$

$$\chi^2 = 12.59$$

$$p = 0.274$$

H_0 : Observed frequencies are consistent with those expected under application of the model.

Evaluation : The measure of variation between the predicted and actual frequencies is low. The model does a good job of predicting proportions of preference.

Least Significant Difference Method

critical difference = 21.7, giving the ordering:

<u>Attribute</u>						
4	6	5	7	3	2	1
—						
	—					
		—				

Any attribute whose scores are not underlined by the same line may be considered distinguishably different.

Table IV-25

Comparison of Attribute Rank by Order Type

BUYER

Attribute	Regular orders	Promotional orders	Emergency orders
Length of order cycle	1	1*	1*
On-time delivery	2	2*	2
Completeness of shipments	3	3	3
Order status information	4	4	5
Upcharge for special delivery options	5	5	4
Damage control	6	7	7
Unitized delivery	7	6	6

*Statistically significant for $\alpha = 0.05$.

Table IV-26
Contribution and Difference Among Attributes for
Regular Orders

BUYER

Attribute	Frequency matrix	Percentage contribution to quality perception	Difference in preference (ratio)
Length of order cycle	219.5	21.9	1.1
On-time delivery	198.5	19.8	1.1
Completeness of shipments	180.5	18.0	1.5
Order status information	123.5	12.3	1.2
Damage control	107.5	10.7	1.2
Upcharge for special delivery options	93.5	9.3	1.1
Unitized delivery	81.5	8.1	

Table IV-27

Attribute Proportional Preference for Regular Orders

BUYER

Attribute	4	5	7	6	3	2	1
4	-	0.49	0.68	0.68	0.78	0.90	1.00
5	0.51	-	0.63	0.56	0.76	0.90	0.90
7	0.32	0.37	-	0.61	0.78	0.90	0.90
6	0.32	0.44	0.39	-	0.68	0.80	0.90
3	0.22	0.24	0.22	0.32	-	0.50	0.60
2	0.07	0.12	0.12	0.20	0.49	-	0.70
1	0.49	0.12	0.07	0.15	0.41	0.30	-

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized delivery
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

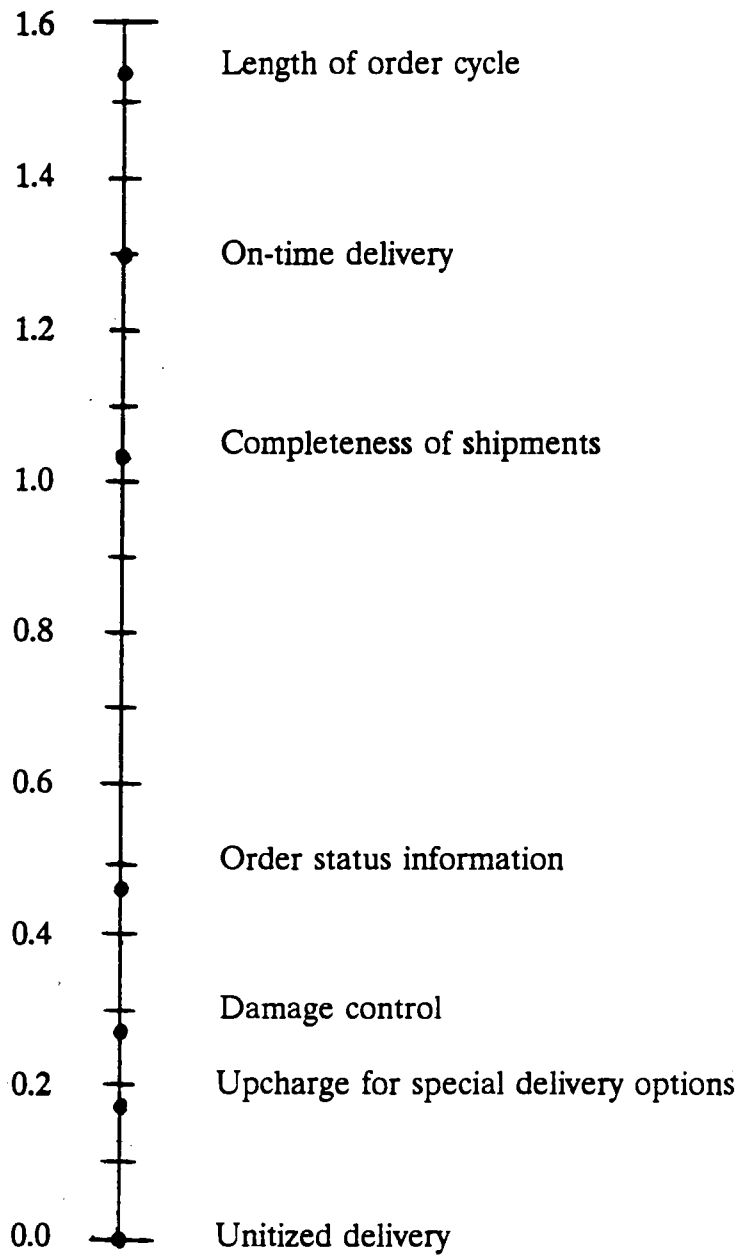


Figure IV-26
Derived Internal Scale of Preference for Regular Orders

BUYER

All of the remaining customer service delivery attributes - order status information, damage control, upcharge for special delivery options, and unitized delivery - are clearly separated from the others. This result is confirmed by the least significant difference test which also indicates this grouping of attributes. The ordering also shows that none of the attributes are considered statistically different from one or more other customer service delivery features in terms of importance (Table IV-28).

Promotional orders appear to be similar to regular orders in several respects. First, the attribute rank is identical for the top five of seven customer service delivery features (Table IV-29 and Table IV-26). Second, the proportional preference between length of order cycle and on-time delivery is 0.70 (Table IV-30). A small difference exists between on-time delivery and completeness of shipments in proportional preference for the same comparison. Buyers in considering promotional orders indicated this preference to be 0.60 versus 0.50 for regular orders. That is, sixty percent of the respondents perceive on-time delivery to be more important than completeness of shipments for promotional orders. For regular orders, this reported figure was only 50 percent.

The derived interval scale of preference, in conjunction with the least significant difference model, indicates that length of order cycle and on-time delivery are distinguishably (statistically) different from the other customer service delivery attributes (Figure IV-27 and Table IV-31). These results are not

Table IV-28

Methods for Judging Contrasts of Scores for Regular Orders

BUYER

Chi-Square Goodness of Fit Test

$$\chi^2 = 12.3912$$

$$Z\text{-value} = -0.4070$$

$$\chi^2 = 12.59$$

$$p = 0.341$$

H_0 : Observed frequencies are consistent with those expected under application of the model.

Evaluation : The model output is in agreement with the actual frequencies.

Least Significant Difference Method

critical difference = 22.2, giving the ordering:

<u>Attribute</u>						
4	5	7	6	3	2	1
_____				_____		
	_____				_____	

Any attribute whose scores are not underlined by the same line may be considered distinguishably different.

Table IV-29
Contribution and Difference Among Attributes for
Promotional Orders

BUYER

Attribute	Frequency matrix	Percentage contribution to quality perception	Difference in preference (ratio)
Length of order cycle	214.5	21.4	1.3
On-time delivery	190.5	19.0	1.3
Completeness of shipments	150.5	15.0	1.1
Order status information	135.5	13.5	1.2
Damage control	110.5	11.0	1.0
Unitized delivery	107.5	10.7	1.1
Upcharge for special delivery options	95.5	9.5	

Table IV-30

Attribute Proportional Preference for Promotional Orders

BUYER

Attribute	5	4	7	6	3	2	1
5	-	0.59	0.61	0.59	0.66	0.90	0.90
4	0.41	-	0.59	0.68	0.61	0.80	0.80
7	0.39	0.41	-	0.63	0.61	0.90	0.90
6	0.41	0.32	0.37	-	0.56	0.80	0.80
3	0.34	0.39	0.39	0.44	-	0.60	0.70
2	0.15	0.22	0.12	0.24	0.41	-	0.70
1	0.12	0.20	0.12	0.22	0.32	0.30	-

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized delivery
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

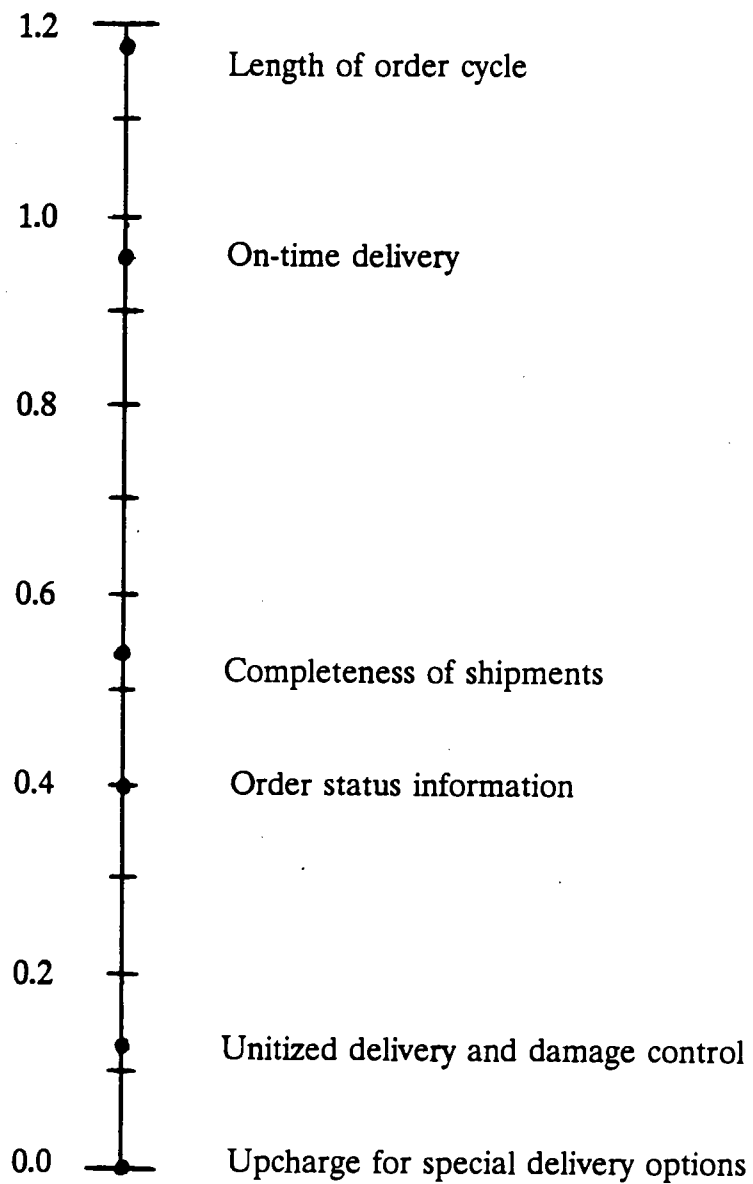


Figure IV-27
Derived Internal Scale of Preference for Promotional Orders

BUYER

Table IV-31

Methods for Judging Contrasts of Scores for Promotional Orders

BUYER

Chi-Square Goodness of Fit Test

$$\chi^2 = 13.0088$$

$$Z\text{-value} = -0.2844$$

$$\chi^2 = 12.59$$

$$p = 0.3897$$

H_0 : Observed frequencies are consistent with those expected under application of the model.

Evaluation : The model does not represent a satisfactory description of the data.

Least Significant Difference Method

critical difference = 22.2, giving the ordering:

<u>Attribute</u>						
5	4	7	6	3	2	1

Any attribute whose scores are not underlined by the same line may be considered distinguishably different.

statistically valid, however, as the chi-square goodness of fit test indicates that the model does not represent a satisfactory description of the data (Table IV-31).

Emergency orders are much more sensitive to damage control and upcharge for special delivery options than either regular or promotional orders (Table IV-32). There also appears to be a larger proportional preference between length of order cycle and on-time delivery for emergency orders versus promotional orders (0.80 (Table IV-33), 0.70, and 0.70 (Table IV-30), respectively). As Figure IV-28 and Table IV-34 show, the top three customer service delivery attributes - length of order cycle, on-time delivery, and completeness of shipments - are grouped differently than the other attributes in terms of preference ranking. However, the least significant difference test indicates that only length of order cycle is statistically different. On-time delivery and completeness of shipment are not considered distinguishably different from each other.

Just as with the model for promotional orders, the chi-square goodness of fit test for emergency orders indicates that the model does not represent a good description of the data. The hypothesis that the output of the theoretical model corresponds with the observed frequencies is rejected.

The analysis of attribute rank by order type and channel segment indicates that for the most part, grocery and non-grocery customers derive similar benefits from the customer service delivery attributes (Table IV-35). In fact, for promotional orders the attribute ranking is identical for the grocery versus

Table IV-32
Contribution and Difference Among Attributes for
Emergency Orders

BUYER

Attribute	Frequency matrix	Percentage contribution to quality perception	Difference in preference (ratio)
Length of order cycle	215.0	21.9	1.2
On-time delivery	184.0	18.8	1.1
Completeness of shipments	166.0	16.9	1.4
Damage control	118.0	12.0	1.0
Order status information	115.0	11.7	1.2
Unitized delivery	99.0	10.1	1.2
Upcharge for special delivery options	83.0	8.5	

Table IV-33

Attribute Proportional Preference for Emergency Orders

BUYER

Attribute	5	4	6	7	3	2	1
5	-	0.57	0.57	0.70	0.72	0.90	0.90
4	0.42	-	0.60	0.60	0.67	0.90	0.90
6	0.42	0.40	-	0.47	0.67	0.80	0.80
7	0.30	0.40	0.52	-	0.65	0.80	0.90
3	0.27	0.32	0.32	0.35	-	0.50	0.60
2	0.07	0.15	0.17	0.17	0.50	-	0.80
1	0.07	0.12	0.17	0.15	0.42	0.20	-

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized delivery
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

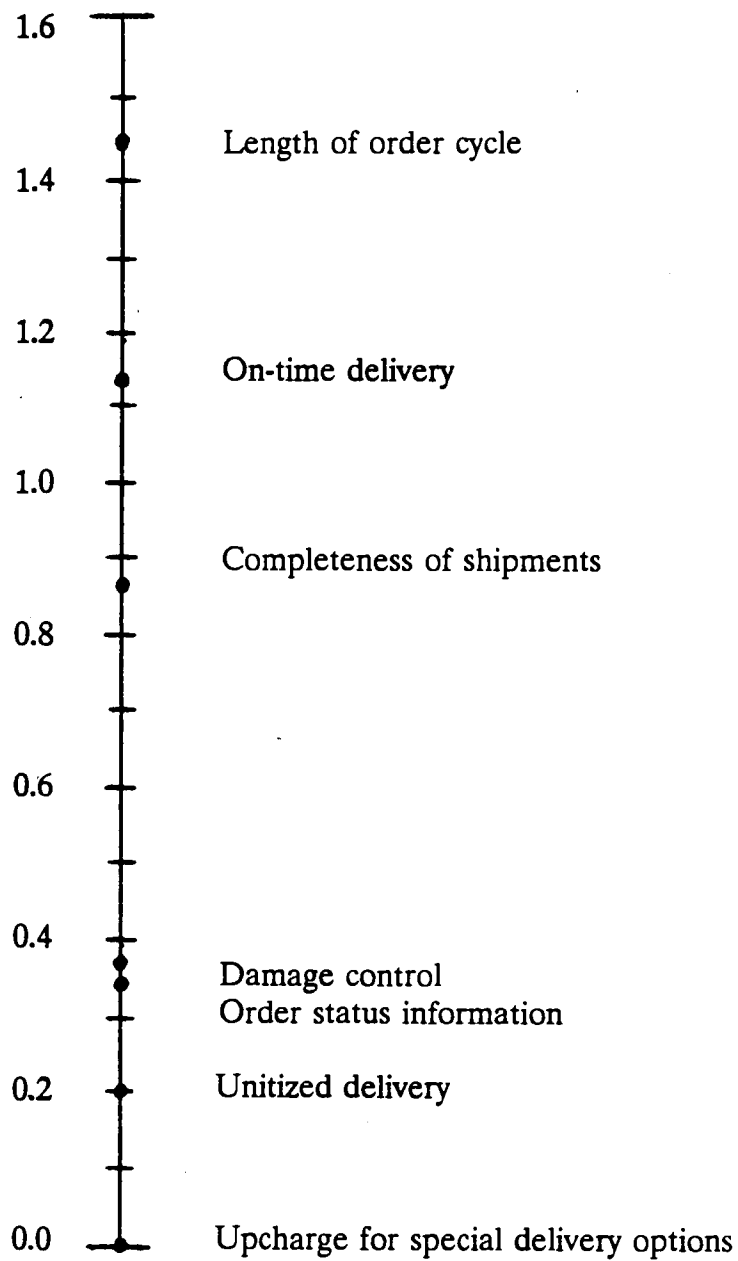


Figure IV-28
Derived Internal Scale of Preference for Emergency Orders
BUYER

Table IV-34

Methods for Judging Contrasts of Scores for Emergency Orders

BUYER

Chi-Square Goodness of Fit Test

$$\chi^2 = 21.3729$$

$$Z\text{-value} = 1.1529$$

$$\chi^2 = 12.59$$

$$p = 0.3897$$

H_0 : Observed frequencies are consistent with those expected under application of the model.

Evaluation : The model does not represent a satisfactory description of the data.

Least Significant Difference Method

critical difference = 21.97, giving the ordering:

<u>Attribute</u>						
5	4	6	7	3	2	1

Any attribute whose scores are not underlined by the same line may be considered distinguishably different.

Table IV-35
Comparison of Attribute Rank by Order and Channel Type

WAREHOUSE

Attribute	REGULAR		PROMOTIONAL		EMERGENCY	
	Grocery	Non-grocery	Grocery	Non-grocery	Grocery	Non-grocery
Length of order cycle	1	1*	1	1*	1	1*
On-time delivery	2	2	2	2*	2	2
Order status information	3	5	3	3	5	6
Completeness of shipments	4	3	4	4	4	3
Upcharge for special delivery options	5	4	5	5	6	5
Damage control	6	6	6	6	3	4
Unitized delivery	7	7	7	7	7	7

*Statistically significant for $\alpha = 0.05$.

non-grocery segment. For emergency orders there is some re-positioning of rank, none of which is significantly different for the two market segments. Grocery and non-grocery customers, however, place different importance on order status information for regular orders. This attribute is more critical to the grocery channel as noted by its rank of 3 versus 5 for the non-grocery segment.

Buyers also perceive the "vanilla" service across market segments, except for promotional orders (Table IV-36). Interestingly, the attribute which accounts for the perceived difference is order status information. Buyers in the non-grocery segment ranked this attribute 3; grocery buyers, however, ranked order status information as a 5 indicating lesser importance. This is opposite of the rank for warehouse regular orders.

In terms of order status information, the bill of lading is the preferred method of communication for both grocery and non-grocery segments across both order types (promotional and emergency). As Table IV-37 and Table IV-38 indicate, electronic communication is the second most desirable method of order communication. This ranking may reflect the technical inability of firms to take advantage of this method. No information at all is totally unacceptable to over 87 percent of the survey respondents, irregardless of market segment or order type.

Summary

The preceding analysis of the individual customer service elements with respect to other components of the mix resulted in the following conclusions:

Table IV-36
Comparison of Attribute Rank by Order and Channel Type

BUYER

Attribute	REGULAR		PROMOTIONAL		EMERGENCY	
	Grocery	Non-grocery	Grocery	Non-grocery	Grocery	Non-grocery
Length of order cycle	1*	1	1*	1	1*	1
On-time delivery	2	2	2*	2	2	2
Completeness of shipments	3	3	3	4	3	3*
Order status information	4	4*	5	3	4	5
Damage control	5	5	6	5	5	4
Upcharge for special delivery options	6	6	7	6	7	7
Unitized delivery	7	7	4	7	6	6

*Statistically significant for $\alpha = 0.05$.

