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OPTIMAL PRODUCT DESIGN AND RESOURCE ALLOCATION WITHIN A NORMATIVE BENEFIT SEGMENTATION FRAMEWORK

By

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ABSTRACT

OPTIMAL PRODUCT DESIGN AND RESOURCE ALLOCATION WITHIN A NORMATIVE BENEFIT SEGMENTATION FRAMEWORK

By

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In a market economy, differences in buyer group preferences result in a set of different demand curves. Heterogeneity in the tastes and preferences of different buyers suggests that adapting the product offering could lead to competitive advantage. Market segmentation embodies theory and methods for unraveling customer heterogeneity and designing appropriate marketing responses.

This dissertation develops a model that simultaneously and rigorously treats segmentation and marketing strategy decisions in a normative benefit segmentation framework. The model incorporates all elements of the marketing mix and it simultaneously considers a firm's objectives and resource constraints. Furthermore, it establishes conceptual and methodological links among product-market structure definition, market segmentation and product positioning. These three decision sets are at the core of marketing strategy.

The model develops a normative segmentation approach that is considerably more applicable in practice than traditional approaches. The information requirements for the developed model are behaviorally based and commonly used in practice. The model is based on managerial input and actionable attributes, therefore the results are highly relevant and implementable.

The model of normative segmentation is tested in an industrial market context and the process is repeated for validation purposes for a consumer product application. A multi-stage methodology is employed, encompassing a conjoint experiment, cluster analysis, a design optimization simulation, and multiobjective integer programming.

Dedicated with love
to
Alan and Sheldon

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CHAPTER I

INTRODUCTION

I. INTRODUCTION

A. Overview

In a market economy, differences in buyer group preferences result in a set of different demand curves. Heterogeneity in the tastes and preferences of different buyers suggests that adapting the product offering could lead to competitive advantage (Chamberlin 1965; Dickson and Ginter 1987). Market segmentation embodies theory and methods for unraveling customer heterogeneity and designing appropriate marketing responses.

Market segmentation has been one of the most researched areas in marketing since Smith's (1956) classic work. Formal economic models pertaining to profit maximization given multiple demand curves date from the 1930's (Frank, Massy and Wind 1972). By the late 1960s and early 1970s, segmentation studies had become a fad (Haley 1985). Since the late 1970s, there have been advances in segmentation methods and strategy but there has been very little theoretical development. There remains signification potential for theory and methodological development in segmentation that would be meaningful and of value to firms.

The precise definition of market segmentation has been debated in the literature (deKluyver and Whitlark 1986; Dickson and Ginter 1987; Mahajan and

Jain 1978). In general, the dominant competing definitions emphasize either the methodological aspect of identifying and defining segments or a more strategic focus on marketing mix resource allocation (Wind 1978; Dickson and Ginter 1987; Plank 1985). There is similar disagreement regarding the definition of product positioning and its relationship to market segmentation (Dickson and Ginter 1987). In addition, it has been noted that product-market structure definition is a fundamental prerequisite for the implementation of market segmentation (Curran and Goodfellow 1990). Thus, the literature suggests some relationship among segmentation, product positioning, and product-market structure, yet the precise conceptual and methodological link is unclear.

Segmentation research in general has not addressed all elements of the marketing mix within the context of a single segmentation model. Behavioral segmentation models have focused on understanding consumer behavior. Normative segmentation models have focused on improving the efficiency of a firm's marketing program. Normative segmentation models are rarely implemented due to operationalization difficulties (Wind 1978). Specifically, information requirements for typical normative segmentation models have severely limited their practicality and value. Although this problem has been noted by previous segmentation theorists (e.g., Frank, Massy and Wind 1972; Mahajan and Jain 1978; Tollefson and Lessig 1978; Wind 1978), it has yet to be fully resolved. Furthermore, normative segmentation models have not incorporated the wealth of information available using behavioral segmentation techniques.

Considerable research on the topic of segmentation in general has been and continues to be conducted. This research may primarily be characterized as research on methodological techniques and research on bases of segmentation. Since the original statements of normative market segmentation theory (Claycamp and Massy 1968) and the subsequent extensions (Frank et al. 1972; Mahajan and Jain 1978; Tollefson and Lessig 1978; and Winter 1979), there has been little focus on theory development. There is a need for continued research to address the gaps in normative segmentation theory and methods so that the practical value of normative segmentation, as a strategy and a process, may be enhanced.

B. Focus of the Dissertation

This dissertation develops a model that simultaneously and rigorously treats segmentation and marketing strategy decisions in a normative benefit segmentation framework. The model incorporates all elements of the marketing mix and it simultaneously considers a firm's objectives and resource constraints. Furthermore, it establishes conceptual and methodological links among product-market structure definition, market segmentation and product positioning. These three decision sets are at the core of marketing strategy.

The proposed model develops a normative segmentation approach that is considerably more applicable in practice than traditional approaches. The information requirements for the developed model are behaviorally based and commonly used in practice. The model is based on managerial input and actionable attributes, therefore the results are highly relevant and implementable.

The proposed model of normative segmentation is tested in an industrial market context and the process is repeated for validation purposes for a consumer product application. A multi-stage methodology is employed, encompassing a conjoint experiment, cluster analysis, a design optimization simulation, and multiobjective integer programming.

The research objectives of this dissertation are as follows:

(1) To establish a conceptual and methodological link among product-market structure definition, market segmentation and product positioning;

(2) To establish a conceptual and methodological link between normative and behavioral segmentation approaches;

(3) To develop a normative segmentation approach that facilitates consideration of all elements of the market mix;

(4) To develop a normative segmentation approach that simultaneously solves the segment selection and resource allocation problems in the context of the firm's objectives and constraints;

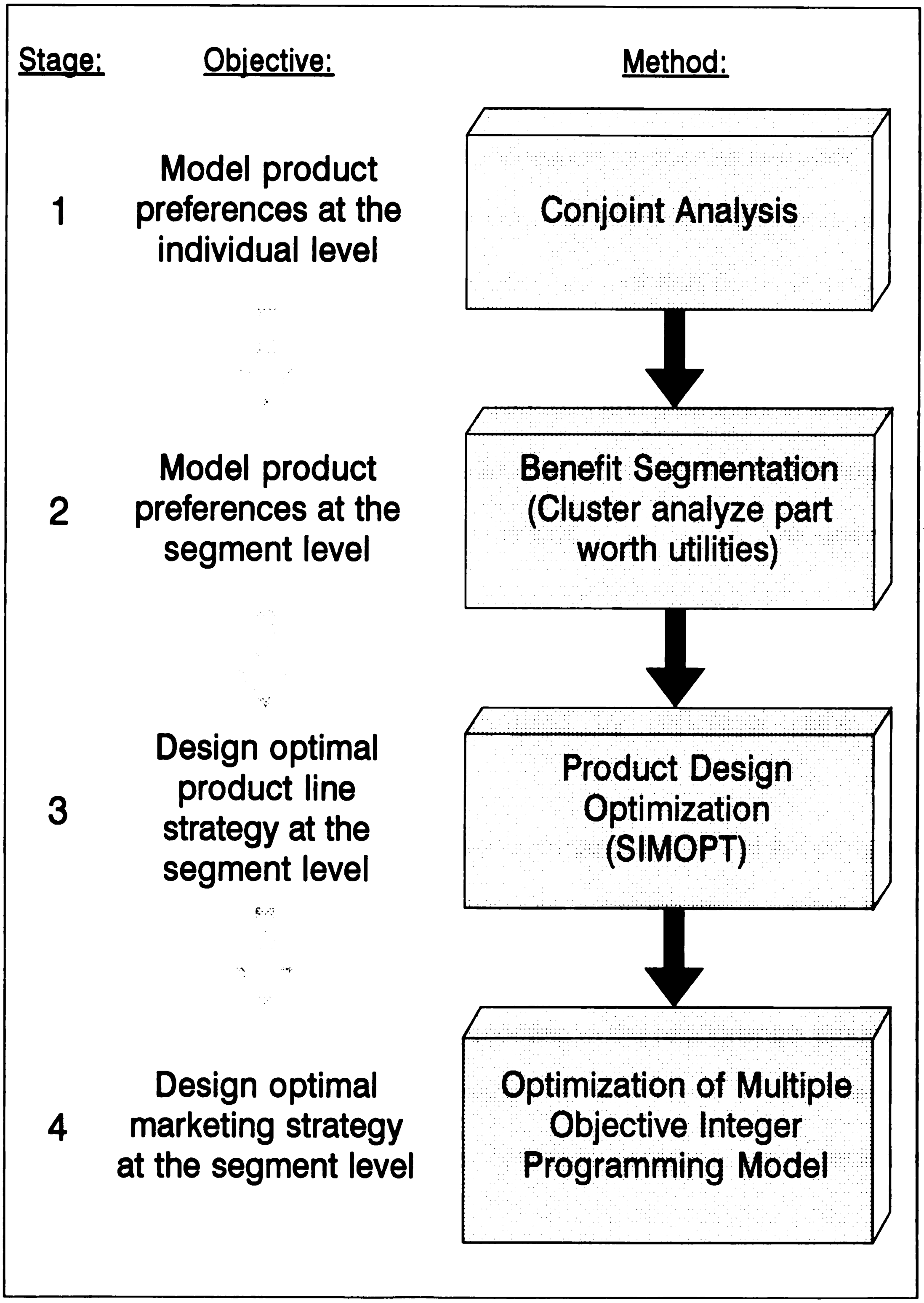
(5) To provide managers with a programmatic approach for devising and assessing segment level marketing strategy;

In order to realize these objectives, the model involves four stages: (1) modeling product preferences at the individual level; (2) modeling product preferences at the segment level; (3) designing optimal product line strategy at the segment level; and (4) designing optimal marketing strategy at the segment level. Figure 1.1 illustrates the proposed model of normative segmentation.