Table IV-37

Method of Communication for Promotional Orders

WAREHOUSE

Method	Market segment	Preferred (percentage)	Unacceptable (percentage)
Electronic communication	Grocery	53.3	0.0
	Non-grocery	46.7	0.0
	TOTAL	36.6	0.0
FAX	Grocery	42.9	0.0
	Non-grocery	57.1	100.0
	TOTAL	17.1	6.5
Bill of lading	Grocery	42.1	0.0
	Non-grocery	57.9	100.0
	TOTAL	46.3	6.5
No information required	Grocery	0.0	51.9
	Non-grocery	0.0	48.1
	TOTAL	0.0	87.1

Table IV-38

Method of Communication for Emergency Orders

WAREHOUSE

Method	Market segment	Preferred (percentage)	Unacceptable (percentage)
Electronic communication			
	Grocery	50.0	0.0
	Non-grocery	50.0	0.0
	TOTAL	34.1	0.0
FAX			
	Grocery	33.3	0.0
	Non-grocery	66.7	100.0
	TOTAL	22.2	6.5
Bill of lading			
	Grocery	44.4	0.0
	Non-grocery	55.6	100.0
	TOTAL	43.9	6.5
No information required			
	Grocery	0.0	51.9
	Non-grocery	0.0	48.1
	TOTAL	0.0	87.1

- o Length of order cycle is the most important attribute in the customer delivery process and offers the firm the best opportunity to improve its perceived quality with regard to market segment and order type.
- o Due to the speed with which emergency orders are processed and delivered, warehouse managers perceive that order status information is not as critical for this type of order as it is for regular and promotional orders.
- o Length of order cycle, on-time delivery, and completeness of shipments, are consistently the highest ranked customer service delivery attributes across market segment and order type.
- o Buyers are more sensitive to upcharges for special delivery options than warehouse managers. Given the job performance criteria for buyers regarding the gross profit margin, this result was expected.
- o Grocery and non-grocery customers derive similar benefits from the customer service delivery attributes as indicated by the relative importance ranking of the features.
- o While no information regarding order status is completely unacceptable, the preferred method of communication is the bill of lading for promotional and emergency orders.

Objective 3. To build customer service profiles based on segmentation factors.

The traditional approach in segmenting customers is based on their impact on the manufacturer's profit performance (e.g. ABC analysis).⁸ As customer service delivery plays an increasing role in creating customer value, the traditional approach to segmentation is not capable of providing an understanding of the

⁸Stock, James R. and Douglas M. Lambert, Strategic Logistics Management (Homewood, IL: Irwin), 2nd ed., 1987, p. 130.

association among variables. By summarizing association among the original variables into a smaller number of derived variables it will be possible to propose a new and possibly more meaningful technique for building customer service profiles. The purpose of the factor analysis for this research is to search and test dimensions that may underlie manifest variables.

For the warehouse sample, the attributes of value were reduced to five factors - delivery, damage elimination/packaging, dock handling, unitization, and cube efficiency. As Table IV-39 indicates, the factor defined as delivery is composed on the attributes on-time delivery, complete shipments, quality of carriers, pick-up program, advance notice of problems, and quality of backhaul customer. Delivery's regression coefficient (0.58) indicates that it explains a large portion of total variation in warehouse customer benefits. This factor is almost three and one-half times more important than either damage elimination or dock handling.

Given the diversity of attributes and the importance of the delivery factor itself, further analysis was conducted to determine the components of this factor. Four factors resulted from the series of computational steps - on-time, completeness of shipments, direct-store delivery, and cost reduction (Table IV-40). As Figure IV-29 indicates, only two of the customer service delivery attributes are significant - on-time delivery and completeness of shipments.

The decomposition of the customer service delivery factors for the warehouse and buyer samples provides very useful information for determining

Table IV-39

Warehouse Attributes of Value

	RANK ORDER OF ATTRIBUTES
Delivery (.58)	. Advance Notice of Problems . Overall Quality of Backhaul Customer Pick-Up Program . On-Time Delivery . Overall Quality of Carriers . Complete Shipment
Damage Elimination/ Packaging (.17)	. Damage-Free Shipments . Durable Packaging . Print On Cases . Damage Policy
Dock Handling (.15)	. Turnaround Time For Trailer Unloading . Ease Of Handling Shipments In Warehouse
Unitization (.03)	. Unitized Delivery . Pallet Fit
Cube Efficiency **	. Cube Efficiency

Table IV-40

Delivery Factors and Components for Warehouse Managers

On-Time	Completeness	DSD	Cost Reduction
Carrier Quality Driver Quality On-Time	Minimize Substitutions Complete Shipments Damage Free	Direct Store Delivery	Competitive Backhaul Unitization Emergency Orders

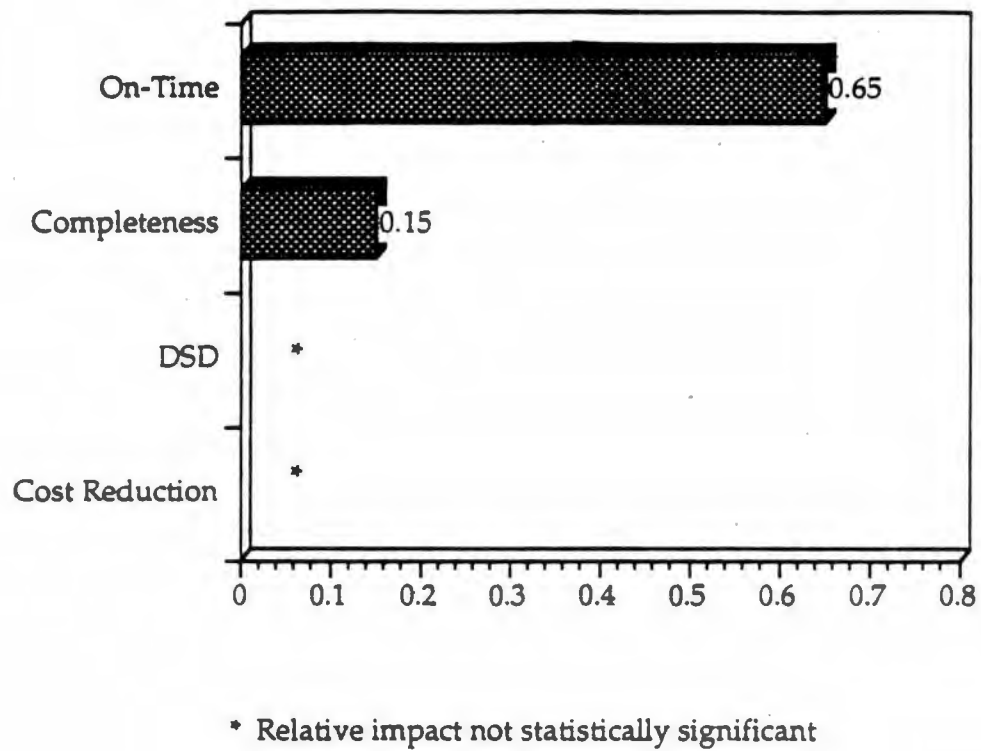


Figure IV-29
Key Drivers of Warehouse Customer Service Delivery

which customer service elements are important with respect to other components of the mix. In addition, valuable knowledge is gained for the firm in that this technique indicates the best opportunity for the firm to improve its perceived performance with regard to customer service. Customer service profiles can also be built based on these factors. However, additional analysis must be conducted to separate individual customers into groups such that each customer is more like other customers in its segment than like customers outside the group.

Cluster analysis was selected to develop customer profiles. Clustering procedures do not use prior information to partition the data. Therefore, information concerning type of order or market segment which could have strong partitioning effects was not used in this computational routine. The Howard-Harris cluster analysis technique was utilized to form groups of customers sequentially using the criterion of minimum within-group variance at each level of clustering. Once the clusters were developed, the next step was to describe them. For purposes of this analysis, the average value of the customer service attributes contained in each cluster was used to develop the profile description.

Table IV-41 presents profiles for four customer groups for the warehouse sample. Based on damage control and on-time performance characteristics specified by survey respondents, these groups are composed of grocery and non-grocery customers, as well as promotional and emergency orders. For example, group 1 contains 29.2 percent non-grocery, emergency orders; 12.5 percent grocery, emergency orders; 37.5 percent non-grocery, promotional orders; and 20.8

Table IV-41

Average Performance Characteristics

WAREHOUSE

Group number	DAMAGE CONTROL		ON-TIME DELIVERY	
	Percentage of customers	Preferred Unacceptable (percentage undamaged)	Preferred Unacceptable	
1	28.6	100.0	98.0	+/- 30 minutes +/- 2 hours
2	31.0	98.6	94.9	+/- 45 minutes +/- 1.75 hours
3	16.7	99.7	90.0	+/- 30 minutes +/- 2 hours
4	23.8	100.0	97.6	exact time +/- 3.75 hours

percent grocery, promotional orders. This exercise demonstrates that customer service segmentation can be done in a non-traditional manner and be quite effective in its ability to achieve increased customer value.

Because two of the three delivery service attributes for the buyer sample were set at different levels for promotional versus emergency orders, the cluster analysis was performed on these sets individually. The comparison of the two order types (Table IV-42 and Table IV-43) shows that the preferred on-time delivery range is similar. The difference between the two order types for this attribute is the unacceptable level. Promotional orders are significantly less sensitive to this service delivery feature than emergency orders. The same is true for the unacceptable level for order cycle length.

A major problem with cluster analysis is that it offers no solution to the problem of determining how valid the results are for the algorithm being used. For this reason, this technique is often thought of as preclassification, where the object is to formulate rather than test categorization of data.⁹ Other techniques such as discriminant analysis proved to be more useful in the assignment of new customers to groups identified on grounds that are not solely restricted to the original cluster analysis.

Canonical analysis of discriminance was used to assign customers to groups based on customer service delivery requirements. The classification matrices were

⁹Green, Paul E. and Donald S. Tull, Research Methods for Marketing Decisions (Englewood Cliffs, NJ: Prentice-Hall, Inc.), 1975, p. 577.

Table IV-42

Promotional Orders Average Performance Characteristics

BUYER

Group number	Percentage of customers	COMPLETENESS OF SHIPMENTS		ON-TIME DELIVERY		LENGTH OF ORDER CYCLE	
		Preferred	Unacceptable (percentage)	Preferred	Unacceptable	Preferred	Unacceptable
1	53.5	99.4	94.2	+/- 30 minutes	+/- 3 hours	+/- 4.6 days	+/- 8.7 days
2	13.9	96.8	90.0	+/- 2.5 hours	+/- 7 hours	+/- 4.2 days	more than 10 days
3	16.3	100.0	80.0	+/- 30 minutes	+/- 4.5 hours	+/- 3 days	+/- 8.4 days
4	16.3	100.0	93.1	+/- 1 hour	+/- 7 hours	+/- 6 days	+/- 9.3 days

Table IV-43

Emergency Orders Average Performance Characteristics

BUYER

Group number	Percentage of customers	COMPLETENESS OF SHIPMENTS		ON-TIME DELIVERY		LENGTH OF ORDER CYCLE	
		Preferred	Unacceptable (percentage)	Preferred	Unacceptable	Preferred	Unacceptable
1	27.9	96.5	82.7	+/- 30 minutes	+/- 3 hours	+/- 1 day	+/- 3 days
2	32.6	99.2	93.9	+/- 15 minutes	+/- 1.25 hours	+/- 3 days	+/- 3 days
3	23.2	98.8	91.5	+/- 20 minutes	+/- 3.33 hours	+/- 2 days	+/- 4 days
4	16.3	99.6	89.8	+/- 2.75 hours	+/- 3.75 hours	+/- 2.5 days	+/- 4 days

computed for both the buyer and warehouse samples by market segment, and within these same samples matrices were determined on the basis of order type. The procedure shows the order in which customer service attributes are entered, and at the conclusion of the stepwise procedure a summary of predictors and associated F-values are presented. The following results were obtained from the analysis:

WAREHOUSE MANAGERS BY MARKET SEGMENT

- o Warehouse managers do not distinguish between orders on the basis of market segment, i.e. grocery versus non-grocery (Table IV-44).
- o The classification matrix shows that the discriminant functions correctly classified only 55.9 percent of the customers by their true market segment (Table IV-45).
- o Because the groups do not differ significantly with respect to market segment, the plot of the individual customer requirements does not show any separation of the two groups (Figure IV-30).

WAREHOUSE MANAGERS BY TYPE OF ORDER

- o In addition to market segment, warehouse managers also do not differentiate service based on type of order (Table IV-46).
- o Only 58.3 percent of the customers were correctly classified by the discriminant analysis according to the actual order type (Table IV-47).

Table IV-44

Summary of Multivariate Analysis of Variance
by Market Segment

WAREHOUSE

Source	Approximate F-statistic	U-statistic
Preferred undamaged	3.064	0.964
Unacceptable on-time	0.867	0.954
Unacceptable damage	0.156	0.952
Preferred on-time	0.015	0.952
d.f. = 4,79		d.f. = 4,1,82

Table IV-45

Classification by Market Segment

WAREHOUSE

	GROCERY	NON-GROCERY	Marginals
GROCERY	22	18	40
NON-GROCERY	19	25	44
Marginals	41	43	84

Evaluation: The groups do not differ significantly with respect to the market segment.

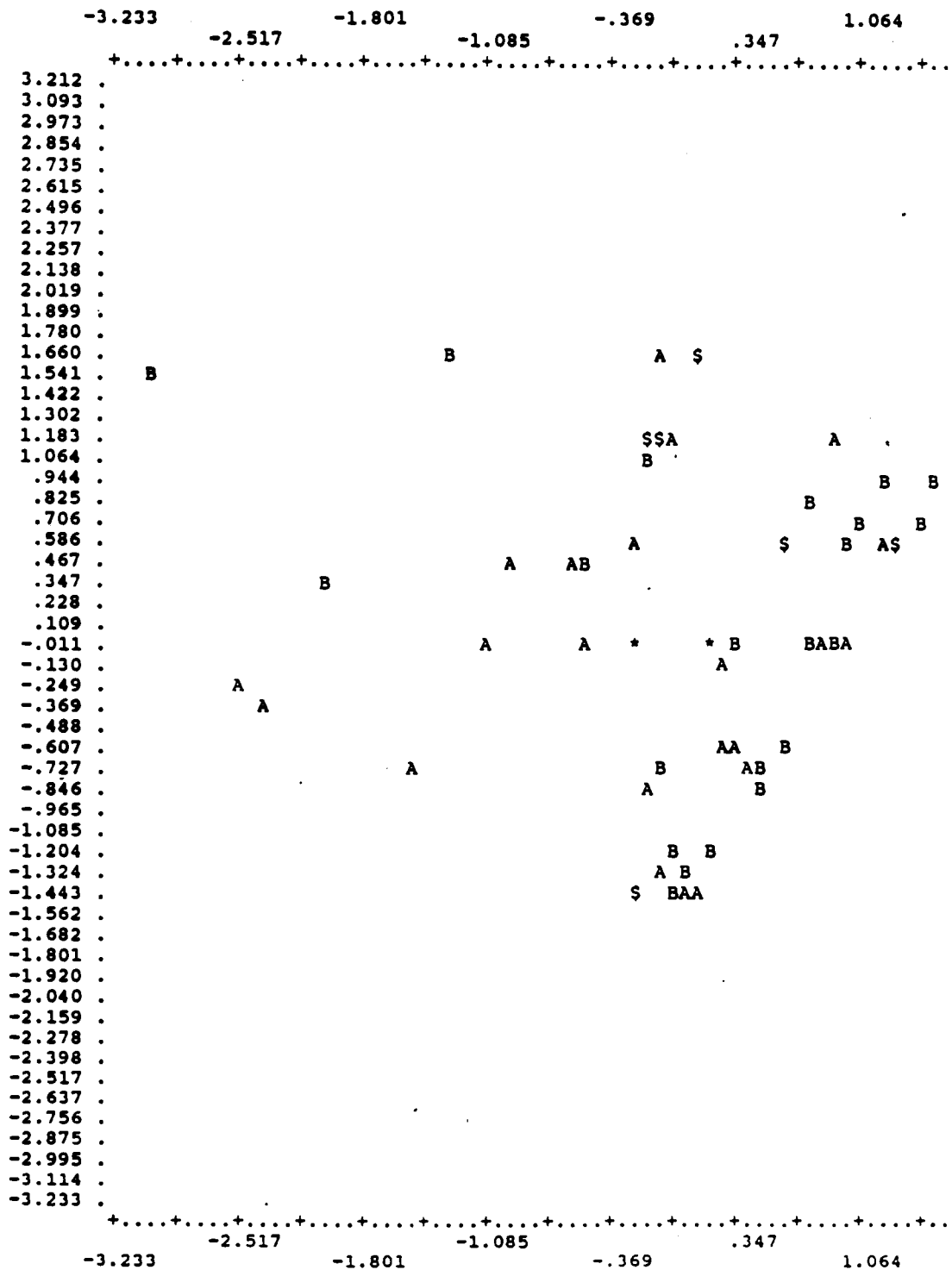


Figure IV-30
Plot of Cannonical Variables

WAREHOUSE MANAGERS by Market Segment

Table IV-46

Summary of Multivariate Analysis of Variance
by Type of Order

WAREHOUSE

Source	Approximate F-statistic	U-statistic
Preferred undamaged	0.755	0.991
Preferred on-time	0.784	0.981
Range of on-time acceptability	0.572	0.974
Range of damage unacceptability	0.301	0.971
d.f. = 4,79		d.f. = 4,1,82

Table IV-47

Classification by Order Type

WAREHOUSE

	PROMOTIONAL	EMERGENCY	Marginals
PROMOTIONAL	23	19	42
EMERGENCY	16	26	42
Marginals	39	45	84

Evaluation: The groups do not differ significantly with respect to the market segment.

- o These findings are clearly shown in the plot of the two order types which indicates that the groups do not differ significantly (Figure IV-31).

Buyers are able to distinguish customers by market segment and especially by order type. Classification by market segment, however, only resulted in an overall correct classification rate of 60.5 percent with no significant source of variation explained by the multivariate analysis (Table IV-48 and Table IV-49). While more than 62 percent of the non-grocery segment was correctly classified, the plot of the two groups indicates that the means do not differ significantly from each other (Figure IV-32).

The order type analysis for the buyer sample produced expected results. Buyers are quite sensitive to customer service delivery features as they relate to promotional versus emergency orders. The discriminant functions correctly classified 94.2 percent of the customers by their actual order type (Table IV-50). This high "hit" rate is also shown in the plot of the two groups which indicates that the group means for emergency versus promotional orders are significantly different (Figure IV-33).