II. A CONCEPTUAL FRAMEWORK OF MARKET BEHAVIOR

As noted, one objective of this dissertation is to establish a conceptual and methodological link among the product-market structure definition, market

Figure 1.1
Model of Normative Segmentation



segmentation, and product positioning. Conceptual integration is achieved by defining and positioning these concepts within a framework of market behavior. Methodological integration is achieved via the proposed model of normative segmentation depicted in Figure 1.1.

Figure 1.2 presents a conceptual framework of market behavior[1]. The framework suggests that the relationship between customers and producers is based on actions that are purposive and adaptive and that result in reciprocal influences. The reality and causes of market behavior may be explained by the mutually-dependent relationship between customers and producers in which each impacts significantly on the other's decision-making environment (Ratneshwar, Shocker and Srivastava 1994). The framework is based on two underlying premises (Ratneshwar et al. 1994):

(1). Mutual dependencies exist between customers and producers; therefore, market behavior is best characterized by reciprocal rather than unidirectional influences.

(2). The behavior of either group represents purposive efforts at adapting to an environment that is partially created and substantially impacted by the perceptions and actions of the other group.

The framework defines market behavior according to the relationships among the perceptions and decisions of customers and producers. There are four elements to the framework. The first two pertain to customers' perceptions and decisions.

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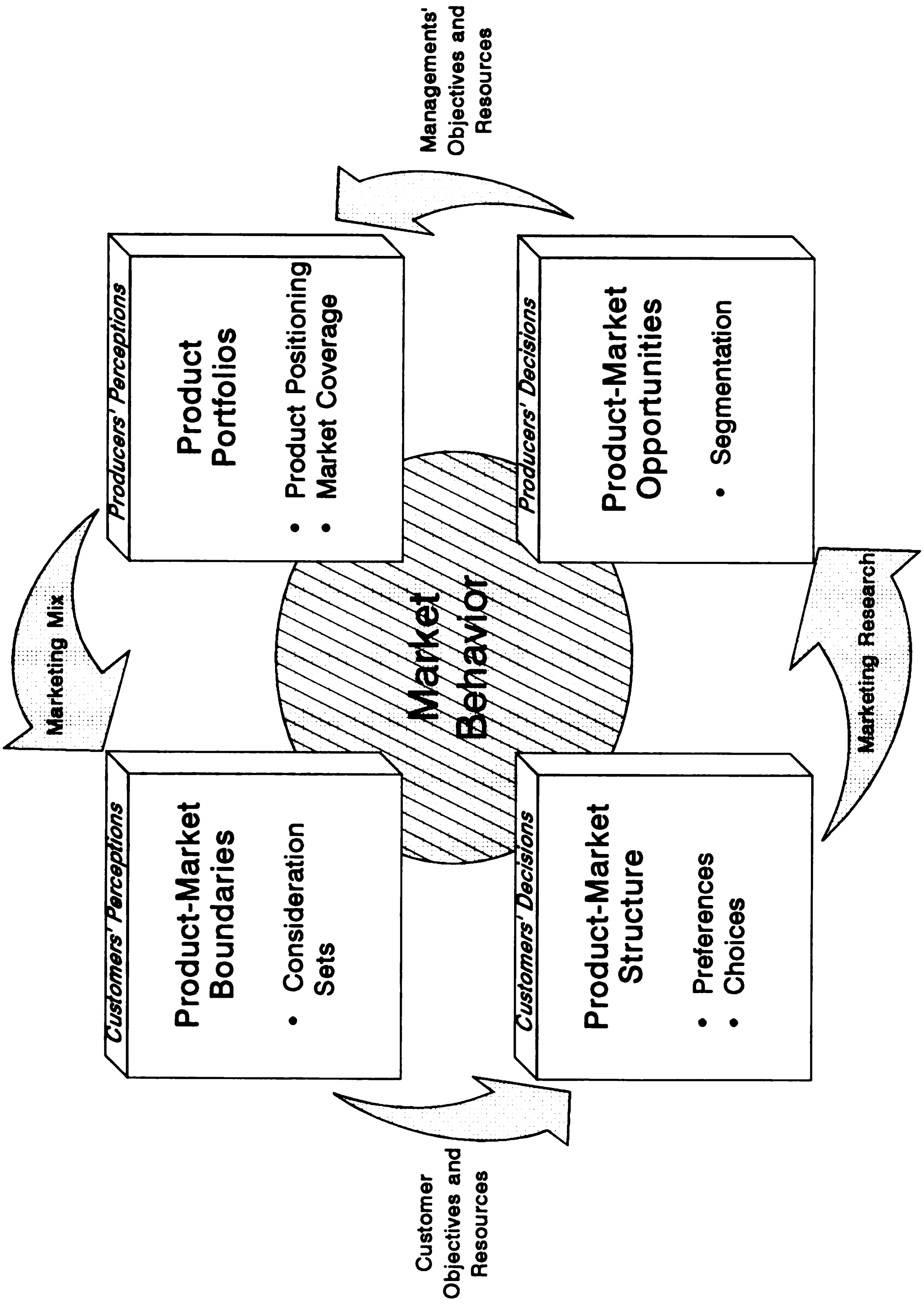
[1] The conceptual framework presented in Figure 1.2 and the ensuing discussion are adapted and drawn from Ratneshwar, Shocker and Srivastava (1994).

Figure 1.2
Conceptual Framework of Market Behavior



First, *product-market boundaries* are defined by customers' perceptions of the products available to satisfy their purposes or usage situations (Day et al. 1979; Myers and Tauber 1977; Ratneshwar and Shocker 1991; Ratneshwar et al. 1994). Customers' perceptions and resulting consideration sets are influenced by the producers' marketing mixes. Second, the decisions of customers in the market determine the degree of competition between the alternatives offered by different producers (Grover and Srinivasan 1987; Shocker et al. 1990; Srivastava et al. 1984). Thus, preference and purpose driven choices reveal *product-market structure*.

The third and fourth elements of the market behavior framework outline the role of producers' perceptions and decisions. Customer behavior actively shapes the producers' environment (Ratneshwar et al. 1994). While this environment constrains the firms' choices in terms of what consumers will support, understanding customer behavior in terms of preferences and choices provides the firm opportunities to address unmet needs (Shocker et al. 1990). The third element involves producers' use of market research techniques to identify *product-market opportunities*. Segmentation systematically relates who customers are to (1) how they respond to feasible alternatives in the product-market and (2) why they respond in that particular manner (Haley 1986; Ratneshwar et al. 1994).

Finally, a firm must choose from among the product-market opportunities while considering management's preferences, objectives and resource constraints. A producer's decisions determine the *product portfolios* offered by the firm. The product portfolios reflect the product positioning and market coverage decisions. Product portfolio decisions require that management consider the impact of multiple product-market combinations and the associated marketing mixes on customer value and satisfaction.

The model of normative segmentation developed in this dissertation (Figure 1.1) reflects the underlying premises of the conceptual framework of market behavior. The proposed model reflects the mutually-dependent relationship between customers and producers by incorporating customers' objectives and preferences into the producers' segmentation and marketing strategy decision processes. The model is developed from the producer's perspective. Reciprocal influences are modeled by incorporating measures of marketing mix effectiveness.

The proposed model of normative segmentation focuses on three aspects of the conceptual framework of market behavior: (1) defining product-market structure according to customer preferences and choices, (2) identifying feasible product-market opportunities, and (3) determining optimal product portfolios in terms of product positioning and market coverage. The elements of the conceptual framework may be linked to the proposed model of normative segmentation as follows. First, product-market structure is defined according to customers' preference-based choices. This is achieved by modeling product preferences at the individual level using conjoint analysis (Stage 1). Second, feasible product-market opportunities are identified via benefit segmentation analysis. This is achieved by modeling product preferences at the segment level using cluster analysis and conjoint inputs (Stage 2). Finally, optimal product portfolios are defined in two stages: (1) optimal product line-strategy is designed at the segment level using a conjoint-based product design optimizer (Stage 3); and (2) optimal marketing strategy is designed at the segment level via a multiobjective integer programming model that simultaneously solves the segment selection and resource allocation problems (Stage 4). Stages 3 and 4 jointly determine the optimal product positioning and market coverage.

III. APPLICATIONS

A. Primary Study - Industrial Application

The industrial application is the primary focus of this dissertation. The specific product studied is the front-end automotive bumper system. The primary study is conducted from a bumper system supplier perspective and the relevant customers are the automotive OEMs (e.g., GM or Ford). The auto industry is traditionally characterized according to vehicle class. There are seven passenger car classes and six light-truck classes. Table 1.1 indicates market share by vehicle class for passenger cars and light-trucks in the U.S. market.

Product-markets in the automotive industry are highly amenable to a segmentation study since the end-use applications of the products (i.e., the vehicle classes) are inherently segmentable. In fact, the current prevailing opinion among bumper system buyers, suppliers, and experts is that the bumper system market is appropriately segmented along traditional vehicle classification lines[2].

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[2] This opinion was explicitly expressed by some industry participants and was implicitly inferred from the organization of the bumper system engineers and buyers at the OEMs and the sales forces at the suppliers.

Table 1.1
Vehicle Classes and Market Shares

Passenger Car		Light-Truck	
	Market Share		Market Share
Mid-sized	37.3%	Full-sized pickup	26.0%
Subcompact	25.6%	Compact sport-utility	22.0%
Compact	14.7%	Minivan	21.1%
Large	10.5%	Compact pickup	19.9%
Luxury	7.0%	Full-sized van	7.4%
Near luxury	3.5%	Full-sized sport-utility	3.5%
Specialty	1.3%		
Total Sales	8,516,694	Total Sales	5,396,474

In general, bumper system redesign is driven by initiatives for weight reduction, performance improvements, cost reduction, manufacturing improvements, recycled content increases, and styling changes. Upon closer examination of bumper system characteristics across vehicle classes, it is not clear that vehicle class is the most appropriate discriminator of bumper system requirements. Preferences for specific characteristics do not appear to be vehicle class based; rather they appear to be need or benefit based. Defining bumper system requirements according to user needs results in a fundamentally different market structure than has been traditionally assumed. This suggests a need for reexamination of the market structure and current marketplace conditions in order to identify the underlying basis of demand heterogeneity and potential product-market opportunities.