The multivariate analysis of variance presented in Table IV-51 shows that the largest and most significant source of variation can be explained by "unacceptable order cycle length." Both of the order types - emergency and promotional - are known to be sensitive to this factor. As discussed earlier in this section, timeliness was the most significant component of the customer service

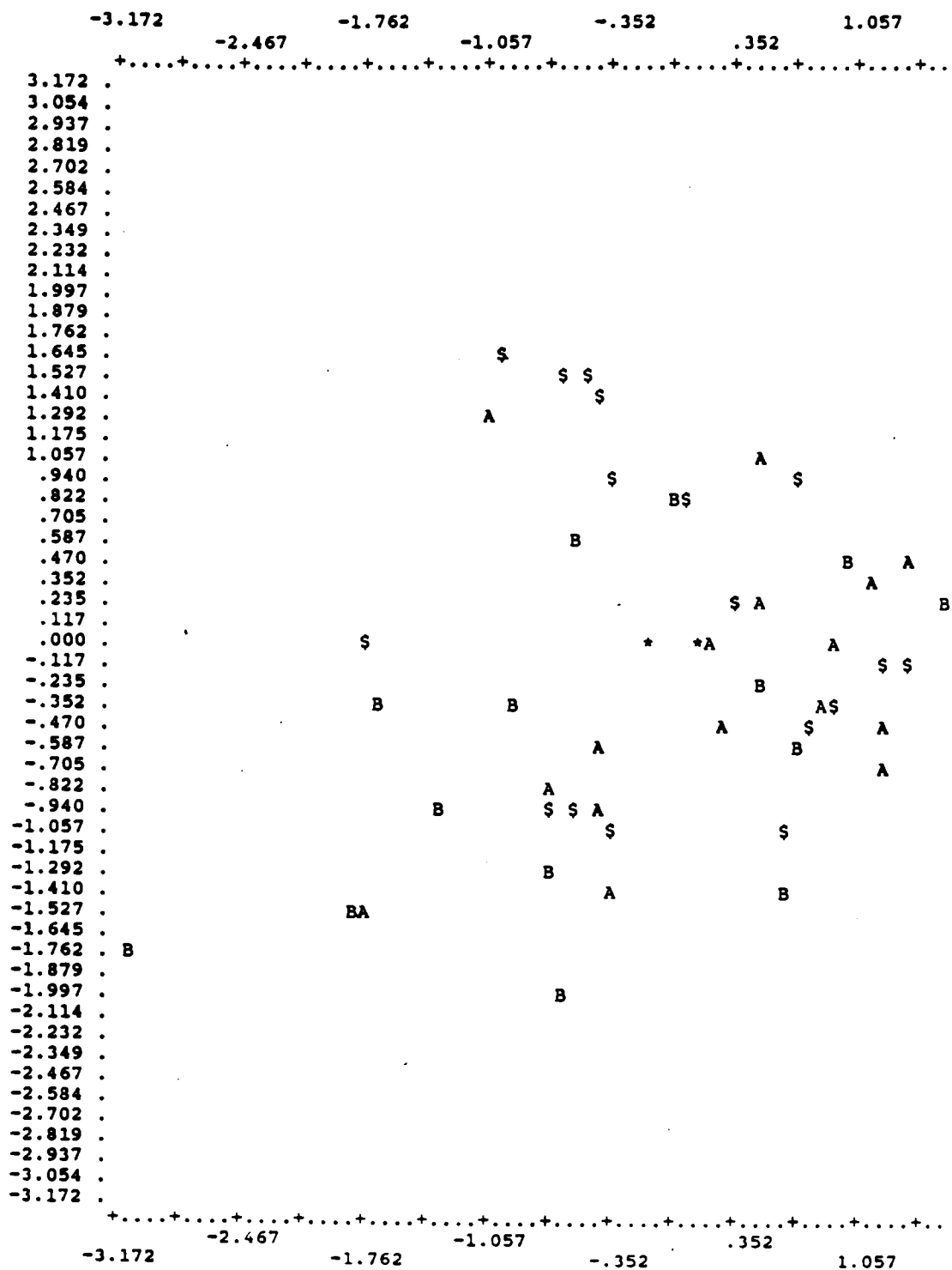


Figure IV-31
Plot of Cannonical Variables

WAREHOUSE MANAGERS by Type of Order

Table IV-48

Summary of Multivariate Analysis of Variance
by Market Segment

BUYER

Source	Approximate F-statistic	U-statistic
Preferred on-time	2.736	0.968
Unacceptable complete shipments	0.167	0.966
Preferred order cycle length	0.201	0.964
Acceptable on-time range	0.418	0.959
Unacceptable order cycle length	0.122	0.958
Preferred complete shipments	0.144	0.956
Acceptable complete shipment range	2.864	0.922
Unacceptable on-time	0.079	0.921
Acceptable order cycle range	0.514	0.921
d.f. = 9,76		d.f. = 9,1,84

Table IV-49

Classification by Market Segment

BUYER

	GROCERY	NON-GROCERY	Marginals
GROCERY	21	15	36
NON-GROCERY	19	31	50
Marginals	30	46	86

Evaluation: The groups do not differ significantly with respect to the market segment.

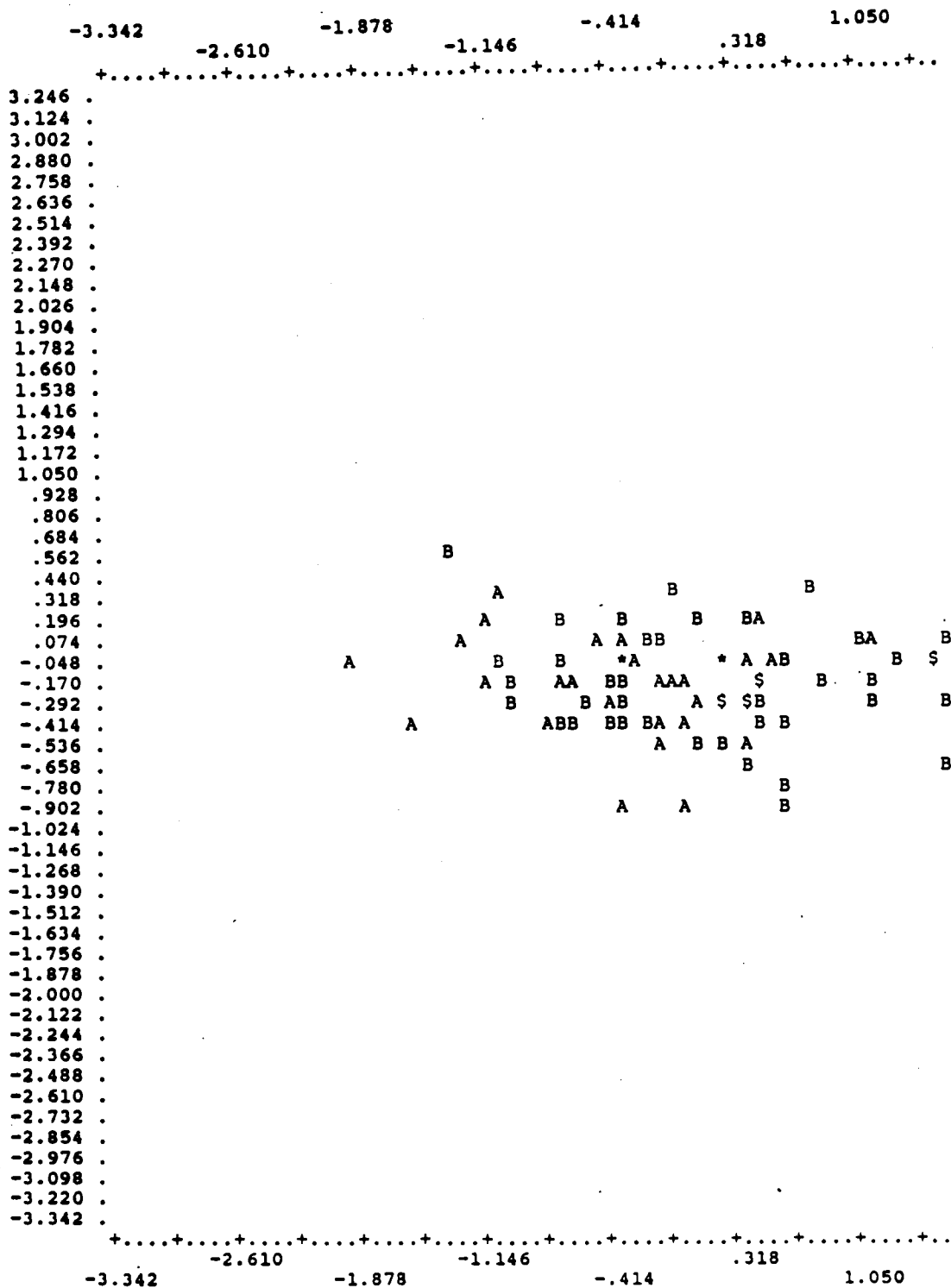


Figure IV-32
Plot of Cannonical Variables
BUYERS by Market Segment

Table IV-50

Classification by Order Type

BUYER

	PROMOTIONAL	EMERGENCY	Marginals
PROMOTIONAL	38	5	43
EMERGENCY	0	43	43
Marginals	38	48	86

Evaluation: The differences between groups equals 0.903. This discriminant function is statistically significant.

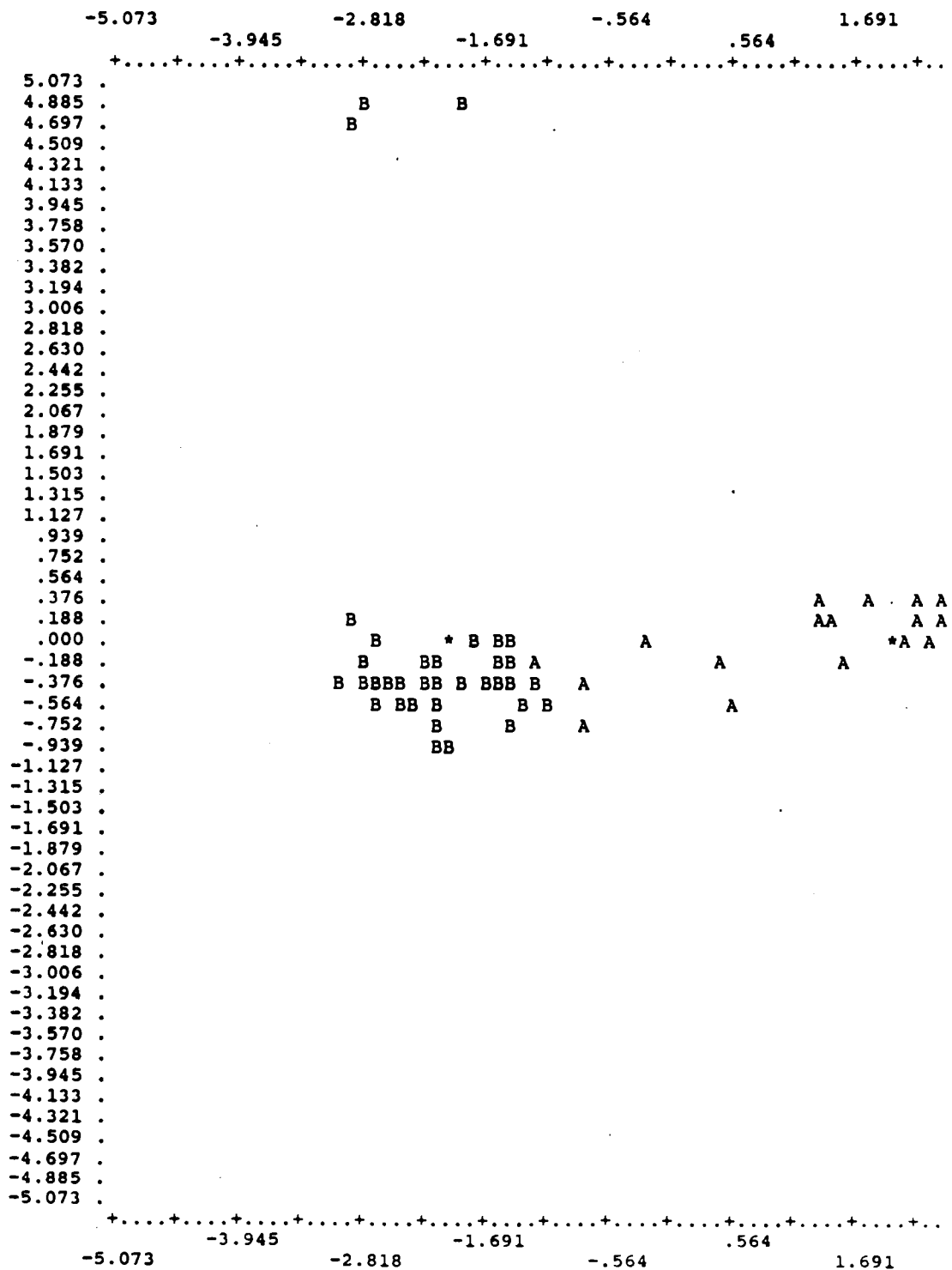


Figure IV-33
Plot of Canonical Variables
BUYERS by Type of Order

Table IV-51
Summary of Multivariate Analysis of Variance
by Order Type

BUYER

Source	Approximate F-statistic	U-statistic
Unacceptable order cycle length	336.847	0.200
Preferred on-time	2.459	0.194
Acceptable on-time range	1.276	0.191
Unacceptable on-time	1.137	0.186
Unacceptable complete shipments	0.132	0.185
Preferred order cycle length	0.027	0.185
Acceptable complete shipment range	0.025	0.185
Acceptable order cycle range	0.013	0.185
d.f. = 8,77		d.f. = 8,1,84

delivery factor. The interesting part of the analysis, however, is that the unacceptable measure rather than the preferred requirement is the driver of segmentation. This information is particularly critical in designing a customer service delivery process which will ensure that the minimum specification will be met.

Segmentation of customers by service delivery features will offer the consumer goods company an effective and responsive means of differentiating customers. As the analysis has indicated, however, this segmentation is significant only by type of order. Buyers and warehouse managers do not appear to differentiate service based on a particular market segment. Warehouse managers also provide a "vanilla" service that does not distinguish by type of order.

Objective 4. To determine which attributes, and levels of these attributes, are statistically significant.

The basic aim of research is to find general explanations (theories) of events or occurrences. Other aims that have been stated include: understanding, prediction, and control.¹⁰ The above stated research objective was established to

¹⁰Kerlinger, Fred N., Foundations of Behavioral Research (New York: Holt, Rinehart and Winston, Inc.), 1964, p. 11.

infer statistically from probabilistic premises of the previous analyses. The following results have been determined to be statistically significant:

- o Length of order cycle is the most important attribute of the customer service delivery process across all order types as designated by warehouse managers.
- o Buyers and warehouse managers report that on-time delivery is of critical importance for promotional orders. Warehouse managers also rank this attribute as the second most important for emergency orders.
- o Emergency orders are sensitive to damage levels. Zero defects is a requirement for the vast majority of customers.
- o Length of order cycle, on-time deliveries, and completeness of shipments are key drivers of buyers and warehouse managers quality perception. These factors are 2-3 times more important than other components of the customer service delivery.
- o The measurement of unacceptable order cycle length can be used to classify (segment) new customers.
- o Buyers prefer a 96-100 percent completeness of shipments for emergency orders. The greatest benefit to the company, however, is derived by establishing a minimum completeness of shipments at 90-95 percent.
- o Warehouse managers are not interested in palletized delivery of emergency orders. Instead, either shrink wrap or slip sheet packaging is preferred.

- o Emergency orders should not result in any increase in price to the customer, irregardless of the special delivery options involved.
- o Warehouse managers prefer the bill of lading as the method of order communication. There should be no increase in price related to supplying this information.
- o Buyers designated 3 to 5 days as the preferred order cycle length for promotional orders.
- o The largest gain in benefit to the company can be realized by shortening the order cycle time for promotional orders from 7 to 10 days to 3 to 5 days.

Managerially significant findings also resulted from the research which was conducted in the pre-test of the Phase 1 questionnaire. These are as follows:

- o Customer service delivery is the most important driver of overall quality for buyers, while this factor ranks second for warehouse managers. Instead, packaging is the number one process concern for this group.
- o Buyers will be responsive to customer service delivery systems which minimize out-of stocks and reduce inventory. These criteria are directly related to on-time delivery, length of order cycle, and completeness of shipments.
- o Key customer service measures - on-time delivery, completeness of shipments, and damage free- are closely linked to important job performance criteria for warehouse/logistics managers.

These results are discussed in further detail in Chapter 5 as a part of the research implications.

Phase 2

The research objectives for this phase of the dissertation are components of parameter design. The goal of parameter design is to determine the parameter values of the customer service delivery process so that the system consistently exhibits a high level of performance and is minimally sensitive to noise. A parameter design typically involves two types of factors: control and noise factors. Parameter design examines interactions between control factors and noise factors in order to achieve robustness. The following objectives were established to meet this goal:

- Objective 1.** To identify the settings of design parameters that reduce cost without affecting quality.
- Objective 2.** To identify those design parameters that have a large influence on the mean value of the performance characteristic, but have no effect on its variation.
- Objective 3.** To identify those design parameters that have no detectable influence on performance characteristics.

Although the Taguchi approach to design of experiments was utilized for Phase 2, the basis of the structure is ex post facto research. Indeed, this type of research is one in which the independent variable(s) have already occurred and the researcher starts with the observation of a dependent variable or variables. The purpose of the study, therefore, is to examine possible relations to, and effects on, the dependent variable. This is a different approach from "true" experimentation where the researcher hypothesizes, uses some method to manipulate or measure the variable of interest, and then observes the process to determine if concomitant variation occurs.

For purposes of the dissertation research, the term "artificial" experiment has been utilized. By demonstrating the effectiveness of this technique through the research, it is anticipated that future study will allow the control and manipulation of the independent variables. The confirmation or disconfirmation of results from this research will then move this effort into the realm of true experimentation. This issue is discussed in greater detail in Chapter IV, Research Implications and Future Direction.

Research Structure

Taguchi recommends the use of orthogonal arrays for constructing control factor and noise factor matrices in experimental design. The $L_8 (2^7)$ orthogonal array was used to examine three customer service delivery factors, and the L_4

outer array was used for noise factors. This design is presented in Table D-1, Appendix D.

Three customer service delivery factors - delivery method, order size, and order lead time - were tested to determine which, if any, of these can be manipulated to reduce variation of performance within the current operating environment. Two additional factors - warehouse arrival specification and buyer delivery specification - were not included due to missing information in the data records sampled. In addition, these two factors are changing almost daily as the logistics staff at the plant work with customers to pre-schedule appointments for deliveries. The selection process for factors is presented in detail in Chapter III, Section 2, "Research Design."

The experimentation was conducted to design customer service programs whose performance is not sensitive to variations of uncontrollable noise factors. Two major events - promotions and brand introductions - have significant influence on the performance of the customer service delivery process and were used as the basis for two different experiments which were conducted. While a continuity of research from Phase 1 regarding promotional and emergency orders was desirable from a research perspective, this was not possible to achieve for emergency orders. The indication of emergency orders does not currently get captured by the customer measurement system. For this reason, it was decided to use brand introductions as the other major event. Introducing new products into the logistics system falls within the purview of regular orders.

Within each of the events "uncontrollable noises" exist. For the customer service process noises take on a very different form than manufacturing.

Marketing and its segmentation of customers by account size and type (e.g. large and small grocery, large and small mass merchandiser, and large and small variety stores) provides a means of examining these factors to determine their effect on the performance of the customer service process.

The results of the promotional orders experiment is detailed in Appendix D. Two techniques were used to derive the response variable "perfect order score": additive values and scale values. The additive values simply operate as the name implies - each of the three performance measurement statistics (on-time delivery, shipment delivered complete, and billed accurately) are each assigned a score of 1 for meeting requirements and 0 for non-conformance to specifications. The maximum possible score for additives therefore is 3.

Based on the utility scores derived in Phase 1 of the research, the performance statistics were also derived by assigning the scale values as determined by the earlier analysis. Because these utilities reflect ranked importance and preference, they offer an alternative to the assumption of additive effect. All analysis was conducted using both measures. The scale values are as follows:

PROMOTIONAL ORDERS

	<u>Scale Value</u>
on-time delivery	0.90
complete shipment	0.44
billed accurately	0.19

BRAND INTRODUCTION

	<u>Scale Value</u>
on-time delivery	1.18
complete shipment	0.89
billed accurately	0.25

Promotional Orders

The response table for promotional orders using additive values indicates that order size has a significant main effect on customer service delivery performance (Table IV-52). The interaction table and graph (Table IV-53 and Figure IV-34) shows that carrier type (truckload and LTL/pool) and order size produce the best results when small orders are sent by LTL/pool shipment. For large orders (more than 100 cases), however, truckload shipment performs better. Furthermore, small orders are best handled with a lead time of 5 days or less while more than 5 days lead time produces less than desirable outcomes with respect to customer service delivery performance (Table IV-54 and Figure IV-35).