There is considerable variation in available bumper system technology.

Thus, the optimal design of a particular bumper system is highly dependent upon the benefits sought by the user (the OEM). The identification of an alternative market structure defined according to benefits sought could have significant ramifications throughout the supply chain, including the bumper system suppliers, the material suppliers, and the OEMs. This suggests that segmentation research in this industry and for this product will be both interesting and worthwhile.

B. Validation Study - Consumer Application

A second study is conducted in a different context for the purpose of validating the conceptual model and methodological process developed in the industrial study. The validation study demonstrates the transferability of the process to a consumer product application by examining the use of small portable entertainment units (e.g., a Sony Walkman) among college students.

The diffusion of small portable entertainment units among college students is quite high (Marketing News 1992), thus this is a relevant product to study in the college student population. The small portable entertainment unit industry has undergone considerable innovation in design and technology in the last decade (Granhaul, 1993). A variety of features (e.g., radio, tape player, CD player, sport model, and several types of headphones), price points, and brands are available from a number of manufacturers. Thus, it is conceivable that the college student market is segmentable on the basis of benefits sought in small portable entertainment units (e.g., style, sound quality, durability, economy).

The consumer application is of value for two primary reasons: (1) it provides a validation of the proposed normative segmentation model and process developed for the industrial application; and (2) it allows consideration of benefits sought in a more emotionally-driven decision context. Thus, the consumer study provides an additional application of the proposed normative benefit segmentation model to a distinct decision environment with different types of subjects.

IV. METHODOLOGICAL TOOLS

Figure 1.1 portrays the multi-stage methodology employed to address the research objectives of this dissertation. The four-stage process involves: (1) modeling product preferences at the individual level using conjoint analysis; (2) modeling product preferences at the segment level via cluster analysis; (3) designing optimal product line strategy at the segment level with SIMOPT (Green and Krieger 1991); and (4) designing optimal marketing strategy at the segment level using multiobjective integer programming.

The four stages are interconnected via inputs and outputs. Table 1.2 illustrates the interdependency among the four stages by delineating the objective, input, analysis, and output of each stage. Each stage is briefly discussed next.

A. Stage 1 - Conjoint Analysis

The objective of Stage 1 is to model product preferences at the individual level. Conjoint analysis is a technique used to measure buyers' tradeoffs among multiattributed products and services in order to understand how customers develop preferences for products (Green and Srinivasan 1990). The basic premise of conjoint is that customers evaluate the value or utility of a product by combining the separate amounts of utility provided by each attribute (Hair et al.

Table 1.2
Research Methodology

Stage	Objective	Inputs	Analysis	Output
Stage 1	Model product preferences at the individual level	Customer preferences for alternative product profiles	Conjoint analysis of choice data	Individual part-worth utility functions
Stage 2	Model product preferences at the segment level	Transformed (normalized) individual part-worth utilities	Cluster analysis using various algorithms	Homogeneous groups of customers with similar product preferences and corresponding segment level utility functions
Stage 3	Design optimal product line strategy at the segment level	Raw individual part-worth utility functions by segment	SIMOPT analysis by segment	Optimal (utility maximizing) product profiles for each market segment
Stage 4	Design optimal marketing strategy at the segment level	Segment level: utility scores for optimal product profiles, profitability potential, communication preferences, communication vehicle costs, manufacturing requirements, and the firm's objectives and resource constraints	Development and solution of a multiobjective integer programming model	Optimal solution to the segment selection and resource allocation problem in light of the firm's objectives and resource constraints

1992). The conjoint exercise realistically portrays customers' choices as trade-offs among multiattribute products or services.

Conjoint analysis is a suitable methodology for the implementation of selected types of market segmentation because (Green and Krieger 1991): (1) the focus of conjoint analysis is on the measurement of buyer preferences for product attribute levels and the benefits the buyer receives from the product attributes; (2) conjoint analysis is a micro-economic based, individual-level measurement technique; and (3) conjoint studies typically involve the collection of respondent background profile information that can be correlated with attribute preferences for segment description purposes.

Conjoint analysis results in quantitative estimates (part-worth utility functions) of how each product attribute impacts customers' preferences and choices; thus, it effectively models product preferences at the individual level. Conjoint segmentation refers to the application of conjoint analysis and cluster analysis in tandem for the purpose of identifying and meeting customer needs (Green and Krieger 1991). The individual part-worth utility functions serve as inputs to cluster analysis in Stage 2.

B. Stage 2 - Cluster Analysis

The objective of Stage 2 is to model product preferences at the segment level. In the context of conjoint segmentation, cluster analysis achieves this objective by sorting customers into groups that are seeking similar product benefits. A benefit segment represents a group of customers who seek similar benefits from a particular product offering (Haley 1968), where benefits sought may be inferred from preferences for product attributes (Gutman 1982).

The sources of benefits from a product can be categorized into three groups (Haley 1985): (1) physical product characteristics, (2) product use characteristics, and (3) emotions about a product. Benefit segments are identified by sorting customers into groups according to product attribute preferences, where the attributes include physical, usage, and emotive product characteristics. The benefit segments for this dissertation are identified by submitting transformed (normalized) individual part-worth utility functions to a cluster analysis.

In the proposed model, cluster analysis results in the identification of homogenous groups of customers with similar product preferences. In order to completely characterize the benefit segments, the conjoint analysis is repeated for each cluster in order to derive segment level utility functions. In sum, the cluster analysis and reapplication of conjoint effectively model segment level preferences. The part-worth utility functions for each segment serve as inputs to the product design optimization simulation (SIMOPT) in Stage 3.

C. Stage 3 - Product Design Optimization (SIMOPT)

The objective of Stage 3 is to design optimal product line strategy at the segment level. The product design optimization model SIMOPT (Green and Krieger 1991, 1993) is employed to achieve this objective. Product design optimizers extend the traditional conjoint exercise from a search for the best product profile in a small set of simulated alternatives to a search for the best profile in all possible attribute combinations (Green and Krieger 1991). The design optimizer identifies "optimal" product design for any given market segment, where "optimal" refers to the customer utility maximizing product design.

Individual part-worth utility functions for each segment are submitted to the SIMOPT design optimizer. SIMOPT matches an optimal product profile to each of the segments identified in Stage 2. The product-market matches effectively identify optimal product line strategies at the segment level, thus achieving the objective of Stage 3. The optimal product-market combinations serve as an input to the multiple objective integer programming model developed in Stage 4.

D. Stage 4 - Multiple Objective Integer Programming

The objective of Stage 4 is to design optimal marketing strategy at the segment level. This is achieved through the development and solution of a multiple objective integer programming (MOIP) model. The MOIP model simultaneously determines the optimal segmentation, product positioning, and communication strategy given management's objectives and resource constraints.

Multiple objective programming is an extension of linear programming that allows simultaneous solution of a system of multiple objectives (Keeney and Raiffa 1976; Zeleny 1982). Multiobjective programming entails the development of a single objective function consisting of all relevant objectives. A multiple criteria objective function reflects the reality that management often makes decisions with reference to several goals rather than to a single goal. The "optimal" solution to a multiple objective programming model is the efficient, nondominated solution preferred by management (Shapiro 1984).

An integer multiple objective programming model is used because of the nature of the decision variables in this dissertation. That is, the decisions involve the selection of a number of segmentation and communication strategies. The MOIP model is a go/no-go integer program where the decision variables are taken to be 0 or 1, indicating that a strategy is rejected or selected. Integer models have two useful features. First, once feasible strategies are identified, integer programming selection insures a meaningful solution. This implies that the results of the MOIP model should be highly implementable. Secondly, since the integer model utilizes discrete functions, assumptions about the shape of the functions are not necessary for model specification (Zoltners and Sinha 1980).

MOIP is a valuable approach to normative segmentation for several reasons (McGlone 1990): (1) segmentation requires the simultaneous optimization of the firm's and customers' objectives; (2) segmentation involves many simultaneous resource allocation decisions among all elements of the marketing mix; (3) effective segmentation requires that the resource constraints facing the firm be explicitly considered; and (4) effective segmentation requires that segment attractiveness be explicitly considered in the segment selection process.

The MOIP developed for this dissertation results in an optimal solution to the segment selection and resource allocation problems given the firm's objectives and resource constraints, thus achieving the objective of Stage 4.

V. RESEARCH QUESTIONS ADDRESSED

The primary research study in this dissertation is the industrial application involving automotive front-end bumper systems. The purpose of the industrial study is to fully develop and test the proposed model of normative segmentation, as well as to demonstrate the link between product-market structure definition, market segmentation and product positioning. The secondary study is conducted in a consumer product context on small portable entertainment units. The purpose of the consumer study is to validate the conceptual and methodological process developed in the industrial study.

Classic normative segmentation research addresses two primary questions (Mahajan and Jain 1978; Claycamp and Massy 1968; Wind 1978): (1) how should users be grouped to form homogeneous segments, and (2) how should resources be allocated to these segments? This dissertation proposes that an intermediate question regarding segment selection is required; how should segments be selected? Segment selection involves the determination of which and how many segments should be selected according to what criteria.

Based on the objectives set forth for this dissertation, the following seven research questions are pertinent to the industrial application:

1. What is the structure of the front-end bumper system product-market?
   a). How can market structure be defined according to customers' preference-based choices?