Table IV-52

Response Table for Promotional Orders
(additive values)

	A	B	C	A B	A C	A C	A B C
LEVEL 1	2.25	2.56	2.25	2.00	2.19	2.38	2.19
LEVEL 2	2.19	1.88	2.19	2.44	2.25	2.06	2.25
Difference between levels	0.06	0.68*	0.06	0.44*	0.06	0.32*	0.06

A = Carrier type

LEVEL 1 = Truckload

LEVEL 2 = LTL/pool

B = Order size

LEVEL 1 = small (less than or equal to 100 cases)

LEVEL 2 = large (more than 100 cases)

C = Lead time

LEVEL 1 = less than or equal to 5 days

LEVEL 2 = more than 5 days

Table IV-53

Interaction Response Table - Carrier Type by Order Size
(additive values)

PROMOTIONAL ORDERS

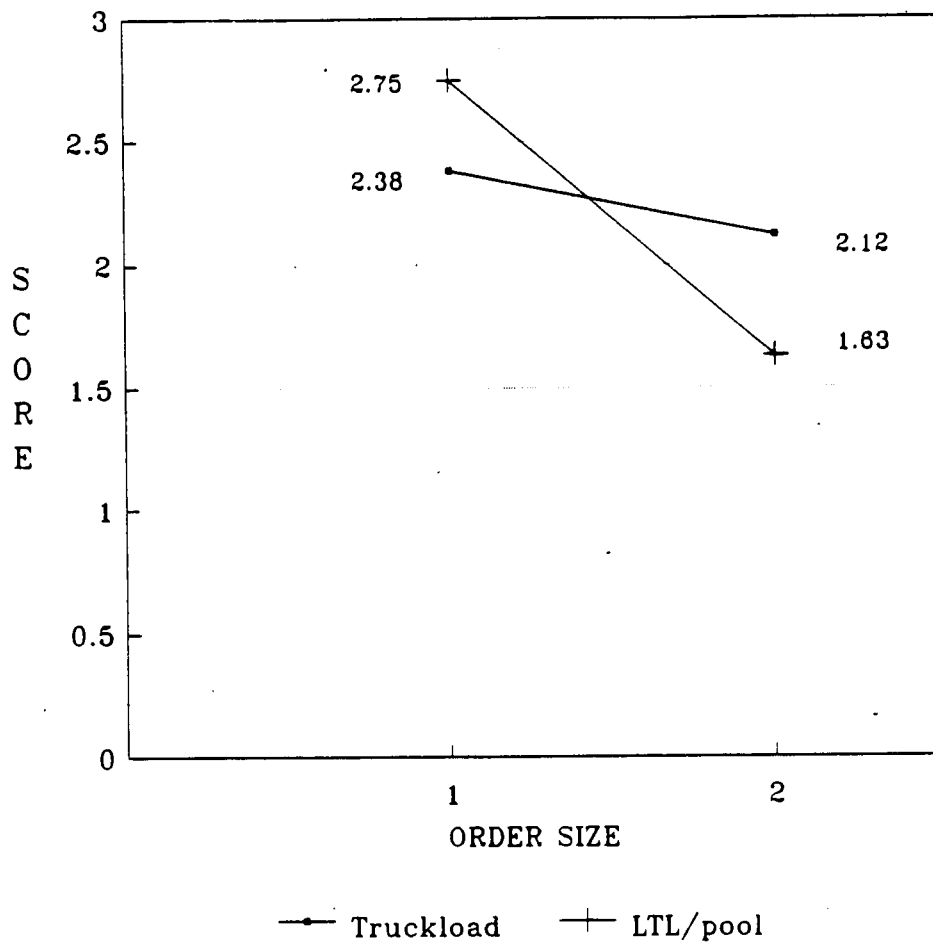
	A1	A2
B1	2.38	2.75
B2	2.12	1.63

A1 = Truckload

B1 = small order

A2 = LTL/pool

B2 = large order



1 = small order
2 = large order

Figure IV-34

Interaction Graph - Carrier Type by Order Size -
for Promotional Orders

(additive values)

Table IV-54

Interaction Response Table - Order Size by Order Lead Time
(additive values)

PROMOTIONAL ORDERS

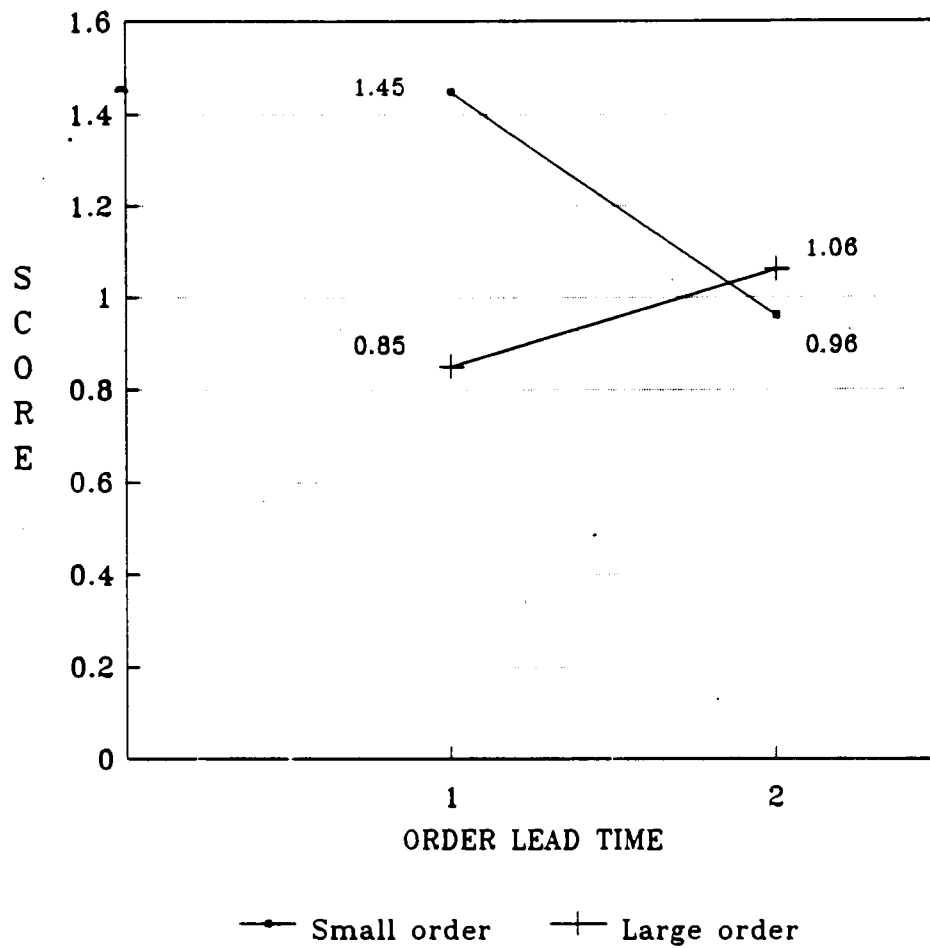
	B1	B2
C1	1.45	0.85
C2	0.96	1.06

B1 = small order

C1 = ≤ 5 days

B2 = large order

C2 = > 5 days



1 = ≤ 5 days
 2 = > 5 days

Figure IV-35

Interaction Graph - Order Size by Order Lead Time -
 for Promotional Orders

(additive values)

A statistical measure of performance called the signal-to-noise (S/N) ratio was calculated to evaluate and measure the level of effect of noise factors on performance. Because a higher additive and scale value indicate a higher level of performance, the appropriate S/N ratio is bigger the better. The S/N ratio is a data transformation that provides an evaluation of both the average and the variability of a factor.

For promotional orders, the S/N ratio analysis also shows that order size has a significant main effect (Table IV-55). To produce the desired customer service delivery performance outcome, the data suggest that small orders are best (Figure IV-36). The interaction response tables (Table IV-56 and Table IV-57) and graphs (Figure IV-37 and Figure IV-38) present findings which parallel the traditional statistical analysis. However, the S/N ratios indicate that variability of customer service delivery performance can be attributed to order size, carrier type, and order lead time.

Table IV-58 shows both the S/N ratios by control factor and the sensitivity measures (change in the mean). Based on this information and the preceding analysis, the control factors can be classified into the following types:

<u>Control Factor</u>	<u>Classification</u>
order size	I: affects both average and variation
carrier type	II: affects variation only
order lead time	II: affects variation only

Table IV-55

Response Table for Signal-to-Noise Ratios for Promotional Orders
(additive values)

	A	B	C	A B	A C	A C	A B C
LEVEL 1	-7.56	-8.43	-7.24	-6.44	-7.33	-7.73	-6.94
LEVEL 2	-6.85	-5.98	-7.17	-7.97	-7.08	-6.67	-7.47
Difference between levels	0.71	2.45*	0.07	1.53*	0.25	1.06*	0.53

A = Carrier type

LEVEL 1 = Truckload

LEVEL 2 = LTL/pool

B = Order size

LEVEL 1 = small (less than or equal to 100 cases)

LEVEL 2 = large (more than 100 cases)

C = Lead time

LEVEL 1 = less than or equal to 5 days

LEVEL 2 = more than 5 days

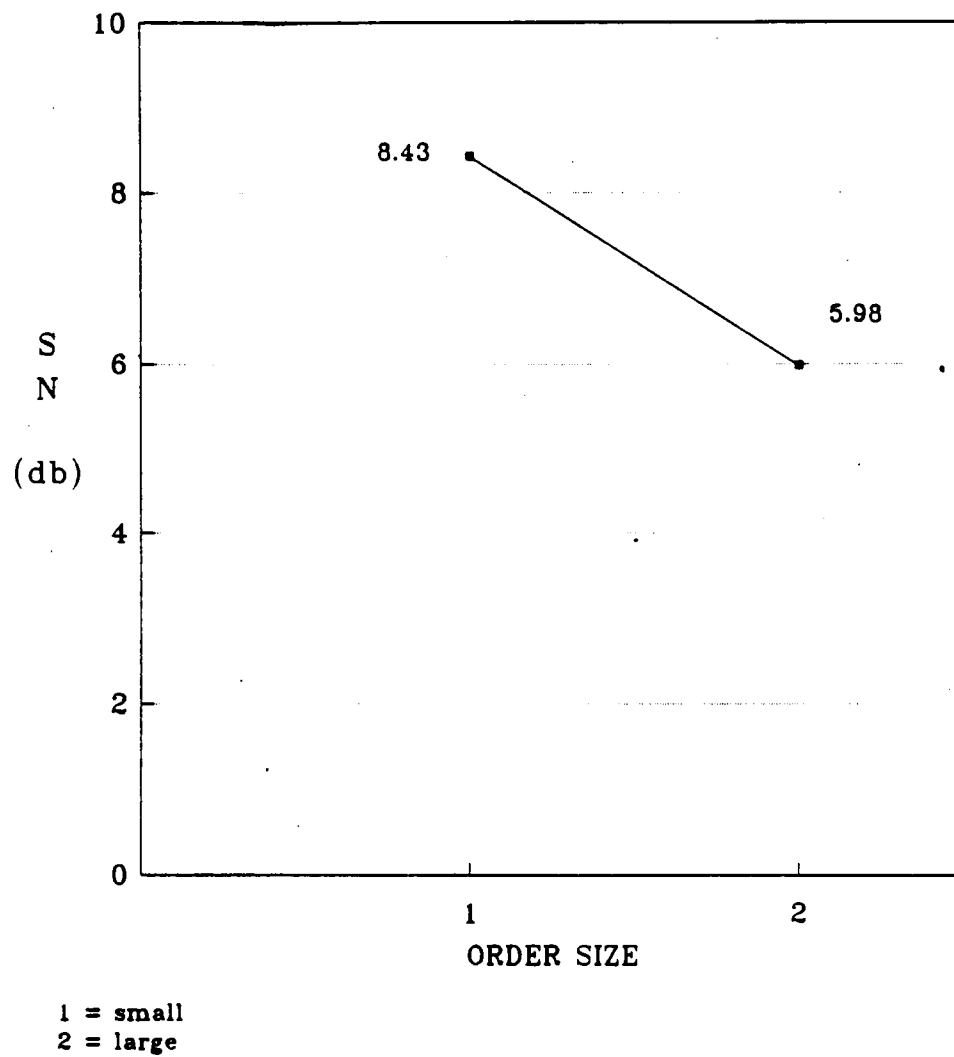


Figure IV-36
Factors that Affect Variability of Promotional Orders
(additive values)

Table IV-56

Interaction Response Table - Carrier Type by Order Size
(additive values - S/N ratios)

PROMOTIONAL ORDERS

	A1	A2
B1	-8.02	-8.84
B2	-7.10	-4.86

A1 = Truckload

B1 = small order

A2 = LTL/pool

B2 = large order

Table IV-57

Interaction Response Table - Order Size by Order Lead Time
(additive values - S/N ratios)

PROMOTIONAL ORDERS

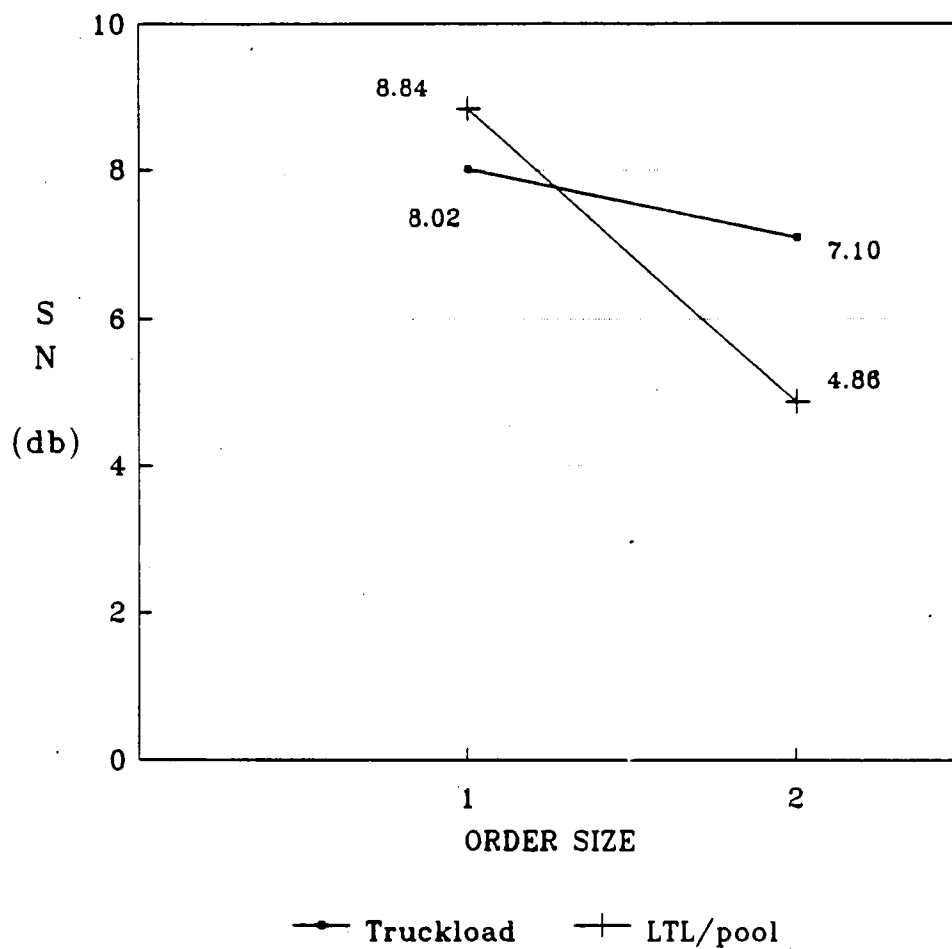
	B1	B2
C1	-9.00	-5.48
C2	-7.86	-6.47

B1 = small order

C1 = ≤ 5 days

B2 = large order

C2 = > 5 days

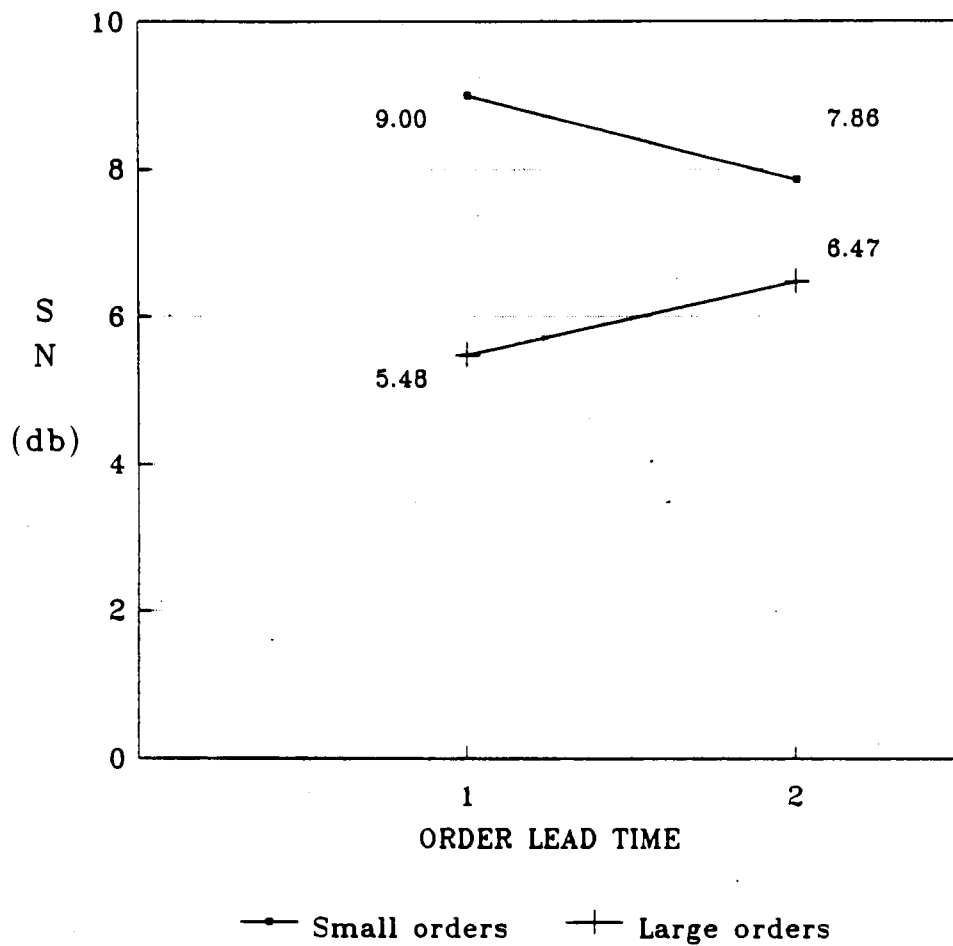


1 = small
2 = large

Figure IV-37

Interaction Graph - Carrier Type by Order Size -
for Promotional Orders

(additive values)



1 = ≤ 5 days
2 = > 5 days

Figure IV-38

Interaction Graph - Order Size by Order Lead Time -
for Promotional Orders

(additive values)

Table IV-58

Signal-to-Noise and Sensitivity Measures for Promotional Orders

(additive values)

Control factors	<u>Noise factors</u>				Total	Average	V_e	S_m	S_m (db)	n (db)
	N1	N2	N3	N4						
A1	1.75	2.75	2.50	2.00	9.00	2.25	0.21	20.25	13.06	-7.18
A2	2.25	2.25	1.75	2.50	8.75	2.19	0.10	19.14	12.82	-6.87
B1	2.50	2.75	2.75	2.25	10.25	2.56*	0.06	26.27*	14.19	-8.20*
B2	1.50	2.25	1.50	2.25	7.50	1.88*	0.19	14.06*	11.48	-5.63*
C1	2.25	2.50	2.00	2.25	9.00	2.25	0.04	20.25	13.06	-7.07
C2	1.75	2.50	2.25	2.25	8.75	2.19	0.10	19.14	12.82	-6.87

A1 = Truckload
A2 = LTL/pool

B1 = small order
B2 = large order

C1 = $\leq$ 5 days order lead time
C2 = $>$ 5 days order lead time

Figure IV-39 shows that only ORDER SIZE can be used for adjusting the mean delivery performance for promotional orders. However, this factor also contributes to the variability of delivery performance (Figure IV-36).

The analysis of mean scale values indicates the following:

- o The customer service delivery process is better at handling small orders (Table IV-59 and Figure IV-40).
- o For the best delivery performance, small orders should have a lead time of 5 days or less (Table IV-60 and Figure IV-41).