2. What are the feasible product-market opportunities for front-end bumper system manufacturers?
   a). How should customers be grouped to form homogeneous segments?
   b). How many and which segments should be selected and according to what criteria?

3. What is the appropriate product portfolio for each segment?
   a). What is the optimal product design for the selected segments?
   b). What is the optimal mix of communication vehicles to use in the selected segments?

c). How should promotion and manufacturing resources be allocated to the selected segments?

4. How should the segment selection and resource allocation problem be modeled to reflect the firm's objectives and constraints?
   a). What is the best approach for solving the resulting multiple objective programming model?
   b). How should each element of the marketing mix be included in the multiple objective programming model?

5. What is the impact of the segmentation and product positioning strategy on profits?

6. What is the impact of the segmentation and product positioning strategy on customer satisfaction?

7. How effectively and efficiently is the product portfolio communicated to each segment?

These research questions address the objectives set forth for this dissertation. Research questions 1 through 3 jointly address the first research objective by establishing a conceptual and methodological link among product-market structure definition, market segmentation and product positioning. Research question 2 accomplishes the second objective by establishing a conceptual and methodological link between normative and behavioral segmentation approaches. Research question 4 realizes the third objective by facilitating consideration of all elements of the market mix. Research questions 4 through 7 jointly achieve the fourth objective by developing a normative segmentation approach that simultaneously solves the segment selection and resource allocation problems in the context of the firm's objectives and constraints. In total, the seven research questions satisfy the fifth objective by developing a programmatic approach for devising and assessing segment level marketing strategy.

The purpose of the consumer application is to reexamine the approach developed for the industrial application in order to validate the overall process. The consumer study provides an assessment of the transferability of the conceptual model and methodological process to a different context.

The research questions pertinent to the consumer study are as follows:

1. Is the conceptual model and methodological process developed in the industrial application (Figure 1.1) transferable to a consumer product-market (small portable entertainment usage by college students)?

2. Are there any differences in the application of the conceptual model or the methodological process to a consumer product-market?

VI. SUMMARY AND OVERVIEW OF REMAINING CHAPTERS

Chapter I provided an overview of the focus of this dissertation. A conceptual framework of market behavior was presented to position the major components of the research. Within this framework, the concepts of product-market structure, segmentation, and product positioning were briefly discussed. The proposed model of normative segmentation and the methods of investigation were introduced, and the research objectives and specific research questions relevant to this dissertation were stated.

Chapter II develops the theoretical foundations of normative segmentation and establishes a clear conceptual link among product-market structure, segmentation, and product positioning. In addition, the link between normative and behavioral segmentation is established. A definitional framework is presented and the proposed normative segmentation model is more fully developed.

Chapter III details the research design and methodology utilized in this dissertation. This chapter links the research questions to information needs and data sources. The survey instrument is described and the data collection processes for the industrial and consumer applications are reviewed. Chapter III establishes the methodological link among (1) product-market structure, segmentation, and product positioning, and (2) normative and behavioral segmentation approaches.

Chapters IV and V present the major findings of the four stages of the proposed model of normative segmentation (Figure 1.1). Chapter IV reveals the findings for Stages 1 through 3, including the conjoint analysis, cluster analysis and SIMOPT results. Chapter V presents the MOIP model development and solutions. Results are presented for alternative approaches to model solution, including priority programming approaches and multiobjective programming approaches. The solutions are compared and contrasted and appropriate sensitivity analyses are reported.

Chapter VI evaluates the contributions, presents conclusions and summarizes the overall research effort. Implications for theory development and for managers are discussed. Future research directions are also developed.

CHAPTER II

LITERATURE REVIEW

This dissertation develops a model that simultaneously treats segmentation and marketing strategy decisions in a normative benefit segmentation framework (Figure 1.1). Chapter II develops the theoretical foundations upon which the model builds. The literature review is organized to achieve two objectives: (1) establish a conceptual link among product-market structure definition, market segmentation and product positioning, and (2) establish a conceptual link between normative and behavioral segmentation approaches. To achieve these objectives, three key elements of the conceptual framework of market behavior (Figure 1.2) are reviewed: (1) product-market structure definition, (2) segmentation theory, and (3) product positioning.

The concept of product-market structure is examined and a definition of market structure is developed and related to segmentation. Next, the major research orientations in market segmentation are reviewed and integrated. The theoretical foundations of market segmentation, specifically normative segmentation, are presented and critiqued. Relevant segmentation analytic techniques are discussed. Finally, the concept of product positioning is developed and related to market segmentation theory. The chapter ends with a review of relevant product positioning techniques.

I. PRODUCT-MARKET STRUCTURE

The definition of competitive market structure has significant impact on many marketing decisions. For example, such strategic issues as the basic definition of the business, the assessment of threats and opportunities, and major resource allocation decisions are all strongly influenced by the breadth or narrowness of the market boundaries (Day, Shocker and Srivastava 1979). A clear definition of the market is a fundamental prerequisite for the implementation of market segmentation analysis (Curran and Goodfellow 1990).

For clarity, it is necessary to distinguish between product-market boundaries and product-market structure. Product-market boundaries are defined by customers' perceptions of the products available to satisfy their purpose or usage situation (Day et al. 1979; Myers and Tauber 1977; Ratneshwar and Shocker 1991; Ratneshwar et al. 1994). A product-market boundary is defined by the set of products judged to be substitutes within usage situations for which similar patterns of benefits are sought by groups of customers (Abell and Hammond 1979; Day et al. 1979; Ratneshwar et al. 1994).

Product-market structure is defined by customers' responses to available market offerings. Customers evaluate and judge alternative product designs according to the benefits they are seeking for a particular usage situation (Day et al. 1979; Gutman 1982; Ratneshwar and Shocker 1991; Ratneshwar et al. 1994). Customers form preferences for and choose product designs with certain attribute combinations based on the benefits delivered. Thus, customer preferences and choices jointly determine market structure.

Lancaster's (1979) Characteristics Theory of Demand proposed that individuals consider products as bundles of various characteristics rather than as *gestalt* entities. This implies that individuals are not interested in goods for their own sake but because of the characteristics the goods possess. Lancaster's theory suggests that demand is derived, indirect and depends on individual preferences for specific characteristics, as well as on the technical properties that determine how characteristics are embodied in different goods. Contemporary marketing theory builds on the basic tenets of Lancaster's economic theory of demand. For example, Gutman (1982) argues that products are selected on the basis of attributes they possess because combinations of attributes imply the product's ability to produce desired consequences or benefits.

When product-markets are defined according to usage criterion, it naturally follows that all product-market boundaries are fluid (Day et al. 1979; Ratneshwar and Shocker 1991). Unless it is the primary focus of the study, it is quite common for market boundaries to be assumed fixed and known, or pre-specified based on criteria determined by the objectives of the investigation (Curran and Goodfellow 1990). This dissertation focuses on a single usage context and application within both the industrial and the consumer studies. It is not an objective of this dissertation to define customers' consideration sets in the industrial and consumer applications. Thus, the product-market boundaries are assumed to be fixed and known. It is, however, an objective of this dissertation to identify market structure. This is achieved by identifying the product preferences and choices of customers (matched) according to benefits sought.

Product-market structure can now be clearly linked to market segmentation. Market segmentation is analysis that leads to the recognition of a marketplace condition of demand heterogeneity such that market demand can be disaggregated into segments with distinct demand functions. In terms of the conceptual framework of market behavior (Figure 1.2), market segmentation is analysis by the producer that leads to the recognition (or perception) of product-market opportunities. This is achieved by sorting customers into subsets according to some criterion. Product-market structure definition is a prerequisite to market segmentation because it defines the criterion for sorting customers into groups. Customers are grouped according to the benefits they seek as reflected by their preferences and choices for alternative product designs.

II. MARKET SEGMENTATION

A. Background

A.1. Segmentation Concept and Definitions

The concept of market segmentation is based on the premise that consumers are different and that these differences are related to differences in market demand and differences in response to marketing variables (Smith 1956). The term market segment was originally used to refer to groups of consumers, homogeneous in some respect(s), who respond differently to marketing mix variables.

The first step in segmentation analysis is the determination of the appropriate variable(s) to use as the segmentation base(s). Then the question of how far the segmentation process should go must be answered. The extent to which differences among buyers are recognized has strong implications for the ability of the firm to effectively target its markets, and as well, it impacts the costs of acquiring data and developing specific market plans (Frank, et al. 1972).

A review of the segmentation literature reveals considerable variation in terminology. In their classic article on a theory of market segmentation, Claycamp and Massy (1968) note that the strategy of segmentation often seems to be roughly equated with the process of defining subsets of the total market. In general, there are two definitional orientations associated with the concept of segmentation: (1) a strategic orientation, and (2) a process orientation (McGlone 1990; Plank 1985).

The strategic orientation views market segmentation as the recognition of multiple demand functions and the development of marketing programs that are matched to segment demand functions. The objective is to develop and use information about market segments to design marketing programs that appeal to specific segments. Essentially, the strategic orientation views segmentation as a management strategy, where the strategies that may be pursued include identifying existing demand heterogeneity or identifying opportunities for segment development via demand function modification (Dickson and Ginter 1987).

The process orientation views segmentation as a marketplace condition. Market segmentation is considered to be a process or method of evaluating markets and identifying segments for the purpose of devising marketing programs. The objectives are to identify segments and then allocate resources among segments rather than alter or enhance differences in the respective demand functions. This view treats market segmentation as a foundation for and analytical precursor to marketing strategy.

The definition employed in this dissertation is adapted from Dickson and Ginter (1987) and Kotler (1991): market segmentation is analysis that leads to the recognition of a marketplace condition of demand heterogeneity such that market demand can be disaggregated into segments with distinct demand functions. Typically, market segmentation involves grouping consumers into subsets according to some criterion and then developing specific marketing strategies to appeal to distinct aggregate demand functions. This definition incorporates both the strategic and process orientation toward segmentation. It views segmentation as a process with important strategic implications.

A.2. Schools of Thought in Segmentation Research

Research on market segmentation can be associated with one of two schools of thought: (1) the behaviorally-oriented school and (2) the decision-oriented or normative school (Frank et al. 1972; Mahajan and Jain 1978; Wilkie 1971). Both streams are aimed at developing segmentation-based strategies for the firm, but have chosen different starting points and research processes. The two schools represent distinct perspectives that result in different assumptions, objectives, and end results. The variables and methods used by each school differ somewhat. Figure 2.1 identifies the objectives and focus of each school of thought (McGlone 1990; Frank, Massy, and Wind 1972; Mahajan and Jain 1978).

Figure 2.1
Schools of Thought in Segmentation Research

Behavioral School	Normative School
Objective: Understand consumer behavior	Objective: Improve efficiency of firm's marketing program
Focus: (1) Are there generalizable differences among consumer groups? (2) Why are there differences among consumers? (3) What are the relations between consumer characteristics and buying behavior that can serve as predictors of behavior?	Focus: (1) Given the assumption of individual differences in consumption, how should homogeneous segments be formed? (2) How should marketing resources be allocated to the segments?

The normative school is strongly influenced by the microeconomic theory of price discrimination. That is, segments are quantitatively defined according to response differentials in price and/or promotion using variables such as demographics and socioeconomic status as bases for segmentation. Resources are allocated to each segment until either (1) marginal returns equal marginal costs, (2) marginal returns are equal across segments, or (3) the budget constraint is reached. The major obstacles to a straight-forward application of normative segmentation are data and measurement constraints (Wilkie 1971). For example, the estimation of individual demand curves or of marketing tool efficiency is often problematic.

The behavioral school relies on various theories from the behavioral sciences (e.g., communication theories; Haley 1985). The behavioral school considers bases for segmentation other than price and promotion response elasticities, such as benefits sought and psychographics. Relevant bases are related to both the person and the product and not to the individual alone, thus, segments are qualitatively defined with respect to the individual's demand for certain configurations of product characteristics (Wilkie 1971). Segmentation findings are used to position products (on physical and nonphysical attributes) in selected segments. The behavioral school does not offer a systematic or programmatic approach to resource allocation.

An important difference between the two schools of thought is in the use of the segmentation results (Wilkie 1971). Normative segmentation results are most relevant for promotional strategy decisions. Media profiles enable allocation and scheduling decision, while the demographic and personality variables suggest suitable copy appeals. Segment differences in sensitivities to types of promotion (i.e., the promotion elasticities) can be used to appropriately direct media decisions.

Behavioral segmentation results are most relevant for product positioning strategy. For example, benefit segmentation reveals segment preferences for various product designs, and thus, it implies what characteristics a new product should possess in order to appeal to a given segment. The product positioning decisions have implications for promotional decisions on copy appeals and themes. Demographic and personality variables describe the segments. These descriptions can direct promotional strategy and copy appeals for segment self-selection, and as well, aid in media selection and scheduling.

There continues to be research in each school. For example, in the normative school, Winter (1989) developed a PC-based normative segmentation model in an effort to provide a convenient and "manager friendly" way to select appropriate marketing mixes for target segments. The model is based on traditional normative segmentation theory and requires response elasticities (based on subjective managerial judgments) as inputs. Dyer, Forman and Mustafa (1992) addressed the media selection problem, a special form of the resource allocation problem. They recommend an approach that utilizes analytic hierarchy process (AHP) in conjunction with integer programming. Kamakura and Russell (1989) propose a flexible choice model that partitions the market into consumer segments differing in both brand preference and price elasticity. The model links the pattern of brand switching and the magnitudes of price elasticities. Farley et al. (1987) examined the stability of segment membership over time where segments were defined in terms of differential response functions.

In the behavioral school, Ramaswamy and DeSarbo (1990) proposed a new methodology for deriving hierarchical product-market structures from disaggregate scanner purchase data. The hierarchical representation of products and segments, estimated in a maximum likelihood framework, are derived simultaneously with the composition of the market segments. Rangan, Moriarty and Swartz (1992) propose customer behavior, in terms of tradeoffs between price and service, as a basis for segmentation in mature industrial markets.

Kamakura (1988) and Ogawa (1987) investigated aspects of conjoint experimentation and segmentation. Kamakura proposed a least squares procedure for benefit segmentation with conjoint experiments, and Ogawa proposed a simultaneous approach to estimating part-worths and aggregating consumers in conjoint analysis. A number of benefit segmentation studies have been conducted, including: Bennion (1987); Brown et al. (1989); deKluyver and Whitlark (1986); Doyle and Saunders (1985); Lynn (1986); Moriarty and Reibstein (1986).

A.3. Segmentation Process

The segmentation process follows from the school of thought. The behavioral school generally follows a two stage approach (Wilkie 1971; Calantone 1976): (1) segment creation, and (2) segment testing. The normative school generally employs a three stage approach, performed either sequentially or simultaneously (Frank et al. 1972; Mahajan and Jain 1978): (1) microsegment creation, (2) macrosegment creation, and (3) resource allocation. Table 2.1 summarizes the steps involved at each stage for both schools.

The variables used as bases of segmentation differ across schools. An implicit goal of the behavioral approach is to identify a relevant basis of segmentation (e.g., benefits sought). Conversely, normative segmentation traditionally uses promotion and/or price elasticities as the basis for segmentation, regardless of relevance. This suggests an even more fundamental difference between the segmentation processes of the two schools. The behavioral and normative schools differ fundamentally in terms of the implied response (by the

Table 2.1
Segmentation Process

BEHAVIORAL SCHOOL

Stage 1: Segment Creation

- Determine importance weights
- Elicit individual importance vectors
- Assign individuals to groups based on importance vector similarities

Stage 2: Segment Testing

- Analyze purchase behavior differences across groups
- Analyze key variables for promotional and pricing differences

NORMATIVE SCHOOL

Stage 1: Microsegment Creation

- Identify relevant descriptor variables
- Assign individuals to groups based on similarities in descriptor categories

Stage 2: Macrosegment Creation

- Determine promotion and/or price response characteristics and differentials of each descriptor category
- Aggregate microsegments according to similarities in average audience response characteristics

Stage 3: Resource Allocation

- Determine the number of units of each promotion type to be directed at each segment based on incremental returns (and response) per incremental promotional dollar, given budget constraints
- Determine optimal price for each segment based on marginal returns

(Source: Calantone 1976; Frank et al. 1972; Mahajan and Jain 1978) firm) to segmentation findings. The behavioral approach entails creating segments, testing for strategic relevance, and then responding accordingly by developing segment-specific marketing mixes. The normative approach entails creating segments and then allocating resources in simultaneous or successive steps, with no test or assessment of strategic relevance of the resulting segments.

Assessing the strategic relevance of segmentation results is an important, but often overlooked, step in segmentation analysis. There are many ways to segment a market. Not all segmentation schemes or approaches are effective. Kotler (1991) suggests that the following criteria should guide the definition and selection of segments (also Calantone 1976; Frank et al. 1972; Wilkie 1971): (1) measurability, (2) substantiality, (3) accessibility, and (4) actionability. Measurability refers to the degree to which the size, purchasing power and preferences of the segment can be measured. Substantiality refers to the degree to which the segments are large and/or profitable enough. Accessibility is the degree to which the segments can be effectively reached and served, and actionability is the degree to which effective programs can be formulated for attracting and serving the segments. Meaningful segmentation requires the simultaneous consideration of all four criteria.

Both the normative and behavioral schools are rich with information concerning market segmentation and its strategic impact on the firm. The behavioral approach provides valuable information concerning product positioning and the strategic relevance of segmentation. The normative approach facilitates optimal promotion mix determination and resource allocation. Considered separately, both approaches have limitations; thus, there is academic and practical value in integrating aspects of each school.

The model developed in this dissertation (Figure 1.1) is a normative segmentation approach that has two integrative characteristics: (1) it uses a traditional behavioral basis for segmentation (benefits sought), and (2) it employs traditional normative segmentation methods for simultaneous resource allocation and segment selection. First, behavioral segmentation bases overcome the information and data constraints associated with traditional normative segmentation models. This enhances the practical value of traditional normative segmentation models. In addition, the use of a behavioral segmentation base creates a heretofore missing link between the normative segmentation approach and underlying product-market structure. Second, systematic segment evaluation and selection is a critical step in segmentation analysis if the process is to result in effective segmentation strategy. Normative segmentation models typically do not include an assessment of strategic relevance of a particular segmentation scheme prior to allocating resources. Neither behavioral nor normative models include a systematic segment selection process.

The proposed model integrates aspects of the behavioral school into a normative segmentation approach, thereby extending the value of normative segmentation as a managerial tool useful in practice for identifying product-market opportunities and designing optimal product portfolios. The proposed model of normative segmentation results in a programmatic approach that facilitates the development of optimal marketing strategy in a segmentation framework.

B. Normative Segmentation: Theory, Models, and Extensions

The theory of normative market segmentation is rooted in microeconomic price theory. However, the microeconomic theory of segmented markets does not address several basic problems related to the implementation of the segmentation concept (Claycamp and Massy 1968): (1) problems related to the definition of mutually exclusive market segments; (2) problems related to the measurement of response elasticities by segment; (3) information constraints limiting the possibility of reaching segments selectively; and (4) institutional constraints limiting the ability to use existing means of reaching segments with the desired degree of selectivity.