The response table for S/N ratios shows that in addition to an order size main effect, order lead time is also significant, i.e. these factors affect the variability of promotional orders (Table IV-61 and Figure IV-42). The sensitivity analysis further indicates that order size can be used for adjusting the mean delivery performance (Table IV-62 and Figure IV-43). The control factors, based on scale values, can be classified as follows:

<u>Control Factor</u>	<u>Classification</u>
order size	I: affects both average and variation
order lead time	II: affects variation only
carrier type	III: affects neither average nor variation

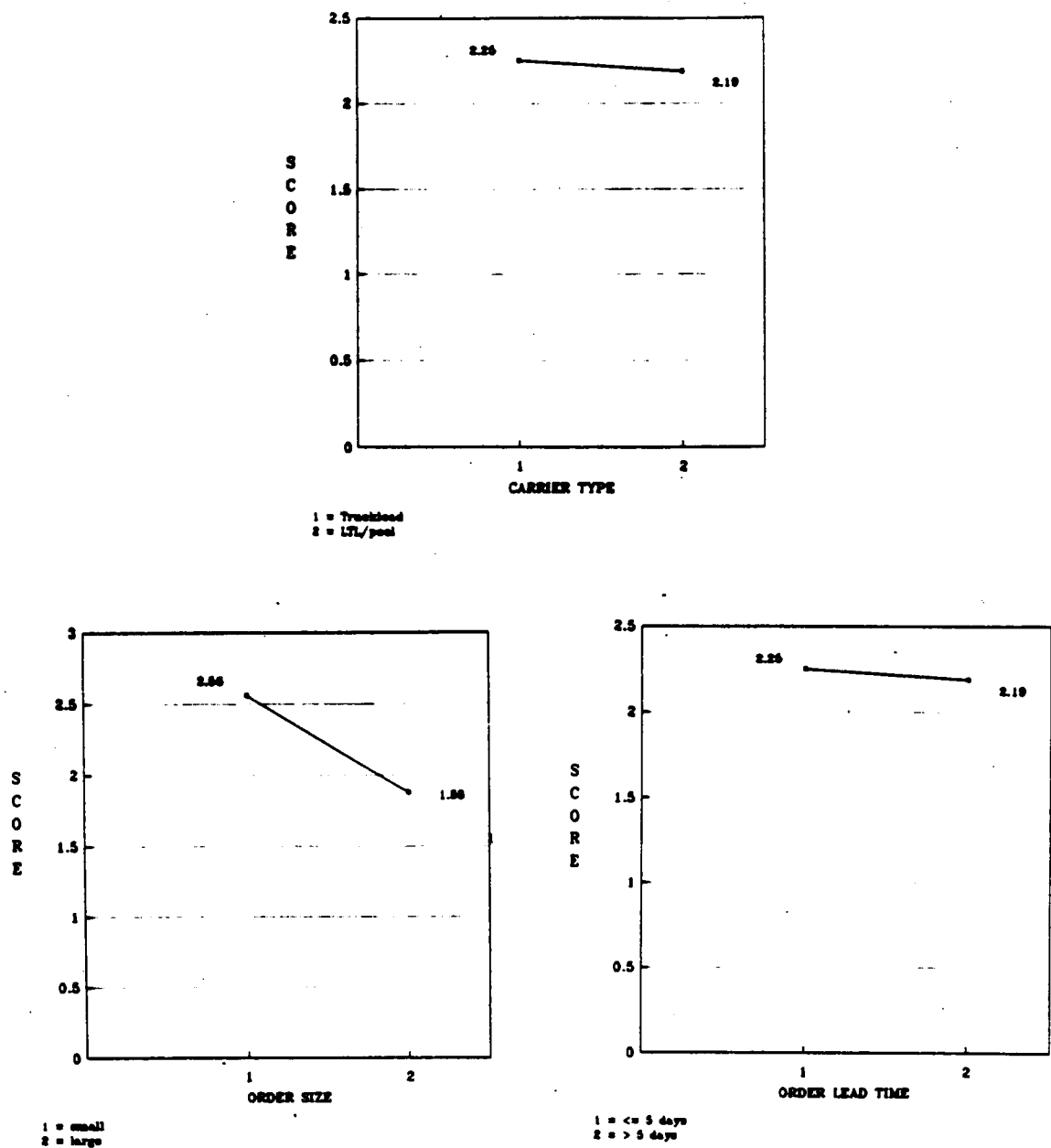


Figure IV-39
Factors for Adjusting the Mean Performance for Promotional Orders
(additive values)

Table IV-59

Response Table for Promotional Orders
(scale values)

	A	B	C	A B	A C	A C	A B C
LEVEL 1	1.15	1.26	1.15	1.06	1.03	1.25	0.99
LEVEL 2	1.00	0.95	1.00	1.10	1.12	0.90	1.16
Difference between levels	0.15	0.25*	0.15	0.04	0.09	0.35*	0.17

A = Carrier type

LEVEL 1 = Truckload

LEVEL 2 = LTL/pool

B. = Order size

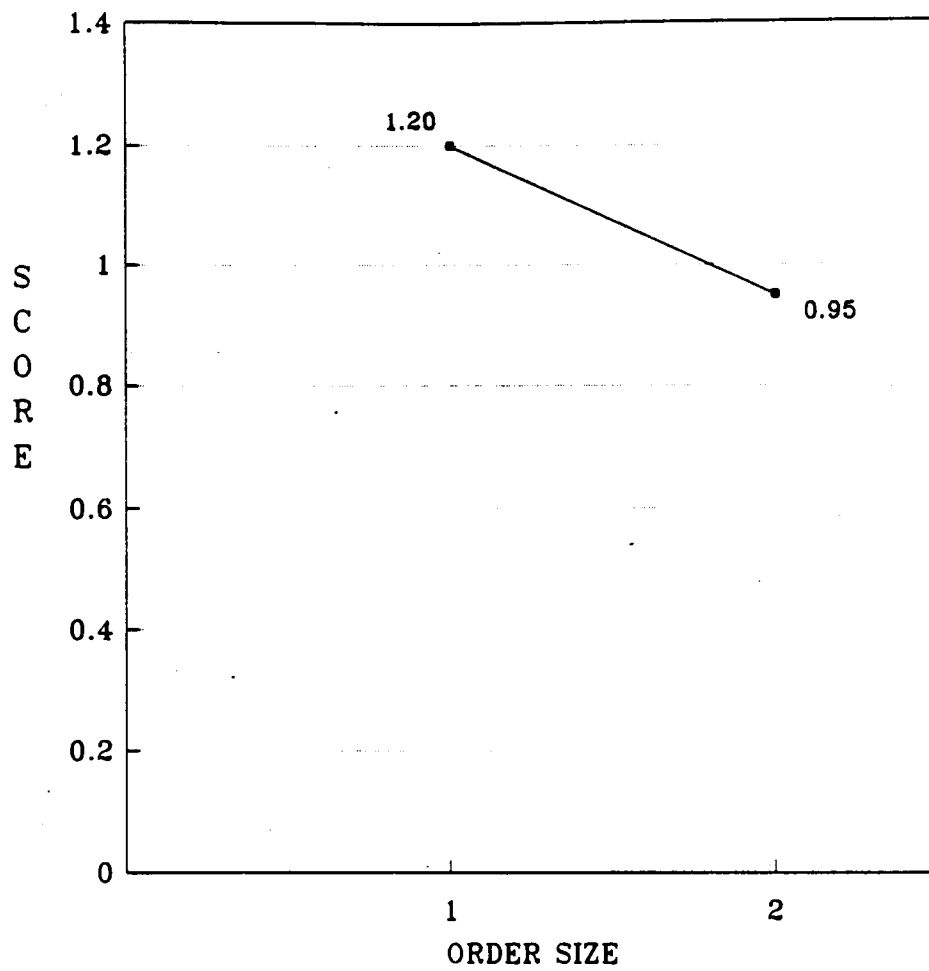
LEVEL 1 = small (less than or equal to 100 cases)

LEVEL 2 = large (more than 100 cases)

C = Lead time

LEVEL 1 = less than or equal to 5 days

LEVEL 2 = more than 5 days



1 = small
2 = large

Figure IV-40
Response Graph for Order Size for Promotional Orders
(scale values)

Table IV-60

Interaction Response Table - Order Size by Order Lead Time
(scale values)

PROMOTIONAL ORDERS

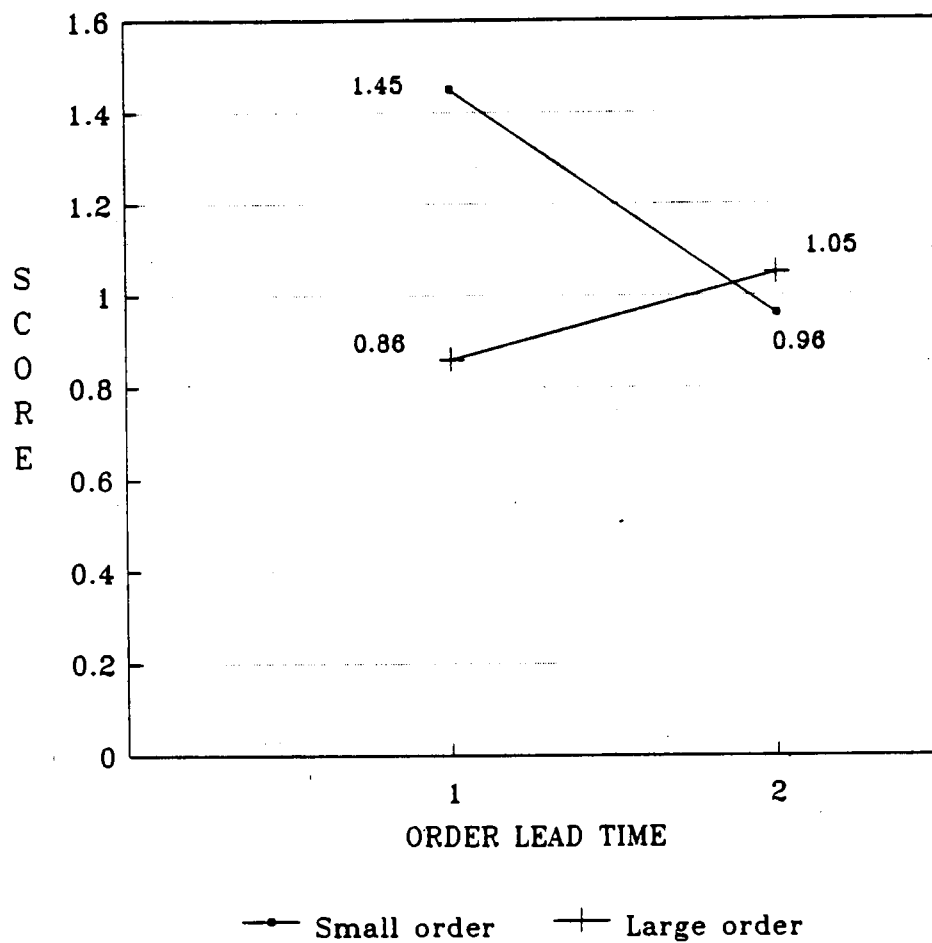
	B1	B2
C1	1.45	0.86
C2	0.96	1.05

B1 = small order

C1 = $\leq$ 5 days

B2 = large order

C2 = $>$ 5 days



1 = ≤ 5 days
2 = > 5 days

Figure IV-41

Interaction Graph - Order Size by Order Lead Time -
for Promotional Orders

(scale values)

Table IV-61

Response Table for Signal-to-Noise Ratios for Promotional Orders
(scale values)

	A	B	C	A B	A C	A C	A B C
LEVEL 1	-1.71	-2.72	-2.53	-1.93	-1.79	-2.12	-2.30
LEVEL 2	-2.34	-1.34	-1.53	-2.13	-2.27	-1.94	-1.76
Difference between levels	0.63	1.38*	1.00*	0.20	0.48	0.18	0.54

A = Carrier type

LEVEL 1 = Truckload

LEVEL 2 = LTL/pool

B = Order size

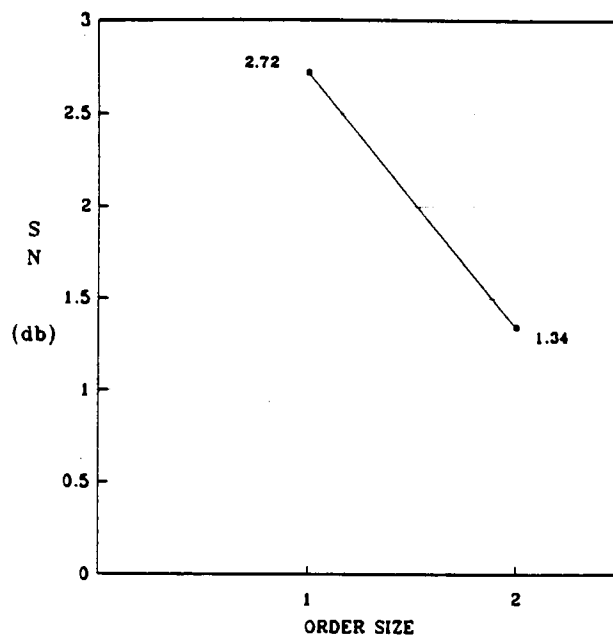
LEVEL 1 = small (less than or equal to 100 cases)

LEVEL 2 = large (more than 100 cases)

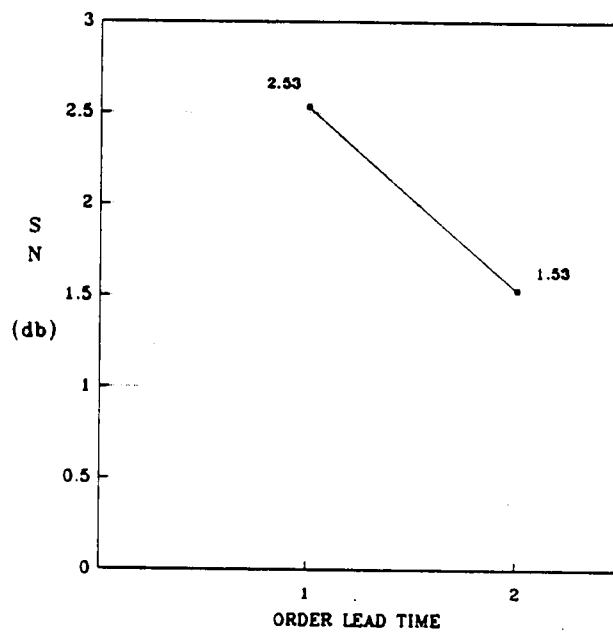
C = Lead time

LEVEL 1 = less than or equal to 5 days

LEVEL 2 = more than 5 days



1 = small order
2 = large order



1 = <= 5 days
2 = > 5 days

Figure IV-42
Factors that Affect Variability of Promotional Orders
(scale values)

Table IV-62

Signal-to-Noise and Sensitivity Measures for Promotional Orders

(scale values)

Control factors	Noise factors				Total	Average	V_e	S_m	S_m (db)	n (db)
	N1	N2	N3	N4						
A1	1.00	1.43	1.26	0.92	4.61	1.15	0.06	5.31	7.25	-1.37
A2	1.16	1.21	1.00	1.21	4.58	1.14	0.01	5.24	7.20	-1.20
B1	1.37	1.43	1.43	1.15	5.38	1.34*	0.02	7.24*	8.60	-2.61*
B2	0.79	1.21	0.83	0.98	3.81	0.95*	0.04	3.63*	5.60	-0.29*
C1	1.16	1.31	0.99	1.15	4.61	1.15	0.02	5.31	7.25	-1.27
C2	1.00	1.33	1.27	0.98	4.58	1.14	0.03	5.24	7.20	-1.26

A1 = Truckload
A2 = LTL/pool

B1 = small order
B2 = large order

C1 = $\leq$ 5 days order lead time
C2 = $>$ 5 days order lead time

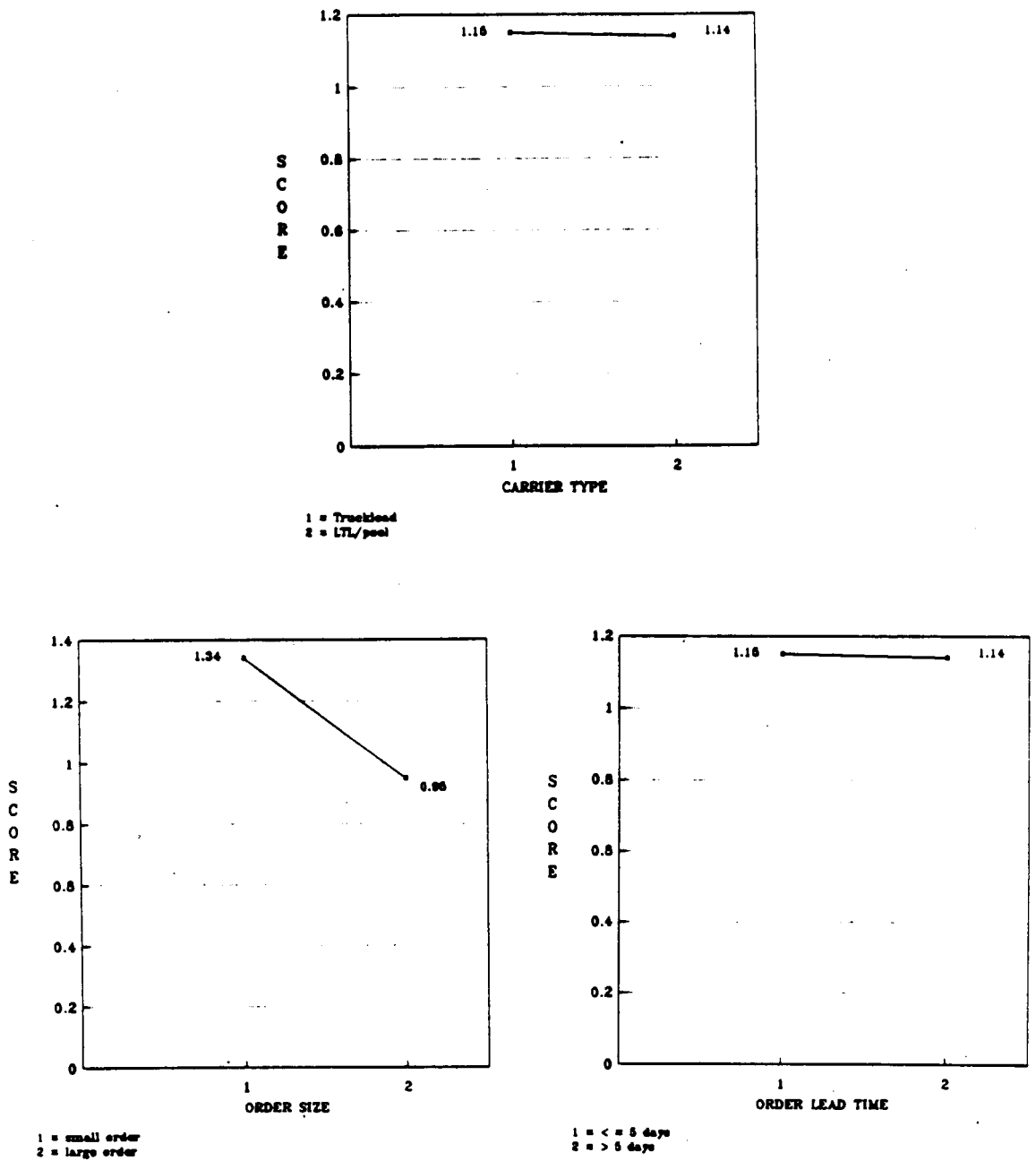


Figure IV-43
Factors for Adjusting the Mean Performance for Promotional Orders
(scale values)

These results differ from the additive values in only one respect. The scale values do not show carrier type as having an affect on performance. Therefore it would be advantageous for the firm to use the most economical choice. However, the additive values indicate that carrier type introduces variation into customer service delivery performance.

Brand Introduction

A similar experiment was conducted for brand introductions as for promotional orders. These events are quite different in that the announcement and subsequent placement of orders for promotional events may occur several months before the actual required delivery. Brand introductions, however, are sometimes one-day start-of-ship notices from marketing for the producing plant. This short time frame has a significant impact on the ability of the customer service delivery process to deliver the "perfect order." It is therefore not surprising that order lead time was determined to have a significant main effect (Table IV-63 and Figure IV-44). Also, depending on the order lead time, certain carrier decisions produce better results (Table IV-64). For example, LTL/pool shipments can do quite well with 5 days or less lead time while more than 5 days usually is best for truckload carriers (Figure IV-45). This result, excepting the carrier type by order lead time interaction, is shown by the scale value analysis as well (Table IV-65 and Figure IV-46).