In an effort to overcome the fundamental problems with the microeconomic theory of segmented markets, Claycamp and Massy (1968) proposed a theory of normative market segmentation. According to this theory, the objectives of normative segmentation are to determine: (1) how homogeneous segments should be formed, and (2) how marketing resources should be allocated among the segments. The Claycamp-Massy theory proposed an extension of the classical price discrimination model into marketing by including promotion. Claycamp and Massy argued that (1) homogeneous segments should be formed by grouping customers according to similarity in response elasticities (price and promotion elasticities) and (2) resource allocation involves finding the optimal values for certain controllable marketing variables (price and promotion).

Claycamp and Massy contended that segmentation should be considered a process of aggregation or building to a viable segmentation strategy rather than tearing a market apart. In the process of aggregation, it is impossible to form meaningful market segments without taking institutional and information constraints into account. The Claycamp-Massy approach to normative market segmentation positions profit maximization as the decision criterion for segmentation strategies. The approach assumes a single product and is developed in five static and deterministic stages. Each stage represents successively more aggregative approaches to market segmentation. The five stages are as follows: (1) segmentation by perfect discrimination among customers; (2) customer segmentation with institutional constraints; (3) microsegmentation; (4) macrosegmentation; and (5) the "mass market" concept (i.e., no segmentation).

Stage 1 treats individual consumer units as segments by modeling market segmentation strategy in the most extreme form. Each customer is identified as a segment on the premise that each person's demand function may be at least slightly unique. Although this may be a viable approach in some markets by some very flexible firms, it is still generally the case that firms seek efficiencies in production and in marketing by aggregating consumers into groups with similar preferences and responses to communication efforts.

Stage 2 uses weighted averages of promotion response derivatives in aggregated equations, rather than individual terms in individual equations. This stage of segmentation accounts for institutional constraints that might restrict the marketing manager's freedom of action. However, stage 2 still requires detailed, individual-level information on promotion response that is very difficult to generate.

To overcome the information constraints faced by stage 2, stage 3 aggregates consumer units into microsegments. Media characteristic coefficients refer to descriptor classes (or microsegments) rather than to individual customers, where the coefficients can be developed from survey information. An aggregate marginal response function is employed for each microsegment, thereby relaxing the information requirements with respect to individual response differentials.

Stage 4 aggregates microsegments into larger macrosegments by considering the problem of estimating the marginal response of sales to promotion. This involves the estimation of the change in sales expected per unit change in promotion. The response function coefficients and the media descriptors from stage 3 can then be used in concert to build more aggregative demand descriptor classes (or macrosegments)

Stage 5 considers the opposite extreme from stage 1; complete aggregation or the mass market concept. Stage 5 effectively represents a situation in which no segmentation strategy is practiced at all.

Claycamp and Massy's theory of normative market segmentation presented the formation of segments and the allocation of resources to segments as distinctly separate analyses. Specifically, media characteristic coefficients are not included in the calculation of segment variance because Claycamp and Massy viewed the development of macrosegments as a prerequisite to the selection of specific promotional programs.

Claycamp and Massy (1968) argued that aggregation is often required because of informational difficulties encountered in the development of response differentials for specific groups and/or individuals. They caution that the addition of constraints and corresponding higher levels of aggregation effectively reduce the level of profit (as a direct result of the mathematical properties of constrained versus unconstrained maxima). Thus, the fundamental problem of market segmentation is finding the point at which the marginal reduction of profits (caused by the imposition of another constraint or level of aggregation) is just balanced by the marginal reduction in research and administration costs created by the constraint. Claycamp and Massy contend that the balance point is most likely achieved in stage 4, macrosegmentation.

Since Claycamp and Massy's (1968) formal statement of a theory of market segmentation, there have been several major contributions to normative segmentation theory. The extensions of Frank, Massy and Wind (1972), Mahajan and Jain (1978), Tollefson and Lessig (1978), and Winter (1979) will be briefly reviewed. In total, the work of these researchers represents the fundamental tenets of normative market segmentation theory.

Frank, Massy and Wind (1972) reformulated the Claycamp-Massy approach in more general terms and extended it to include the promotion allocation problem. Specifically, the Frank-Massy-Wind model combined Stages 1 and 2 of the Claycamp-Massy model and explicitly incorporated uncertainty. Frank et al. proposed that the allocation of marketing resources to various segments should be based on the principle of marginal returns to marketing efforts. They argued that optimal resource allocation strategy is achieved when the marginal returns per incremental promotion dollars are equal for all promotion types and segments.

The Frank-Massy-Wind model adds budget constraints to a profit maximization objective function in order to link the market segments and decision variables more closely. The model considers all segments and decision variables in determining an optimal marketing plan, however, it does not do so simultaneously. The Frank-Massy-Wind optimization model maximizes profits and determines the price, units of media, and type of media for *a priori* defined segments.

Mahajan and Jain (1978) proposed a dynamic approach to normative segmentation in which market segments are developed within the managerial, institutional, and resource constraints of the firm. Mahajan and Jain argued that the development of market segments and allocation of resources to these segments are closely intertwined and cannot be separated. The development of market segments must explicitly consider the available corporate resources and marketing tools. Thus, they maintained that feasible schemes of homogeneous market segments should be developed within the managerial, institutional, and resource constraints of the firm.

According to Mahajan and Jain, typical segmentation problems require the consideration of technological requirements for product design, availability of budgets, number of salesmen, and the availability of media types, distribution channels, and time. In an effort to incorporate the managerial, institutional, and resource constraints into the normative segment composition problem, Mahajan and Jain propose a model that effectively groups consumers into segments, subject to a variety of constraints. The constraints include mutual exclusivity requirements, restrictions on segment size, and segment cohesiveness goals. In effect, Mahajan and Jain develop a clustering algorithm that permits specification of constraints on the development of market segments. The basis of aggregation is price and promotion response elasticities.

Mahajan and Jain add budget-type constraints to the segment development model to incorporate resource constraints. Based on the Claycamp-Massy price theory model, Mahajan and Jain propose a dynamic price model that includes promotion-related decision variables and constraints. The objective function entails the maximization of profit resulting from sales revenue less production and promotion costs. The resulting model simultaneously assigns subjects to segments, determines the price to charged in each segment, and allocates the promotional budget to each segment within managerial, institutional, and resource constraints.

Tollefson and Lessig's (1978) evaluation of aggregation criteria was another important contribution to the normative segmentation literature. Tollefson and Lessig argued that the standard practice of aggregating consumers into market segments on the basis of similarity of elasticities, marginal responses, or response function coefficients is most often not optimal. Based on simulations, they found that hierarchical aggregation through the minimization of profit differential (D_{ij}) is a more effective basis of segmentation than similarity of response function or elasticities. D_{ij} is the difference in the profit between the optimal solution to the allocation problem where segments i and j are not aggregated, and the optimal solution to the allocation problem where i and j are aggregated. Thus, D_{ij} is the profit reduction if segments i and j are aggregated.

Tollefson and Lessig's (1978) results suggest that the validity of a given segment structure is more accurately determined by required differences in marketing treatments, rather than differences in elasticities, response function coefficients, or marginal responses (evaluated over some convenient range). Tollefson and Lessig's extension may be interpreted as an evaluation of the attractiveness of alternative segmentation schemes. Specifically, the D_{ij} measure is a comparative measure of segment substantiality (profitability) (Kotler 1991). Though not stated as such, Tollefson and Lessig's work represents the first attempt in normative segmentation to assess the strategic relevance of alternative segmentation schemes.

The profit-based aggregation criterion proposed by Tollefson-Lessig is an important conceptual contribution to normative segmentation theory. However, the same information problems associated with other normative segmentation models apply to the Tollefson-Lessig conceptualization. Tollefson and Lessig's proposition is based on microeconomic theory; the D_{ij} are derived from response elasticity differentials. The allocation problem referred to in the aforementioned definition of D_{ij} is formulated using response elasticities.

Winter (1979) offered an alternative view of normative segmentation by proposing a cost-benefit approach to aggregation in market segmentation. The premise of Winter's approach is that segmentation is a disaggregative process followed by an aggregative process such that the cost-benefit issues inherent in the level of (dis)aggregation are explicitly considered. Winter's approach involves six steps: (1) cluster (disaggregate) consumers on the basis of determinant variables into homogeneous subsegments; (2) determine elements of the marketing mix that fit with other elements; (3) derive feasible marketing mixes; (4) estimate segment-marketing mix profit matrix; (5) estimate fixed costs of feasible marketing mixes; and (6) determine the optimal and appropriate marketing mixes. The proposed method uses profit criteria to determine which subsegments should be aggregated to produce a workable segmentation plan.

Winter develops an integer programming model with a profit-oriented objective for the purpose of determining how many and which distinctive marketing mixes are necessary to serve a differentiated and segmented market. Winter assumed no advertising in his application of the model. This is quite a departure from the standard normative segmentation models which focus almost exclusively on optimal promotion determination and allocation by segment. Winter was primarily concerned with product design and type of distribution.

There are three important points to note about Winter's model. First, Winter's approach views target marketing as unnecessary; i.e., segment selection is unnecessary. The model selects an optimal (profit maximizing) subset of marketing mixes from a predefined feasible set. Thus, Winter implicitly assumes that customers self-select the appropriate marketing mix. It may be argued (as Winter acknowledges) that selecting marketing mixes in this manner is suboptimal because: (1) it assumes that segment demand is not responsive to the marketing mix; and (2) the predefined feasible set of marketing mixes is arbitrarily and subjectively determined. The other models of normative segmentation also ignore the segment selection step, though not for the same reasons put forth by Winter.

Second, Winter builds on the work of Tollefson and Lessig by arguing that the basis for segment aggregation is more appropriately achieved using a cost-benefit criterion. Although Winter was referring to aggregation of marketing mixes rather than of consumers, the approach reflects an effort to assess the strategic relevance of alternative segmentation strategies. Finally, Winter's approach is an important departure from traditional normative segmentation models in terms of the basis of segmentation employed, probit-conjoint coefficients. Winter recommends that subsegments be formed on the basis of measurable determinant variables that reflect the response of the subsegment to various marketing mixes.