Table IV-63

Response Table for Brand Introductions
(additive values)

	A	B	C	A B	A C	A C	A B C
LEVEL 1	2.12	2.06	1.87	2.12	1.94	2.12	2.19
LEVEL 2	2.19	2.25	2.44	1.94	2.38	2.19	2.12
Difference between levels	0.07	0.19	0.57*	0.18	0.44*	0.07	0.07

A = Carrier type

LEVEL 1 = Truckload

LEVEL 2 = LTL/pool

B = Order size

LEVEL 1 = small (less than or equal to 100 cases)

LEVEL 2 = large (more than 100 cases)

C = Lead time

LEVEL 1 = less than or equal to 5 days

LEVEL 2 = more than 5 days

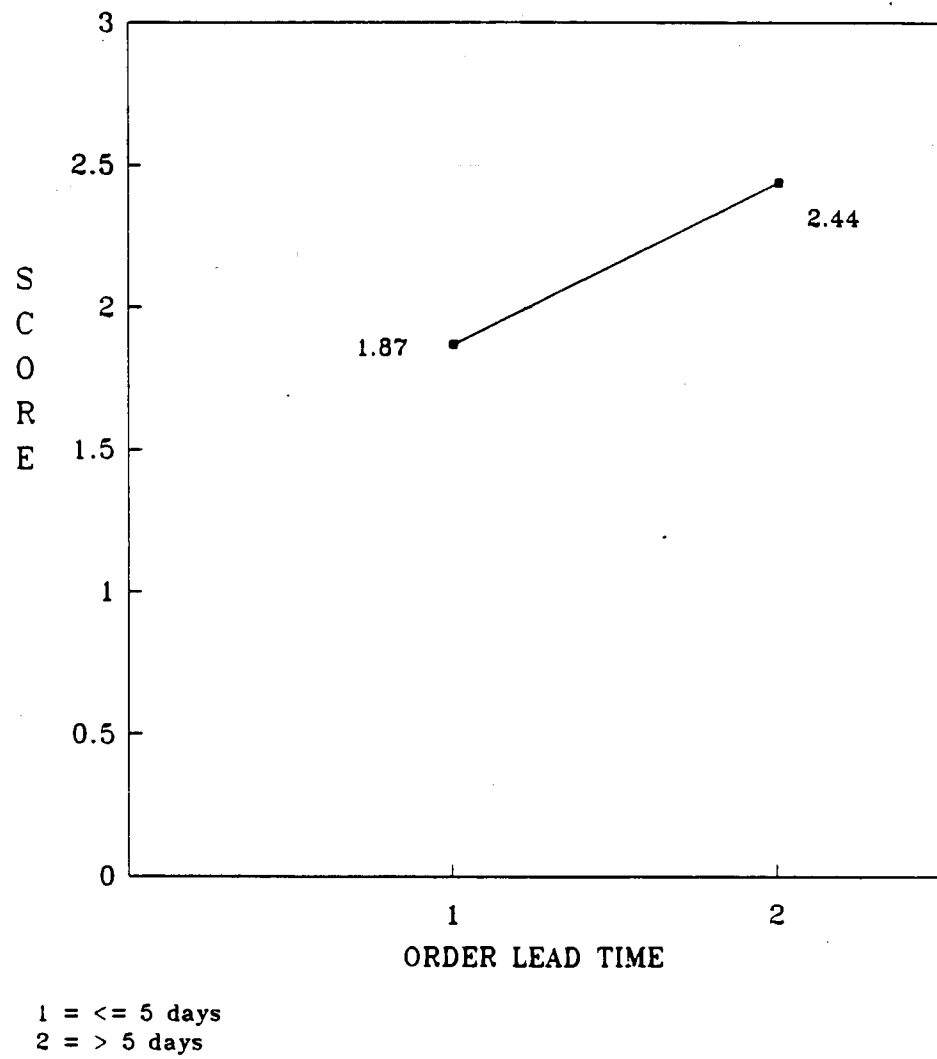


Figure IV-44
Response Graph for Order Lead Time for Brand Introductions
(additive values)

Table IV-64

Interaction Response Table - Carrier Type by Order Lead Time
(additive values)

BRAND INTRODUCTIONS

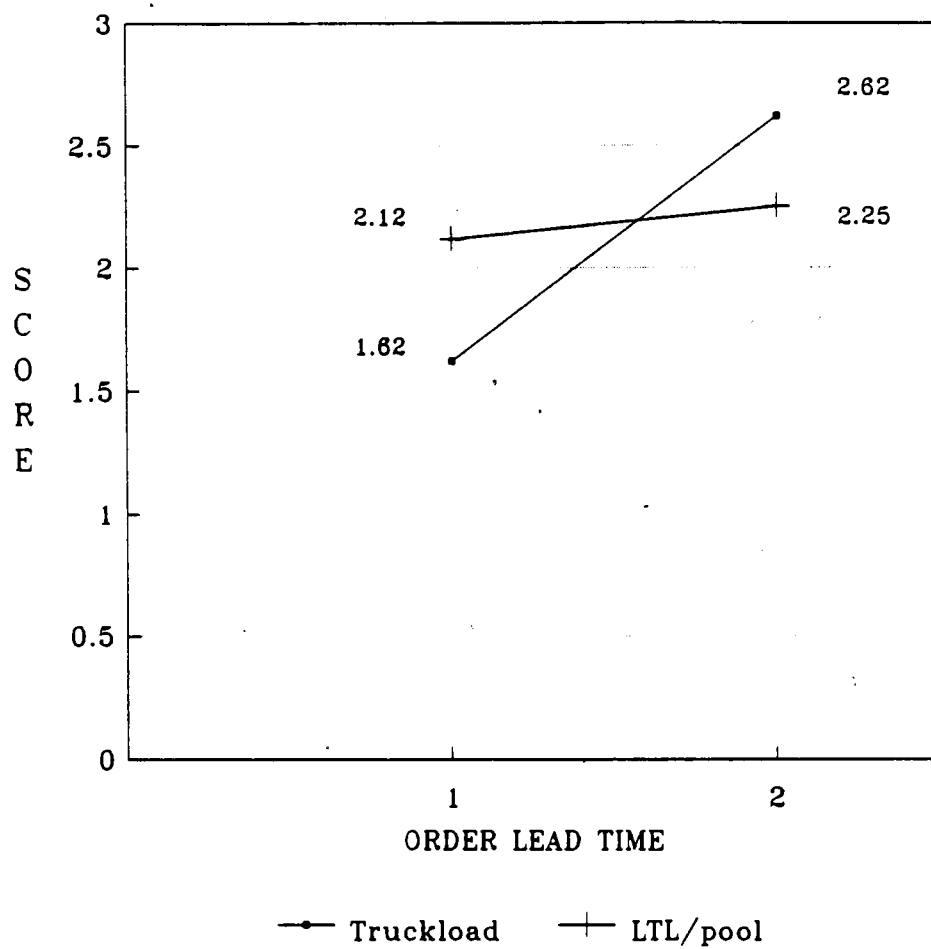
	A1	A2
C1	1.62	2.12
C2	2.62	2.25

A1 = Truckload

C1 = ≤ 5 days

A2 = LTL/pool

C2 = > 5 days



1 = ≤ 5 days
2 = > 5 days

Figure IV-45

Interaction Graph - Carrier Type by Order Lead Time -
for Brand Introductions

(additive values)

Table IV-65

Response Table for Brand Introductions
(scale values)

	A	B	C	A B	A C	A C	A B C
LEVEL 1	1.69	1.50	1.41	1.58	1.49	1.71	1.63
LEVEL 2	1.52	1.71	1.79	1.63	1.72	1.50	1.58
Difference between levels	0.17	0.21	0.38*	0.05	0.23	0.21	0.05

A = Carrier type

LEVEL 1 = Truckload

LEVEL 2 = LTL/pool

B = Order size

LEVEL 1 = small (less than or equal to 100 cases)

LEVEL 2 = large (more than 100 cases)

C = Lead time

LEVEL 1 = less than or equal to 5 days

LEVEL 2 = more than 5 days

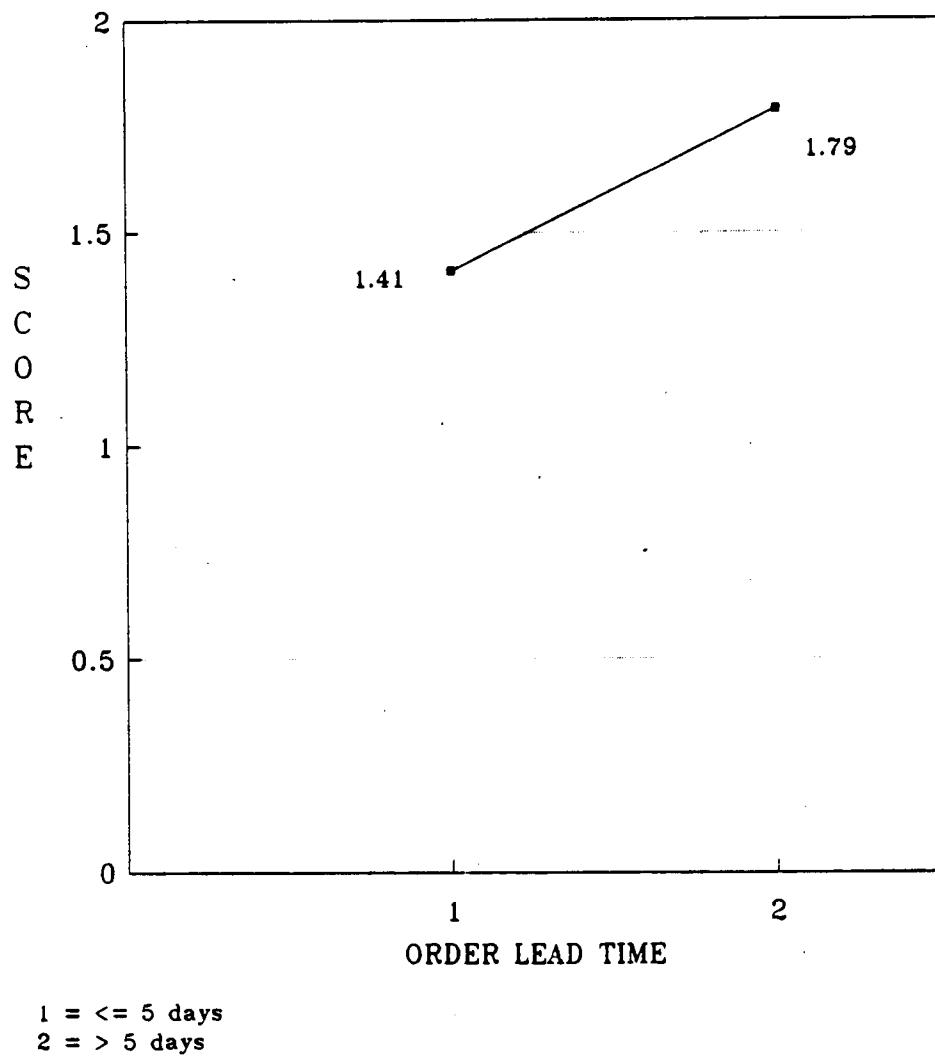


Figure IV-46

Response Graph for Order Lead Time for Brand Introductions

(scale values)

The S/N ratio analysis (both additive and scale values) also indicates that order lead time is a critical factor that affects the variability of brand introductions (Table IV-66 and Table IV-67). The same question of carrier type influence with order lead time arises for the different response measurements. The sensitivity measure (S_m) shows that order lead time can further be used to adjust the mean delivery performance for brand introductions for both additive and scale values (Table IV-68, Figure IV-47, and Table IV-69).

The evaluation of S/N ratios and sensitivity measures presented in Table IV-70 indicate that order size does not affect customer service delivery mean performance or variation. Depending on the response measurement, however, carrier type may produce variability in performance. To effectively change the level of delivery performance of brand introductions, it is obvious from the analysis that order lead time must be carefully considered.

Summary of Phase 2

The major events under consideration - promotional orders and brand introductions - are direct contributors to customer service delivery performance which is not "on target." Each of these events are very different with respect to control factors. For promotional orders, order size has a significant main effect on service delivery performance. In fact, this attribute impacts both average performance on service delivery and contributes to the variability of conformance to requirements. This result can be compared to brand introductions where order

Table IV-66

Response Table for Signal-to-Noise Ratios for Brand Introductions
(additive values)

	A	B	C	A B	A C	A C	A B C
LEVEL 1	-6.53	-6.46	-5.71	-6.73	-5.97	-6.75	-6.82
LEVEL 2	-7.13	-7.20	-7.96	-6.94	-7.69	-6.91	-6.84
Difference between levels	0.60	0.74	2.25*	0.21	1.72*	0.16	0.02

A = Carrier type
LEVEL 1 = Truckload
LEVEL 2 = LTL/pool

B = Order size
LEVEL 1 = small (less than or equal to 100 cases)
LEVEL 2 = large (more than 100 cases)

C = Lead time
LEVEL 1 = less than or equal to 5 days
LEVEL 2 = more than 5 days

Table IV-67

Response Table for Signal-to-Noise Ratios for Brand Introductions
(scale values)

	A	B	C	A B	A C	A C	A B C
LEVEL 1	-4.67	-3.95	-3.43	-4.34	-3.82	-4.81	-4.40
LEVEL 2	-4.07	-4.79	-5.31	-4.40	-4.92	-3.93	-4.34
Difference between levels	0.60	0.84	1.88*	0.06	1.10	0.88	0.06

A = Carrier type

LEVEL 1 = Truckload

LEVEL 2 = LTL/pool

B = Order size

LEVEL 1 = small (less than or equal to 100 cases)

LEVEL 2 = large (more than 100 cases)

C = Lead time

LEVEL 1 = less than or equal to 5 days

LEVEL 2 = more than 5 days

Table IV-68

Signal-to-Noise and Sensitivity Measures for Brand Introductions

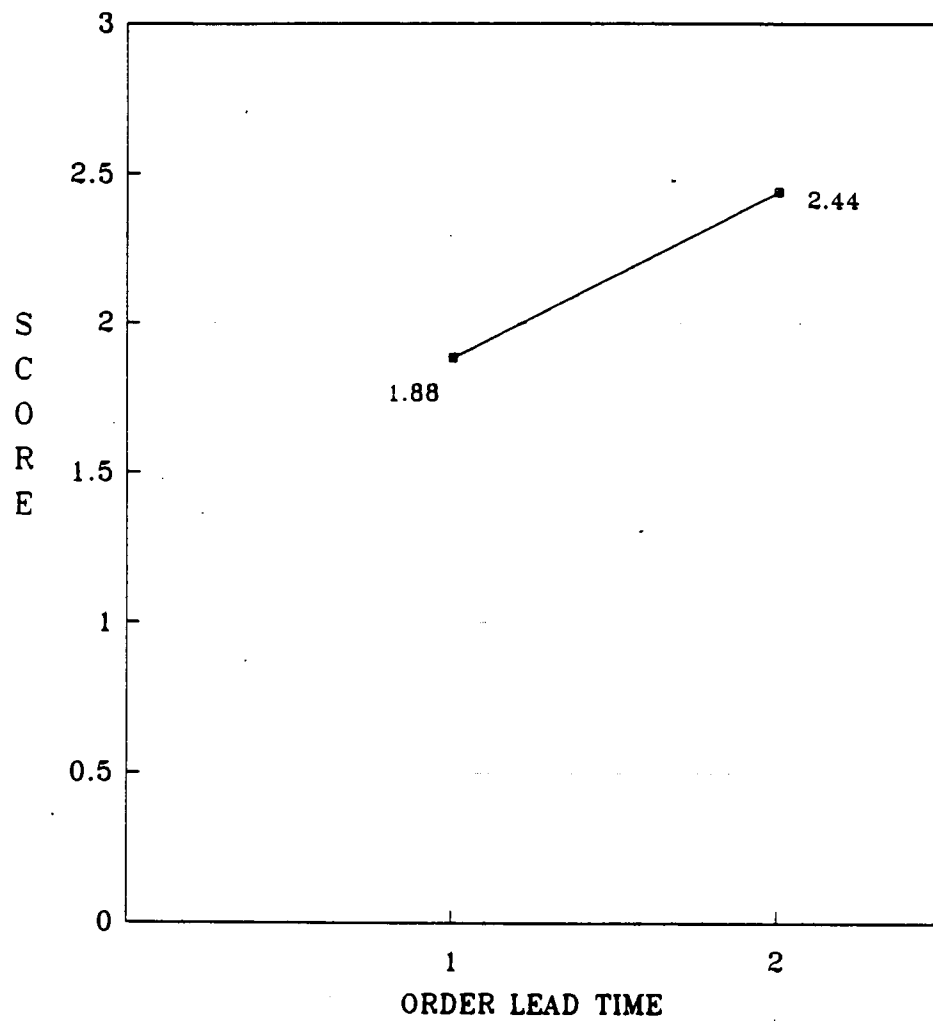
(additive values)

Control factors	<u>Noise factors</u>				Total	Average	V_e	S_m	S_m (db)	n (db)
	N1	N2	N3	N4						
A1	2.00	2.25	2.00	2.25	8.50	2.13	0.02	18.06	12.57	-6.56
A2	2.50	2.00	2.25	2.00	8.75	2.19	0.06	19.14	12.82	-6.84
B1	1.75	2.25	2.50	1.75	8.25	2.06	0.14	17.02	12.31	-6.39
B2	2.75	2.00	1.75	2.50	9.00	2.25	0.21	20.25	13.06	-7.18
C1	2.00	2.00	1.75	1.75	7.50	1.88*	0.05	14.06*	11.48	-5.48*
C2	2.50	2.25	2.50	2.50	9.75	2.44*	0.02	23.77*	13.76	-7.75*

A1 = Truckload
A2 = LTL/pool

B1 = small order
B2 = large order

C1 = $\leq$ 5 days order lead time
C2 = $>$ 5 days order lead time



1 = ≤ 5 days
2 = > 5 days

Figure IV-46

Factors for Adjusting the Mean Performance for
Brand Introductions

(additive values)

Table IV-69

Signal-to-Noise and Sensitivity Measures for Brand Introductions

(scale values)

Control factors	<u>Noise factors</u>				Total	Average	V_e	S_m	S_m (db)	n (db)
	N1	N2	N3	N4						
A1	1.44	1.74	1.91	1.67	6.76	1.69	0.04	11.42	10.58	-4.60
A2	1.73	1.45	1.44	1.45	6.07	1.52	0.02	9.21	9.64	-3.65
B1	1.15	1.74	1.96	1.15	6.00	1.50	0.17	9.00	9.54	-3.76
B2	2.02	1.45	1.38	1.96	6.81	1.70	0.11	11.59	10.64	-4.75
C1	1.45	1.45	1.38	1.38	5.66	1.42*	0.01	8.00*	9.04	-3.02*
C2	1.73	1.74	1.96	1.73	7.16	1.79*	0.01	12.82*	11.08	-5.07

A1 = Truckload
A2 = LTL/pool

B1 = small order
B2 = large order

C1 = $\leq$ 5 days order lead time
C2 = $>$ 5 days order lead time

Evaluation of S/N Ratios and Sensitivity Measures for Brand Introductions

Class I: both average and variation ----- order lead time

Class II: variation only ----- type of carrier

Class III: average only

Class IV: affects neither average
nor variation ----- order size

Class I:	both average and variation -----	order lead time
Class II:	variation only	
Class III:	average only	
Class IV:	affects neither average nor variation -----	type of carrier and order size

size was found to affect neither the average nor variability of performance. Much of this finding can be explained by the longer lead times associated with planning and implementing brand introductions. The interesting part, however, is that for the logistics system brand introductions are sometimes on-day start-of-ship notices. Further research is needed to "sort out" this finding. The data suggest that the push versus pull system definitely produces different outcomes.

Small orders (less than 100 cases) are best handled by the logistics delivery system when the lead time is 5 days or less. Beyond this point, less than desirable performance outcomes are produced, i.e. service deterioration in the form of variability appears to happen. The analysis of brand introductions indicates that order lead time is also critical to service performance. However, the impact is even more significant with this event as both variability and average performance is affected. The research results for Phase 2 also show that small orders are best handled by LTL/pool shipments. This finding is particularly important as the firm would like to benefit from efficiencies through consolidation of shipments without loss in customer service delivery levels.

4. INTEGRATION OF RESEARCH PHASES

Phase 1 and Phase 2 of the dissertation research are different in several respects. First, Phase 1 involved the collection and dissemination of survey data. From the perceptual perspective, this information involved past, present, and

future service delivery. Phase 2, however, dealt only with historical (although quite current) data. Perception of service was not a consideration as this phase measured actual recorded performance. Second, Phase 1 survey research was conducted as a part of the corporate research effort while Phase 2 concerned only the customer base for the particular plant under study.

The differences in approach and method of research design add to the strength and depth of knowledge of research findings. In Phase 1 of the study it was possible to identify the relative preference rankings of various customer service attributes among multi-level alternatives. The ensuing understanding of the trade-offs that various customer groups (market segments) are willing to make among specified attributes permitted the building of customer profiles based on service segmentation factors.

By itself, the analysis in Phase 1 identified variables that offer the best opportunity for the firm to improve its perceived performance with regard to customer service delivery. However, the research at this stage offered little insight into how these attributes performed in combination with other components of the delivery process. The manipulation of customer service variables in Phase 2 identified the settings of parameters to improve the quality of service delivery and reduce variation of performance within the current operating environment.