B.1 Summary and Implications

A review of the classical theoretical development of normative segmentation approaches reveals two points of interest. First, although the normative segmentation models reviewed were said to be generalizable to include all elements of the marketing mix, these extensions have not been developed. The Claycamp-Massy model focused on price elasticities. The Frank-Massy-Wind, Mahajan-Jain, and Tollefson-Lessig models all considered price and promotion variables. Winter's model examined product and distribution variables. This suggests a need for a normative segmentation model that explicitly incorporates aspects of all elements of the marketing mix.

Second, none of the normative segmentation models address the segment selection problem. It is a critical link between the segment formation problem and the resource allocation problem. That is, once segments are formed and prior to resource allocation, it is necessary to select how many and which segments to serve according to some criteria. Segment formation is an analytic process wherein customers are sorted groups with similar preferences. Segment selection is a strategic process involving the evaluation of the identified segments according to some criteria of strategic relevance[1].

The importance of the segment selection decision (how many and which segments to target) was noted by Frank, et al. (1972) and Mahajan and Jain (1978). Frank et al. (1972) do not suggest a solution to the problem. Mahajan and Jain (1978) propose a modification of the segment formation problem to include specific goals and constraints on the segment formation process (e.g., mutual exclusivity requirements, restrictions on segment size, and segment cohesiveness goals). In the end, the proposed approach to segment formation does not facilitate evaluation and selection of segments. That is, *all* of the developed segments (representing some sorting of the entire market) are included in the resource allocation problem. Claycamp and Massy (1968), Tollefson and Lessig (1978) do not explicitly address segment selection. Winter (1979) argues that marketing mix selection is the key problem, not segment selection, because the market self-selects its most preferred market mix from among those offered. This dissertation maintains that segment self-selection is an inefficient approach to marketing strategy given the tools and capabilities available to a firm to identify and deliver optimal marketing mixes to customer segments.

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[1] The criteria for defining and selecting meaningful segments were previously defined as: (1) measurability, (2) substantiality, (3) accessibility, and (4) actionability.

Segment selection has significant implications for marketing strategy. Omitting the intermediate segment selection process in normative segmentation implies that firms target the entire market and thus allocate scarce resources across the entire market. This is an unrealistic and unreasonable assumption. The competitive reality is that firms often select (by rational choice or by market demand) to serve only certain segments of a market. A practical resource allocation problem would consider only selected segments. Normative segmentation models would better reflect and aid managerial decision-making if the segment selection problem was explicitly incorporated. This can be achieved by modifying the objective function and constraints of traditional normative segmentation models.

The normative segmentation approach proposed in this dissertation builds on and extends traditional normative segmentation models in several ways:

(1) It explicitly incorporates the segment selection problem, in terms of how many and which segments should be selected;

(2) It recognizes that firms' make decisions according to criteria other than strict profit maximization. Specifically, maximizing customer satisfaction and communication effectiveness are added to the objective function;

(3) It systematically evaluates segment attractiveness by considering the substantiality and accessibility of each segment in light of the cost of serving each segment. Specifically, segment profitability, customer satisfaction, and communication effectiveness are maximized subject to constraints on the promotion budget and manufacturing assembly capacity;

(4). The optimal marketing mix is simultaneously determined for each selected segment while considering resource constraints. The product profile and promotion mix are explicitly determined and the distribution and price factors are implicitly determined;

Winter's (1979) use of probit conjoint coefficients (also Rao and Winter 1978) is important to this dissertation for three reasons: (1) it presents theoretical (and empirical) justification for investigating alternative bases of normative segmentation besides response elasticity functions, (2) it indirectly provides a motivation for circumventing the oft noted information problem associated with normative segmentation research (namely, the collection and calculation of response elasticity data), (3) it suggests the value of behavioral bases of segmentation as measurable determinant variables that reflect segment response to various marketing mixes.

With the theoretical framework in place, the mechanics of segmentation can now be considered. The next section reviews relevant approaches to segment formation and bases for segment definition.

C. Segmentation Variables

Bases. Many bases of segmentation have been proposed for industrial and consumer markets. Theoretically, demand functions should serve as the basis for segment definition (McGlone 1990). However, since demand functions are not directly observable and are difficult to measure, surrogate variables must suffice. Most segmentation variables can serve as dependent or independent variables; i.e., they can serve as bases or as descriptors of derived segments.

Frank, Massy and Wind (1972) classified bases for segmentation according to the type of customer characteristic (general or situation-specific) and the nature of the measurement procedure (objective or inferred). General characteristics are independent of the product and particular circumstances faced by the customer whereas situation-specific characteristics depend largely on the subject under investigation. Various categories of industrial and consumer segmentation bases can be organized within the Frank, et al. (1972) classification scheme.

Bonoma and Shapiro (1983) identified five general categories of segmentation bases for industrial markets: demographics, operating variables, purchasing approach, situation factors, and personal characteristics. Frank, Massy and Wind (1972) proposed six general categories of segmentation bases for consumer markets (also Kotler 1991): demographics, socioeconomic factors, purchase and loyalty patterns, buying situations, personality and life style, and attitudes. Table 2.2 presents the integration of the assorted categories and the Frank-Massy-Wind bivariate classification.

Important considerations in the selection of segmentation variables are: (1) management's specific needs, and (2) the relevance of particular variables as bases for and descriptors of market segments. A review of the segmentation literature suggests that different bases are relevant for different research objectives. Table 2.3 presents a classification of preferred segmentation bases for various marketing decision[2].

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[2] Table 2.3 is adapted from Wind (1978) and confirmed by Haley 1985; VanAuken and Lonial 1984; Lilien, et al. 1992; Dickson 1982; Dickson and Ginter 1987; Winter 1984; Moriarty and Reibstein 1986; Grover and Srinivasan 1987; Young, et al. 1978; and Beane and Enis 1987.

Table 2.2
Classification of Market Segmentation Bases

	Nature of Characteristics	
Type of Measure	General	Situation Specific
Objective	**INDUSTRIAL:** Demographics Operating Variables Purchasing Approaches --- **CONSUMER:** Demographics Socioeconomic Factors	**INDUSTRIAL:** Operating Variables Situational --- **CONSUMER:** Consumption Patterns Loyalty Patterns Buying Situations
Inferred	**INDUSTRIAL:** Purchasing Approach Personal Characteristics --- **CONSUMER:** Personality Traits Life Style	**INDUSTRIAL:** Situational Personal Characteristics Purchasing Approaches --- **CONSUMER:** Attitudes (benefits sought, preferences)

Table 2.3
Effective Segmentation Bases for Marketing Decisions

(1) For a general understanding of a market:
- Benefits sought
- Product purchase and usage pattern
- Needs
- Brand loyalty and switching pattern
- Hybrid of above variables

(2) For positioning studies:
- Product usage
- Product preference
- Benefits sought
- Hybrid of above variables

(3) For new product concepts and new product introductions:
- Reactions to new concepts (intentions to buy, preference over current brand, etc.)
- Benefits sought

(4) For pricing decisions:
- Price sensitivity
- Deal proneness
- Price sensitivity by purchase/usage pattern

(5) For advertising decisions:
- Benefits sought
- Media usage
- Psychographic/life style
- A hybrid of above variables and/or purchase/usage patterns

(6) For distribution decisions:
- Store loyalty and patronage
- Benefits sought

[Adapted from Wind (1978)]

Table 2.3 indicates a consistent emphasis on benefits sought (a behaviorally-oriented variable) as an appropriate segmentation base for addressing a number of important marketing problems. Knowledge of benefits sought is pertinent for developing a general understanding of the market, and decisions on positioning, new products, advertising, and distribution. This implies that benefits sought is an effective basis for defining product-market structure, identifying product-market opportunities, and designing optimal product portfolio responses. The conclusion drawn is that benefits sought is the appropriate segmentation variable to use in a normative segmentation approach if the results are to have impact on marketing strategy decisions.

Benefits sought are defined in this dissertation as those benefits derived from product attribute combinations that are identified as desirable by current and potential customers. Benefits delivered are defined as those benefits a firm can provide given its technological and managerial capabilities and resources. Benefit segmentation identifies homogeneous groups of buyers based on their preferences for various selection criteria (e.g., product attributes) (Moriarty and Reibstein 1986). The concept of benefit segmentation originated with Russell Haley (1968) who suggested that the differences in benefits sought by buyers are the basic reasons for the existence of true market segments. It is the total configuration of benefits sought that differentiates a segment, not the importance of any one benefit in particular.

The information obtained in the course of a benefit segmentation study is rich with a wide range of potential marketing implications. Benefits segments can imply particular physical product attributes, packaging characteristics, communication messages, media choices, and distribution methods (Haley 1985). Segments derived based on benefits sought are most often meaningful for product planning, positioning, and communication decision.

Descriptors. The selection of descriptor variables for segment description is less straightforward for several reasons (Frank et al. 1972; Wind 1978): (1) there is an enormous number of possible combinations of potential descriptor variables; (2) there are few guidelines in the literature regarding the links between selected bases and descriptor variables and between descriptors and customer responses to marketing actions; and (3) there are few generalizations in the literature as to which descriptor variables have what effect under what conditions. It is often more fruitful to conduct the segmentation research using the preferred base (here benefits sought) and then investigate the resulting segment structure for meaningful and valid descriptors.

Once the segmentation variables are defined, the method for determining the segments must be decided. A brief overview of the relevant segmentation analytic techniques is presented in the next section. The technique relevant to this dissertation, conjoint segmentation, is the primary focus.