The customer service measurement system currently in place at the plant for the consumer goods company evaluates each component of service delivery as being of equal importance and value. The research findings of Phase 1 indicate

that while this approach may be used, it will be much more meaningful in the achievement of customer satisfaction to use importance scores such as those calculated from the survey data to compute the "perfect order score" for Phase 2. The utilization of this method of measurement leads to the creation of both quality and customer value.

In summary, the combination of the two phases offers the consumer goods firm specific and actionable information on what customers value most and how the service delivery process must be designed to deliver that value. The methodology identifies opportunities to improve the quality of the customer service delivery process - both from a requirements perspective and actual measured performance within the complicated, current operating environment of regular, promotional, and emergency orders, and new brand introductions.

CHAPTER V

RESEARCH IMPLICATIONS AND FUTURE DIRECTION

This chapter is divided into two sections. Section 1 presents a discussion of the implications of the research findings from the theoretical, methodological, and managerial viewpoint. Section 2 presents future directions and opportunities for research in the area of customer service measurement.

1. IMPLICATIONS OF THE RESEARCH FINDINGS

The traditional concept of value added by logistics has been viewed as that of cost efficiency versus competitive service levels. Throughout the eighties, however, the scope and role of logistics customer service evolved to the extent that strategic tools and techniques were needed to create and implement a value-added logistics process. The underlying premise of the strategic logistics orientation is that value is created when customer satisfaction is achieved. In its continuing quest for new ways to create customer value, the logistics area has evidenced the development of a relatively wide range of methods and approaches which are suited to this task.

The methodology presented in this dissertation research represents a new and innovative approach to the creation of customer value. The overall objective was to develop a comprehensive method for designing, assessing, and improving

customer service offerings. This goal is compatible with today's business environment where new-customer driven strategies are emerging. In the future, successful companies will be even more customer oriented as characterized by the development of value-added products and services and responsiveness to customer needs. To this end, a major contribution of the research was to demonstrate the effectiveness of the methodology as an integral part of the logistics customer service process.

The implications of the research can be categorized from a variety of perspectives, including theoretical, methodological, and managerial. Due to the integrative nature of the dissertation research with the consumer goods company's customer satisfaction research, a considerable amount of effort was spent in the dissemination and transfer of knowledge for managerial edification. This focus by no means lessened the research contribution of a theoretical nature. Indeed, the rigorous questioning and testing of theories underlying this research served to increase the knowledge gained in this area. The methodological contribution is also discussed in this section. The importance of this area is significant in that it forms the very basis for the research itself.

Theoretical Contribution

Although customer service has received a considerable amount of attention as an area of research, the efforts have involved discussions of the concepts, their elements, and their relative importance. The theoretical contribution of this

research effort lies in its ability to provide a method for analyzing the components of customer value, and process design for delivering the right mix of service elements desired.

Past research has indicated that different customer service packages are not only feasible, but highly desirable. This research has suggested that opportunity exists for differentiating the service levels offered to customers. The findings show that "one size fits all" service does not contribute to customer satisfaction or to the perception of high quality service. Also, the customer service mix increases the number of primary attributes that can be adapted to the different levels desired by customers. The various assortments of attributes offer customers a customized bundle, and aids in creating competitive advantage.

The traditional method of quality improvement in the area of logistics and customer service is statistical process control. These tools and techniques represent a "downstream" approach to continuous quality improvement, and are a maintenance device to be used after a process is brought under control. Design of experiment provides a means of improving the performance of the logistics system through understanding of complex relationships among and between customer service delivery attributes and their respective multi-level alternatives.

By utilizing the Taguchi methods and strategies of parameter design in a logistics context, it was possible to develop a robust customer service program based on three delivery attributes. Furthermore, the methodology provides the establishment of a theoretical basis for the design of a customer service delivery

process which does not require the control or elimination of certain causes of variation, while still obtaining "perfect order" performance.

Conformance requirements for customer service delivery features in general fall within a "window" of acceptability. An underlying premise of the research was that the measurement of on-time delivery was shifting from a service performance window (+/- 15 minutes or more) to an "on-target" requirement. While the research findings indicate that certain segments of the customer base are moving in this direction, the majority of customers still determine conformance based on the performance window. The sensitivity to on-time delivery appears to be most closely linked with type of order. The longer the planning horizon (or order lead time), the more important and critical on-time, target delivery becomes.

While customer service has received a considerable amount of attention as an area of research, a large portion of the efforts have dealt with discussions of the concepts, their elements, and their relative importance. Because customer service is a multi-dimensional phenomenon, with significant differences between customer segments, effective measurement must focus on the relevant variables and their relationships. The approach presented in this dissertation offers a means of measurement which is sufficient for the establishment of customer service policies.

Methodological Contribution

A number of studies have been conducted over the years by various researchers on determining requirements for logistics customer service. These studies have ranged from generic in form ("average" customer requirements) to specific customer needs. The attainment of value and customer satisfaction requires a method which helps the firm identify the service delivery attributes that customers value the most, and provides structure for designing the process to deliver that value. While it is possible to ascertain the value of each feature of the customer service delivery process, it is much more difficult to understand how to design a system to provide the right mix of the service elements which are desired.

The development of this methodology provides the following to the discipline and industry knowledge and understanding of the customer service delivery process and its importance in creating value:

- o a method for understanding the trade-offs that various customer groups (market segments) are willing to make among specified attributes;
- o the ability to build customer service profiles based on delivery service attributes;
- o a means of defining what customer service delivery attributes offer the firm the best opportunity to improve its perceived and measured performance;

- o a method for identifying customer service parameters that have a large influence on the mean value and variation of the delivery process;
- o the ability to determine those customer service parameters that have no detectable influence on service delivery performance; and
- o the design of a customer service program whose performance is not sensitive to variations in the operating environment.

Overall, the methodology offers the firm a means of determining the importance of a number of services, and then provides an approach to deliver better service on those items considered to be of highest value.

In Phase 1 of the research, conjoint measurement was utilized as a means of determining customer preferences among multi-attribute alternatives. Although this methodology has been utilized in other methodological frameworks to add to the knowledge and understanding of the customer service component in the logistics function, it has not been used to identify the mix of elements of customer service for which reduced variability in performance would lead to higher quality perception.

The traditional method of quality improvement has been statistical quality control. At best, the tools and techniques associated with this approach are a maintenance device to be used only after the process is brought under control. Improvements in the design of the customer service delivery process through statistical experimentation will provide significant gains in the performance of the

logistics system, and are more meaningful in the long run. For this reason, the Taguchi method of parameter design has been utilized in this research to demonstrate the potential contribution of this approach.

To date, applications of the Taguchi method in the U.S. have focused mostly on improving production processes. There are relatively few existing applications of the Taguchi strategy in the service area. None of these have been published other than for internal distribution purposes. The dissertation was not solely a study of the Taguchi methods. The major contribution of this approach was its demonstrated effectiveness as an integral part of the logistics customer service process in the creation of value. By utilizing the Taguchi methods and strategies, it was also possible to evaluate and assess means of achieving "on-target" performance through reduction and elimination of variation.

The different approaches and methods used in the research add to the strength and depth of knowledge of the research findings. Not only was it possible to identify elements of value to the customer service delivery process, but it was also possible to measure this attribute's influence on the performance of the system itself. The methodology employed in Phase 1 offered little insight into how statistically significant attributes perform in combination with other components of the delivery process. But when these results are used as input to the Phase 2 methodology it is possible to improve on the determinants of customer value.

Managerial Contribution

The basic challenge facing logistics professionals and top management in the 1990s is the creation of customer value. The achievement of customer satisfaction will involve much more than just simply having the "right product, at the right place, at the right time, in the right quantity, and in the right condition." The dissertation research confirmed other reported evidence that the customer service component will become more important in the future as compared with product, price, or promotion. Continuous quality improvement produces superior customer service performance in the value-added logistics system. This approach requires the informed application of a wide range of new and existing quality technology to be used within the firm's process of service delivery, such as the methodology developed and presented in this dissertation.

Customer value is enhanced by adopting a total channel perspective of the logistics function. The integration of attributes such as customization and responsiveness result in highly valued and expected levels of service that become the new standard for competitive advantage. The development of the methodology for this dissertation has made it possible for management to identify opportunities for the firm which will lead to superior quality performance. The approach also represents a new and innovative way of helping the firm achieve on-target process specifications. Although the research has indicated that this objective is not a "given" in today's operating environment, it most certainly will be the criteria for competition of the future.

On a fundamental level, several research findings contribute to the significance of the effort. First, customer service delivery was reported as the most important driver of overall quality for buyers. The data further indicated that the largest improvement in overall quality perception can be achieved through superior performance in customer service delivery. The importance of customer service delivery and its contribution to quality is somewhat in conflict with pre-test results which indicated that logistics/transportation had little to no influence on the buying process itself. The implication is that many firms still do not realize the scope and role that logistics can play in creating value and sustaining competitive advantage.

Second, of the two customer groups - buyers and warehouse managers - only buyers differentiate requirements by type of order. The data suggest that warehouse managers deliver "vanilla" service to all customers and for all types of orders. This finding is of particular importance in that the conflicting conformance specifications sometimes exist with channel participants in the same organization. Until this conflict is resolved, it will not be possible to achieve a high degree of customer satisfaction.

While the research has indicated that the standard for on-time delivery is still predominantly the service window, the proportion of customers that require target performance is increasing. Target performance is not a "given" in today's operating environment, but it most certainly will be the criteria for competition of the future. The proportional increases in customer groups (market segments)

which report this as a desired performance criteria is indicative of the evolving trend. Competitiveness in the 1990s will require firms to provide product and services with less variation and consistent performance across the entire mix of elements.

2. FUTURE DIRECTION

Due to the specificity of the research within industry and company, it was not possible to generalize the results. While this does not diminish the knowledge gained regarding the measurement and creation of customer value, much more can be learned by replicating these results in different settings. In order to accomplish this, further research must be conducted in other industries or product divisions with similar results obtained. The experience gained in developing the survey instrument - from both a content and implementation perspective - will be utilized in subsequent research.

In order to more fully develop the design of experiment approach for customer service measurement, a more comprehensive management information system is needed. The management and understanding of customer service elements using this methodology will require a certain degree of disaggregated measurement information on performance. To date, this level of detail is not readily available. Future effort will be required to help firms collect the necessary data to fully utilize the methodology developed and proposed in this dissertation.

While the results have been demonstrated as an essential and critical part of understanding and creating customer value, and ultimately increasing customer satisfaction, further research is needed in the design of experiments area. First, a confirmation test should be conducted to confirm/disconfirm the results of the Taguchi parameter design. To accomplish this, a select group of customers must be solicited to participate in a "controlled" environment. The ensuing measurement of customer satisfaction will serve to test the validity of the methodology utilized for this research. Second, the control group should also be used to test the viability of differentiation based on customer service levels. Once again, perception of quality and value of service will prove to be an effective measure.

The research findings indicate that certain segments of the customer base require service responsiveness. However, the majority of customers still determine conformance based on a wide range of acceptability. In cases where sensitivity appears to exist, such as on-time delivery, understanding of how to provide and deliver responsiveness to customers is needed. To key to this task is further research on customer segmentation based on service delivery requirement configurations.

The research indicated that buyers clearly differentiate service responsiveness based on type of order. Warehouse managers, however, did not perceive this differentiation. These findings have created an awareness that the delivery of benefits through service responsiveness is being greatly impacted by a

channel participant. Furthermore, this participant may be in direct conflict with other members in his/her organization regarding performance criteria.

Competitiveness in the 1990s will require manufacturing firms to provide products with less variation and consistent performance. The scope and role of logistics in the manufacturing sector is expanding beyond the integrated concept to the extent that a customized bundle of logistics benefits is highly desirable. As the customer service mix increases the number of primary attributes that can be adapted to the different levels desired by customers, customer value increases. The advantage will be gained by those firms that build service responsiveness into the delivery process to the degree that it becomes a major function with considerable impact on the organization's profitability and competitive advantage.

The findings of this research suggest that one of the managerial challenges is to develop ways of furthering the understanding of service responsiveness throughout the entire logistics channel. This process will require some degree of resolution of internal conflict for service delivery responsiveness by the customer. In addition, the provider must more fully explore the opportunity that exists through the creation of service responsiveness. Further research is needed to quantify the possible benefits. In the current value-driven environment, the "ante to the game" is constantly being raised. Therefore, companies that demonstrate superior service will become the strategic leaders of the future.

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APPENDICES

APPENDIX A

EMERGENCY ORDERS

Experimental Design

No.	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	2	2	2	2	2	2	2	2	2
3	1	1	1	1	3	3	3	3	3	3	3	3	3
4	1	2	2	2	1	1	1	2	2	2	3	3	3
5	1	2	2	2	2	2	2	3	3	3	1	1	1
6	1	2	2	2	3	3	3	1	1	1	2	2	2
7	1	3	3	3	1	1	1	3	3	3	2	2	2
8	1	3	3	3	2	2	2	1	1	1	3	3	3
9	1	3	3	3	3	3	3	2	2	2	1	1	1
10	2	1	2	3	1	2	3	1	2	3	1	2	3
11	2	1	2	3	2	3	1	2	3	1	2	3	1
12	2	1	2	3	3	1	2	3	1	2	3	1	2
13	2	2	3	1	1	2	3	2	3	1	3	1	2
14	2	2	3	1	2	3	1	3	1	2	1	2	3
15	2	2	3	1	3	1	2	1	2	3	2	3	1
16	2	3	1	2	1	2	3	3	1	2	2	3	1
17	2	3	1	2	2	3	1	1	2	3	3	1	2
18	2	3	1	2	3	1	2	2	3	1	1	2	3
19	3	1	3	2	1	3	2	1	3	2	1	3	2
20	3	1	3	2	2	1	3	2	1	3	2	1	3
21	3	1	3	2	3	2	1	3	2	1	3	2	1
22	3	2	1	3	1	3	2	2	1	3	3	2	1
23	3	2	1	3	2	1	3	3	2	1	1	3	2
24	3	2	1	3	3	2	1	1	3	2	2	1	3

EMERGENCY ORDERS (continued)

Experimental Design

25	3	3	2	1	1	3	2	3	2	1	2	1	3
26	3	3	2	1	2	1	3	1	3	2	3	2	1
27	3	3	2	1	3	2	1	2	1	3	1	3	2

a	b	a	a	c	a	a	b	a	a	b	a	a
		b	b ²		c	c ²	c	b	b ²	c ²	b ²	b
							c	c ²			c	c ²

PROMOTIONAL ORDERS

Experimental Design

No.	1	2	3	4	5	6	7	8	9	10
1	1	1	1	1	1	1	1	1	1	1
2	1	1	2	2	2	2	2	2	2	2
3	1	1	3	3	3	3	3	3	3	3
4	1	1	4	4	4	4	4	4	4	4
5	1	2	1	1	2	2	3	3	4	4
6	1	2	2	2	1	1	4	4	3	3
7	1	2	3	3	4	4	1	1	2	2
8	1	2	4	4	3	3	2	2	1	1
9	1	3	1	2	3	4	1	2	3	4
10	1	3	2	1	4	3	2	1	4	3
11	1	3	3	4	1	2	3	4	1	2
12	1	3	4	3	2	1	4	3	2	1
13	1	4	1	2	4	3	3	4	2	1
14	1	4	2	1	3	4	4	3	1	2
15	1	4	3	4	2	1	1	2	4	3
16	1	4	4	3	1	2	2	1	3	4
17	2	1	1	4	1	4	2	3	2	3
18	2	1	2	3	2	3	1	4	1	4
19	2	1	3	2	3	2	4	1	4	1
20	2	1	4	1	4	1	3	2	3	2
21	2	2	1	4	2	3	4	1	3	2
22	2	2	2	3	1	4	3	2	4	1
23	2	2	3	2	4	1	2	3	1	4
24	2	2	4	1	3	2	1	4	2	3

PROMOTIONAL ORDERS (continued)

Experimental Design

25	2	3	1	3	3	1	2	4	4	2
26	2	3	2	4	4	2	1	3	3	1
27	2	3	3	1	1	3	4	2	2	4
28	2	3	4	2	2	4	3	1	1	3
29	2	4	1	3	4	2	4	2	1	3
30	2	4	2	4	3	1	3	1	2	4
31	2	4	3	1	2	4	2	4	3	1
32	2	4	4	2	1	3	1	3	4	2

APPENDIX B

WAREHOUSE SURVEY, PROMOTIONAL ORDERS ANALYSIS

PREFERRED UNDAMAGED

VALUE	COUNT	VALID %	PERCENT	CUMULATIVE%
97.000	1	.024	.024	.024
98.000	1	.024	.024	.048
99.000	12	.286	.286	.333
100.000	28	.667	.667	1.000
=====				
	42	1.000	1.000	1.000

UNACCEPTABLE DAMAGE

VALUE	COUNT	VALID %	PERCENT	CUMULATIVE%
90.000	7	.167	.167	.167
92.000	1	.024	.024	.190
93.000	1	.024	.024	.214
95.000	11	.262	.262	.476
96.000	2	.048	.048	.524
97.000	2	.048	.048	.571
98.000	7	.167	.167	.738
99.000	7	.167	.167	.905
100.000	4	.095	.095	1.000
=====				
	42	1.000	1.000	1.000

PREFERRED ON TIME

VALUE	COUNT	VALID %	PERCENT	CUMULATIVE%
.000	23	.548	.548	.548
1.000	1	.024	.024	.571
2.000	7	.167	.167	.738
4.000	6	.143	.143	.881
8.000	5	.119	.119	1.000
=====				
	42	1.000	1.000	1.000

WAREHOUSE SURVEY, EMERGENCY ORDERS ANALYSIS

PREFERRED UNDAMAGED

VALUE	COUNT	VALID %	PERCENT	CUMULATIVE%
97.000	2	.048	.048	.048
98.000	3	.071	.071	.119
99.000	11	.262	.262	.381
100.000	26	.619	.619	1.000
=====				
	42	1.000	1.000	1.000

UNACCEPTABLE DAMAGE

VALUE	COUNT	VALID %	PERCENT	CUMULATIVE%
90.000	8	.190	.190	.190
92.000	2	.048	.048	.238
94.000	1	.024	.024	.262
95.000	13	.310	.310	.571
96.000	2	.048	.048	.619
97.000	1	.024	.024	.643
98.000	5	.119	.119	.762
99.000	5	.119	.119	.881
100.000	5	.119	.119	1.000
=====				
	42	1.000	1.000	1.000

PREFERRED ON TIME

VALUE	COUNT	VALID %	PERCENT	CUMULATIVE%
.000	25	.595	.595	.595
1.000	2	.048	.048	.643
2.000	5	.119	.119	.762
4.000	7	.167	.167	.929
8.000	2	.048	.048	.976
12.000	1	.024	.024	1.000
=====				
	42	1.000	1.000	1.000

UNACCEPTABLE ON TIME

VALUE	COUNT	VALID %	PERCENT CUMULATIVE%	
1.000	1	.024	.024	.024
2.000	1	.024	.024	.048
3.000	1	.024	.024	.071
4.000	11	.262	.262	.333
5.000	1	.024	.024	.357
8.000	8	.190	.190	.548
12.000	7	.167	.167	.714
16.000	12	.286	.286	1.000
=====				
	42	1.000	1.000	1.000

BUYER SURVEY, PROMOTIONAL ORDERS ANALYSIS

PREFERRED COMPLETE

VALUE	COUNT	VALID %	PERCENT CUMULATIVE%	
95.000	1	.023	.023	.023
96.000	3	.070	.070	.093
98.000	4	.093	.093	.186
99.000	10	.233	.233	.419
100.000	25	.581	.581	1.000
=====				
	43	1.000	1.000	1.000

UNACCEPTABLE COMPLETE

VALUE	COUNT	VALID %	PERCENT CUMULATIVE%	
80.000	6	.140	.140	.140
85.000	1	.023	.023	.163
88.000	2	.047	.047	.209
90.000	12	.279	.279	.488
91.000	1	.023	.023	.512
92.000	2	.047	.047	.558
93.000	1	.023	.023	.581
94.000	1	.023	.023	.605
95.000	4	.093	.093	.698
96.000	7	.163	.163	.860
97.000	2	.047	.047	.907
98.000	4	.093	.093	1.000
=====				
	43	1.000	1.000	1.000

PREFERRED ON TIME

VALUE	COUNT	VALID %	PERCENT CUMULATIVE%	
.000	27	.628	.628	.628
.500	1	.023	.023	.651
1.000	4	.093	.093	.744
2.000	9	.209	.209	.953
4.000	1	.023	.023	.977
8.000	1	.023	.023	1.000
=====				
	43	1.000	1.000	1.000

UNACCEPTABLE ON TIME

VALUE	COUNT	VALID %	PERCENT CUMULATIVE%	
.500	2	.047	.047	.047
1.000	2	.047	.047	.093
2.000	7	.163	.163	.256
2.500	1	.023	.023	.279
3.000	4	.093	.093	.372
4.000	10	.233	.233	.605
5.000	2	.047	.047	.651
6.000	5	.116	.116	.767
8.000	10	.233	.233	1.000
=====				
	43	1.000	1.000	1.000

BUYER SURVEY, EMERGENCY ORDERS ANALYSIS

PREFERRED COMPLETE

VALUE	COUNT	VALID %	PERCENT CUMULATIVE%	
90.000	2	.047	.047	.047
94.000	1	.023	.023	.070
95.000	2	.047	.047	.116
96.000	3	.070	.070	.186
98.000	6	.140	.140	.326
99.000	8	.186	.186	.512
100.000	21	.488	.488	1.000
=====				
	43	1.000	1.000	1.000

UNACCEPTABLE COMPLETE

VALUE	COUNT	VALID %	PERCENT CUMULATIVE%	
80.000	8	.186	.186	.186
83.000	1	.023	.023	.209
85.000	2	.047	.047	.256
86.000	2	.047	.047	.302
88.000	2	.047	.047	.349
90.000	10	.233	.233	.581
91.000	1	.023	.023	.605
92.000	2	.047	.047	.651
93.000	2	.047	.047	.698
94.000	4	.093	.093	.791
95.000	2	.047	.047	.837
96.000	2	.047	.047	.884
97.000	2	.047	.047	.930
98.000	2	.047	.047	.977
100.000	1	.023	.023	1.000
=====				
	43	1.000	1.000	1.000

PREFERRED CYCLE

VALUE	COUNT	VALID %	PERCENT CUMULATIVE%	
1.000	6	.140	.140	.140
2.000	6	.140	.140	.279
3.000	2	.047	.047	.326
4.000	1	.023	.023	.349
5.000	17	.395	.395	.744
6.000	5	.116	.116	.860
7.000	1	.023	.023	.884
8.000	3	.070	.070	.953
10.000	2	.047	.047	1.000
=====				
	43	1.000	1.000	1.000

UNACCEPTABLE CYCLE

VALUE	COUNT	VALID %	PERCENT CUMULATIVE%	
4.000	1	.023	.023	.023
5.000	3	.070	.070	.093
6.000	2	.047	.047	.140
7.000	1	.023	.023	.163
8.000	5	.116	.116	.279
9.000	7	.163	.163	.442
10.000	23	.535	.535	.977
14.000	1	.023	.023	1.000
=====				
	43	1.000	1.000	1.000

PREFERRED ON TIME

VALUE	COUNT	VALID %	PERCENT CUMULATIVE%	
.000	23	.535	.535	.535
.250	3	.070	.070	.605
.500	1	.023	.023	.628
1.000	8	.186	.186	.814
2.000	5	.116	.116	.930
3.000	1	.023	.023	.953
4.000	2	.047	.047	1.000
=====				
	43	1.000	1.000	1.000

UNACCEPTABLE ON TIME

VALUE	COUNT	VALID %	PERCENT CUMULATIVE%	
.000	1	.023	.023	.023
.250	2	.047	.047	.070
.500	2	.047	.047	.116
1.000	1	.023	.023	.140
1.500	2	.047	.047	.186
2.000	10	.233	.233	.419
2.500	1	.023	.023	.442
3.000	8	.186	.186	.628
3.500	1	.023	.023	.651
4.000	15	.349	.349	1.000
=====				
	43	1.000	1.000	1.000

PREFERRED CYCLE

VALUE	COUNT	VALID %	PERCENT CUMULATIVE%	
1.000	23	.535	.535	.535
2.000	17	.395	.395	.930
2.500	1	.023	.023	.953
3.000	2	.047	.047	1.000
=====				
	43	1.000	1.000	1.000

UNACCEPTABLE CYCLE

VALUE	COUNT	VALID %	PERCENT CUMULATIVE%	
2.000	3	.070	.070	.070
2.500	3	.070	.070	.140
3.000	16	.372	.372	.512
4.000	21	.488	.488	1.000
=====				
	43	1.000	1.000	1.000

APPENDIX C

Table C-1

Z-Values Related to Reference Proportions for Regular Orders

WAREHOUSE

Attribute	4	7	5	6	3	2	1
4	-	0.18	0.30	0.30	0.37	0.80	0.90
7	-0.18	-	- 0.30	-0.12	0.30	0.70	0.80
5	-0.30	0.03	-	0.09	0.18	0.40	0.40
6	-0.30	0.12	-0.09	-	0.06	0.30	0.40
3	-0.37	-0.30	-0.18	-0.06	-	0.20	0.30
2	-0.79	-0.71	-0.37	-0.30	-0.18	-	0.70
1	-0.88	-0.79	-0.43	-0.43	-0.30	-0.70	-
Z Total	-2.82	-1.48	-0.79	-0.52	0.43	1.64	3.55

1 = Length of order cycle

2 = On-time delivery

3 = Completeness of shipments

4 = Unitized delivery

5 = Upcharge for special delivery options

6 = Order status information

7 = Damage control

Table C-2

Scale Values and Discrepancies for Regular Orders

WAREHOUSE

Attribute	4	7	5	6	3	2	1
SCALE VALUE	0.00	0.19	0.29	0.33	0.46	0.64	0.91
4	-	-	-	-	-	-	-
7	0.42	-	-	-	-	-	-
5	0.39	0.46	-	-	-	-	-
6	0.37	0.44	0.48	-	-	-	-
3	0.32	0.39	0.43	0.45	-	-	-
2	0.26	0.33	0.36	0.38	0.43	-	-
1	0.18	0.24	0.27	0.28	0.33	0.40	-

Average discrepancy = 0.0371

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized delivery
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

Table C-3

Z-Values Related to Reference Proportions for Promotional Orders

WAREHOUSE

Attribute	4	5	7	6	3	2	1
4	-	0.06	0.52	0.52	0.38	0.80	1.00
5	-0.06	-	0.25	0.19	0.32	0.60	0.70
7	-0.52	-0.25	-	0.03	0.25	0.70	0.80
6	-0.52	-0.19	-0.03	-	-0.06	0.30	0.50
3	-0.38	-0.32	-0.25	0.06	-	0.40	0.50
2	-0.75	-0.60	-0.67	-0.32	-0.38	-	0.70
1	-1.04	-0.67	-0.75	-0.45	-0.45	-0.70	-
Z Total	-3.29	-1.97	-0.94	0.03	0.05	2.06	4.05

1 = Length of order cycle

2 = On-time delivery

3 = Completeness of shipments

4 = Unitized delivery

5 = Upcharge for special delivery options

6 = Order status information

7 = Damage control

Table C-4

Scale Values and Discrepancies for Promotional Orders

WAREHOUSE

Attribute	4	5	7	6	3	2	1
SCALE VALUE	0.00	0.19	0.34	0.47	0.47	0.77	1.05
4	-	-	-	-	-	-	-
5	0.42	-	-	-	-	-	-
7	0.37	0.44	-	-	-	-	-
6	0.32	0.39	0.44	-	-	-	-
3	0.32	0.39	0.44	0.50	-	-	-
2	0.22	0.28	0.33	0.39	0.39	-	-
1	0.15	0.19	0.24	0.28	0.28	0.40	-

Average discrepancy = 0.0384

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized delivery
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

Table C-5

Z-Values Related to Reference Proportions for Emergency Orders

WAREHOUSE

Attribute	4	6	5	7	3	2	1
4	-	0.29	0.29	0.36	0.43	1.00	1.30
6	-0.29	-	0.03	0.26	0.36	0.60	0.80
5	-0.29	-0.03	-	0.16	0.29	0.70	0.70
7	-0.36	-0.26	-0.16	-	0.29	0.70	0.80
3	-0.43	-0.36	-0.29	-0.29	-	0.60	0.80
2	-1.02	-0.58	-0.65	-0.65	-0.58	-	0.90
1	-1.27	-0.82	-0.74	-0.82	-0.82	-0.90	-
Z Total	-3.67	-1.76	-1.52	-0.99	-0.02	2.57	5.39

1 = Length of order cycle

2 = On-time delivery

3 = Completeness of shipments

4 = Unitized delivery

5 = Upcharge for special delivery options

6 = Order status information

7 = Damage control

Table C-6

Scale Values and Discrepancies for Emergency Orders

WAREHOUSE

Attribute	4	6	5	7	3	2	1
SCALE VALUE	0.00	0.28	0.31	0.38	0.53	0.89	1.30
4	-	-	-	-	-	-	-
6	0.39	-	-	-	-	-	-
5	0.38	0.49	-	-	-	-	-
7	0.35	0.46	0.47	-	-	-	-
3	0.30	0.40	0.41	0.44	-	-	-
2	0.19	0.27	0.28	0.30	0.35	-	-
1	0.10	0.15	0.16	0.18	0.22	0.30	-

Average discrepancy = 0.0380

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized delivery
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

Table C-7

Z-Values Related to Reference Proportions for Regular Orders

BUYER

Attribute	4	6	5	7	3	2	1
4	-	- 0.03	0.48	0.48	0.77	1.50	1.70
6	0.03	-	0.34	0.15	0.69	1.20	1.20
5	-0.48	-0.34	-	0.28	0.77	1.20	1.50
7	-0.48	-0.15	-0.28	-	0.48	0.90	1.10
3	-0.77	-0.69	-0.77	-0.48	-	0.00	0.20
2	-1.45	-1.17	-1.17	-0.86	-0.03	-	0.40
1	-1.66	-1.17	-1.45	-1.05	-0.22	-0.40	-
Z Total	-4.80	-3.55	-2.85	-1.48	2.47	4.26	5.95

1 = Length of order cycle

2 = On-time delivery

3 = Completeness of shipments

4 = Unitized delivery

5 = Upcharge for special delivery options

6 = Order status information

7 = Damage control

Table C-8

Scale Values and Discrepancies for Regular Orders

BUYER

Attribute	4	5	7	6	3	2	1
SCALE VALUE	0.00	0.18	0.28	0.47	1.04	1.30	1.54
4	-	-	-	-	-	-	-
5	0.43	-	-	-	-	-	-
7	0.39	0.46	-	-	-	-	-
6	0.32	0.38	0.42	-	-	-	-
3	0.15	0.19	0.22	0.29	-	-	-
2	0.10	0.13	0.15	0.20	0.40	-	-
1	0.06	0.09	0.10	0.14	0.31	0.40	-

Average discrepancy = 0.0433

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized delivery
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

Table C-9

Z-Values Related to Reference Proportions for Promotional Orders

BUYER

Attribute	5	4	7	6	3	2	1
5	-	0.22	0.28	0.22	0.41	1.10	1.20
4	-0.22	-	0.22	0.48	0.28	0.80	0.90
7	-0.28	-0.22	-	0.34	0.28	1.20	1.20
6	-0.22	-0.48	-0.34	-	0.15	0.70	0.80
3	-0.41	-0.28	-0.28	-0.15	-	0.20	0.50
2	-1.05	-0.77	-1.17	-0.69	-0.22	-	0.50
1	-1.17	-0.86	-1.17	-0.77	-0.48	-0.50	-
Z Total	-3.34	-2.39	-2.46	-0.59	0.43	3.35	5.00

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized delivery
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

Table C-10

Scale Values and Discrepancies for Promotional Orders

BUYER

Attribute	5	4	7	6	3	2	1
SCALE VALUE	0.00	0.13	0.13	0.40	0.54	0.96	1.19
5	-	-	-	-	-	-	-
4	0.45	-	-	-	-	-	-
7	0.45	0.50	-	-	-	-	-
6	0.35	0.39	0.40	-	-	-	-
3	0.29	0.34	0.34	0.44	-	-	-
2	0.17	0.20	0.20	0.29	0.34	-	-
1	0.12	0.14	0.15	0.21	0.26	0.40	-

Average discrepancy = 0.0477

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized delivery
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

Table C-11

Z-Values Related to Reference Proportions for Emergency Orders

BUYER

Attribute	5	4	6	7	3	2	1
5	-	0.19	0.19	0.52	0.60	1.40	1.40
4	-0.19	-	0.25	0.25	0.45	1.00	1.10
6	-0.19	-0.25	-	-0.06	0.45	0.90	0.90
7	-0.52	-0.25	0.06	-	0.38	0.90	1.00
3	-0.60	-0.45	-0.45	-0.38	-	0.00	0.20
2	-1.44	-1.04	-0.93	-0.93	-0.00	-	0.20
1	-1.44	-1.15	-0.93	-1.04	-0.19	-0.90	-
Z Total	-4.38	-2.96	-1.82	-1.64	1.70	3.41	5.68

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized delivery
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

Table C-12

Scale Values and Discrepancies for Emergency Orders

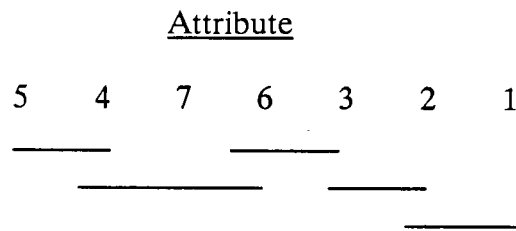
BUYER

Attribute	5	4	6	7	3	2	1
SCALE VALUE	0.00	0.20	0.37	0.39	0.87	1.11	1.44
5	-	-	-	-	-	-	-
4	0.42	-	-	-	-	-	-
6	0.36	0.43	-	-	-	-	-
7	0.35	0.42	0.49	-	-	-	-
3	0.19	0.25	0.31	0.32	-	-	-
2	0.13	0.18	0.23	0.23	0.40	-	-
1	0.07	0.11	0.14	0.15	0.28	0.40	-

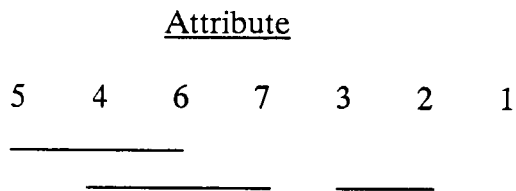
Average discrepancy = 0.0530

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized delivery
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

Grocery



Non-grocery



Any attribute whose scores are not underlined by the same line may be considered distinguishably different.

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized shipments
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

Figure C-1

Least Significant Difference Method by Type of Order
for WAREHOUSE

EMERGENCY

Grocery

<u>Attribute</u>						
5	7	6	4	3	2	1

Non-grocery

<u>Attribute</u>						
4	5	7	3	6	2	1

Any attribute whose scores are not underlined by the same line may be considered distinguishably different.

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized shipments
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

Figure C-2

Least Significant Difference Method by Type of Order
for WAREHOUSE

PROMOTIONAL

Grocery

<u>Attribute</u>						
4	5	7	6	3	2	1

Non-grocery

<u>Attribute</u>						
4	5	7	6	3	2	1

Any attribute whose scores are not underlined by the same line may be considered distinguishably different.

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized shipments
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

Figure C-3

Least Significant Difference Method by Type of Order
for WAREHOUSE

REGULAR

Grocery

<u>Attribute</u>						
4	5	6	3	7	2	1

Non-grocery

<u>Attribute</u>						
4	6	5	7	3	2	1

Any attribute whose scores are not underlined by the same line may be considered distinguishably different.

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized shipments
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

Figure C-4

Least Significant Difference Method by Type of Order
for BUYER

EMERGENCY

Grocery

<u>Attribute</u>						
4	5	7	6	3	2	1

Non-grocery

<u>Attribute</u>						
4	7	5	3	6	2	1

Any attribute whose scores are not underlined by the same line may be considered distinguishably different.

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized shipments
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

Figure C-5

Least Significant Difference Method by Type of Order
for BUYER

PROMOTIONAL

Grocery

<u>Attribute</u>						
4	7	5	3	6	2	1

Non-grocery

<u>Attribute</u>						
4	7	6	5	3	2	1

Any attribute whose scores are not underlined by the same line may be considered distinguishably different.

- 1 = Length of order cycle
- 2 = On-time delivery
- 3 = Completeness of shipments
- 4 = Unitized shipments
- 5 = Upcharge for special delivery options
- 6 = Order status information
- 7 = Damage control

Figure C-6

Least Significant Difference Method by Type of Order
for BUYER

REGULAR

APPENDIX D

Table D-1. Design With Two Noise Factors at Two Levels

No.	A			B			C			L			M			2		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2
2	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
3	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	2	2	2
4	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
5	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	2	2
6	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
7	2	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2
8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Table D-2

Mean Responses for Noise Factors by Trial Number
PROMOTIONAL ORDERS

No.	<u>Perfect Score</u>		<u>S/N Ratio</u>	
	Additive	Scale	Additive	Scale
1	2.50	1.37	-8.45	-2.92
2	2.50	1.15	-7.60	-1.68
3	2.00	0.99	-6.99	-1.03
4	2.25	1.11	-7.20	-1.22
5	3.00	1.53	-9.54	-3.69
6	2.50	0.77	-8.13	-2.57
7	1.50	0.71	-3.98	-2.47
8	1.75	1.00	-5.74	-0.63

Table D-3

Performance Statistics Across Noise Factors - Additive and Scale Values
PROMOTIONAL ORDERS

No.	<u>Additive Values</u>				<u>Scale Values</u>			
	N1	N2	N3	N4	N1	N2	N3	N4
1	3	3	3	1	1.53	1.53	1.53	0.90
2	1	3	3	2	0.90	1.53	1.53	0.63
3	1	3	1	3	0.44	1.53	0.44	1.53
4	2	2	3	2	1.13	1.13	1.53	0.63
5	3	3	3	3	1.53	1.53	1.53	1.53
6	3	2	2	3	1.53	1.13	1.13	1.53
7	2	1	1	2	1.13	0.63	0.44	0.63
8	1	3	1	2	0.44	1.53	0.90	1.13

N1 = grocery, small account
N2 = grocery, large account

N3 = non-grocery, small account
N4 = non-grocery, large account

Table D-4

Mean Responses for Noise Factors by Trial Number
BRAND INTRODUCTIONS

No.	<u>Perfect Score</u>		<u>S/N Ratio</u>	
	Additive	Scale	Additive	Scale
1	1.50	1.39	-3.98	-3.21
2	2.50	1.73	-8.13	-5.24
3	1.75	1.38	-5.12	-3.16
4	2.75	2.26	-8.89	-7.08
5	2.00	1.45	-6.53	-3.70
6	2.25	1.44	-7.20	-3.66
7	2.25	1.44	-7.20	-3.66
8	2.25	1.74	-7.60	-5.27

Table D-5

Performance Statistics Across Noise Factors - Additive and Scale Values
BRAND INTRODUCTIONS

No.	<u>Additive Values</u>				<u>Scale Values</u>			
	N1	N2	N3	N4	N1	N2	N3	N4
1	1	1	2	2	1.18	1.18	2.07	1.14
2	2	3	3	2	1.14	2.32	2.32	1.14
3	2	2	1	2	1.14	1.14	1.18	2.07
4	3	3	2	3	2.32	2.32	2.07	2.32
5	2	3	2	1	1.14	2.32	1.14	1.18
6	2	2	3	2	1.14	1.14	2.32	1.14
7	3	2	2	2	2.32	1.14	1.14	1.14
8	3	1	2	3	2.32	1.18	1.14	2.32

N1 = grocery, small account
N2 = grocery, large account

N3 = non-grocery, small account
N4 = non-grocery, large account

VITA

Mary Collins Holcomb holds B.S., M.B.A., and Ph.D. degrees from the University of Tennessee with a major in Business Logistics. For the Ph.D. degree, her minor was in Industrial Engineering. Her research and teaching interests include two related areas of strategic logistics management: customer service measurement and process design. While at Tennessee, she received the Graduate Teaching Award for the College of Business, the Burlington Industries scholarship, and the Walter H. Bonhom Dissertation Award.

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She is one of the contributors to the book, Competing Globally Through Customer Value. She is the former editor and project principal investigator of the Transportation Energy Data Book for nine annual editions. She has authored and co-authored numerous technical reports in the area of transportation policy. In addition, she has presented papers to the Council of Logistics Management which have been published in the Annual Proceedings.

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