D. Segmentation Analytic Techniques

Marketing research has been quite prolific in terms of continual development of segmentation analysis techniques. Basically, these techniques may be categorized as classification or discrimination procedures (Beane and Enis 1987; Wind 1978). Classification procedures focus on the assignment of individuals to segments. The specific method employed varies markedly according to the specific segmentation model used. The discrimination procedures develop segment profiles and are not dependent on model selection. While most segmentation studies follow a two-step procedure (classification of respondents into segments and then determination of key discriminating characteristics), there are techniques that facilitate simultaneous classification and discrimination.

Of particular interest for this dissertation is conjoint segmentation analysis. Conjoint analysis is especially helpful in the identification and understanding of benefit segments (Kamakura 1988). Benefits sought logically flow from product attribute combination preferences (Green and Krieger 1991; Gutman 1982; Haley 1985; Ratneshwar et al. 1994). Conjoint analysis is based on the premise that buyers evaluate the value or utility of a multiattribute product by combining the separate amounts of utility provided by each attribute. Conjoint assumes that buyers evaluate products in terms of the bundle of salient attributes.

Conjoint segmentation involves the application of conjoint analysis and cluster analysis in tandem to aid in the optimal design of products for delineated market segments (Green and Krieger 1991). The goals of conjoint segmentation are (1) to sort customers into homogeneous groups with similar product preferences, and (2) to estimate the aggregate utility functions that best explain segment preferences (Kamakura 1988). Conjoint analysis is well-suited for the implementation of benefit segmentation because (Green and Krieger 1991; Green and Srinivasan 1978, 1990): (1) the focus of conjoint analysis is on the measurement of buyer preferences for product attributes; (2) conjoint analysis is an individual-level measurement technique that captures preference heterogeneity; and (3) conjoint studies usually include the collection of respondent background information that is useful for segment description.

Green and Krieger (1991) propose a conceptual framework for market segmentation in the context of conjoint analysis and product design models. Green and Krieger demonstrate that different segmentation strategies can lead to different product positioning. An important aspect of their framework is the evaluation of alternative segmentation strategies using a profitability criterion (rather than discrimination ability or differences in response variables). For example, Green and Krieger's empirical analysis showed that segmentation based on conjoint derived part-worth utilities outperformed segmentation based on demographic characteristics.

In the context of the conceptual framework of market behavior presented in this dissertation (Figure 1.2), conjoint segmentation analysis is a suitable method for defining product-market structure and linking this definition to the identification of product-market opportunities. Conjoint analysis effectively elicits customer preferences and choices for alternative product designs, thereby defining product-market structure. Segmentation analysis on the basis of conjoint-inputs results in the identification of benefit segments. A clear delineation of benefit segments provides management with critical information on customer preferences that is necessary for product-market opportunity identification and optimal product portfolio design.

In the context of a normative segmentation model, conjoint segmentation analysis is a suitable method for linking the normative and behavioral segmentation approaches. Conjoint analysis results in quantitative estimates of customers' preference functions. Segmentation on the basis of these preference functions results in the identification of benefit segments. Thus, conjoint segmentation affords a quantitative, behavioral segmentation base that can be applied in a normative segmentation model to overcome the information and data constraints associated with traditional normative models. This improves the applicability of normative segmentation models in practice. Furthermore, using benefits sought as a segmentation base links the normative segmentation approach to the underlying product-market structure.

III. PRODUCT POSITIONING

A. Definitional Framework

The conceptual framework of market behavior (Figure 1.2) suggests that product portfolio design is the result of the firms' response to its product-market opportunities. Given managements' preferences, objectives and resource constraints, the firm makes product positioning and market coverage decisions based on the segmentation results. Kotler (1991) presents market segmentation, market targeting, and product positioning as a three-step process at the core of strategic analysis (also Urban and Star 1991; Jain 1990). Segmentation analysis defines the market for management and identifies target market opportunities. Market targeting involves segment evaluation and selection. Product positioning takes place within a target market segment and involves the determination of how to compete and allocate resources most effectively in a given segment.

Normative segmentation models are decision-oriented models that seek to simultaneously segment the market and design optimal responses. Recall that traditional normative segmentation models address two basic questions: (1) how should users be grouped to form homogeneous segments, and (2) how should resources be allocated to these segments? In addition, this dissertation has argued for an intermediate question: how should segments be selected? The discussion in a previous section on benefits sought as an appropriate basis of segmentation addresses the first question. Product positioning addresses the second question. Market targeting, or market coverage, decisions address the intermediate question of segment selection. Thus, segment selection and resource allocation decisions define a firm's product portfolios.

In this dissertation, product positioning is defined as the process of differentiating a product offering so that it occupies a distinct and valued place in the target customers' minds (Kotler 1991). Product differentiation is a marketplace condition wherein a product offering is perceived by the customer to differ from alternative offerings on some physical or nonphysical product characteristic (Dickson and Ginter 1987). Product positioning is concerned with the customer's evaluation of the complete product offering, including the promotion and distribution effort, physical product features, and price (Urban and Star 1991). Successful positioning requires offering and communicating a product concept that matches customers' needs and preferences.

The next section reviews the analytic techniques in current product positioning modeling efforts. Of particular interest is recent work in the area of product design optimization.

B. Analytic Techniques

Product design optimization techniques provide a mechanism by which product positioning may be implemented and evaluated in the context of a segmentation study. A significant stream of research on product positioning has been the development of formal methods for designing optimal products and product lines. There are two basic measurement approaches that underlie current design optimization modeling efforts: multidimensional scaling (MDS) and conjoint analysis (Green and Krieger 1989; Kholi and Krishnamurthi 1987; Sen 1982; Shocker and Srinivasan 1979). Relative to product design optimization, both MDS and conjoint analysis are based on the assumption that product design preference is related to the buyer's perceptions and preferences for underlying product attributes, relative to those of competing products (Green and Krieger 1989; Huber and Holbrook 1979; Schiffman, Reynolds and Young 1981).

Multidimensional Scaling Approaches. MDS attempts to determine the perceived relative image of a set of products in a joint person-product space (Green, Carmone, and Smith 1989). The purpose is to transform customer judgments of similarity or preference into distances represented in multidimensional space. Ideal points in the joint space represent a person's most preferred combination of perceived attributes.

Virtually all of the MDS optimal product design and positioning models employ the notion of an ideal point model (Cooper 1983; Stefflre 1972). Shocker and Srinivasan (1979) developed the first rigorous, programmatic approach to MDS-based, optimal product positioning. Additional contributions to MDS-based optimal product design models include: Sudharshan, May and Shocker's (1987) PRODSRCH algorithm; Albers and Brockhoff's (1977) PROPOPP model; Gavish, Horsky and Srikanth's (1983) Method IV approach; and Sudharsan, May, and Gruca's (1988) DIFFSTRAT algorithm.

Conjoint Approaches. Conjoint analysis is a technique used to measure buyers' tradeoffs among multiattributed products and services in order to understand how customers develop preferences for products (Green and Srinivasan 1990). The basic premise of conjoint is that customers evaluate the value or utility of a product by combining the separate amounts of utility provided by each attribute (Hair et al. 1992). Conjoint choice simulators identify the "best" (utility maximizing) product profile from a limited set of simulated alternatives. Given that there are hundreds of thousands (or even millions) of possible profiles, limiting the considered set to a few simulated profiles is unnecessarily restrictive (Green, Carroll, and Goldberg, 1981; Green and Krieger 1985, 1991).

Zufryden (1977) was the first to examine the product design optimization problem in a conjoint context. Zufryden (1982) later extended the single-product conjoint model to encompass product-line optimization. Green et al. (1981) developed the POSSE model of the single product-positioning optimization problem using conjoint inputs. Green and Krieger (1985) proposed a two-step approach to optimal product line selection. Green and Krieger (1985; 1987), Dobson and Kalish (1988), and McBride and Zufryden (1988) deal with additional aspects of a the product line optimization problem. Kohli and Sukumar (1988) proposed a single-step procedure to optimal product line design using original attribute level part-worths.

Recently, Green and Krieger (1993) developed a commercially-oriented conjoint-based optimization model. SIMOPT (SIMulation OPTimization model) is an optimal product-positioning model applicable to either the single-product or the product-line problem. The principal inputs are a matrix of buyers' part-worths and competitive product profiles. The part-worths are estimated using conjoint analysis. SIMOPT has options for including: (1) buyer importance weights that reflect frequency and/or amount of purchase; (2) demographic or other background characteristics; (3) demographic weights for use in segment selection and/or market-share forecasting; (4) current market-share estimates of all competitive profiles under consideration; and (5) cost/return data at the individual-attribute level (Green and Krieger 1993).

A common caveat and limitation of design optimization models is incomplete optimization; i.e., the models typically consider product factors (including price), but not promotion or distribution factors. The resource allocation decisions required for product portfolio design require simultaneous consideration of product, price, promotion, and distribution attributes. This suggests that the product design optimization methods are most appropriately positioned as techniques applicable to elements of a broader framework of market behavior.

In this dissertation, the conjoint-based product design optimizer SIMOPT is employed for two reasons: (1) it determines optimal product design, a central component of product portfolio decisions; and (2) it maintains continuity in analysis from the product-market opportunity identification stage wherein conjoint segmentation was applied. The SIMOPT model is used as one component of the methodology of this dissertation for the purpose of generating optimal product designs for each segment, thereby designing optimal product line strategy at the segment level. It is not an objective of this dissertation to further develop the SIMOPT optimization algorithm.

IV. SUMMARY

This chapter developed the theoretical foundations upon which the proposed model of normative segmentation builds. The literature review achieved two objectives: (1) it established a conceptual link among product-market structure definition, market segmentation and product positioning, and (2) it established a conceptual link between normative and behavioral segmentation approaches. The conceptual framework of market behavior provided an overarching framework for integrating these concepts. In addition, this chapter presented conjoint analytic techniques as a coherent and congruous method for (1) establishing a methodological link among product-market structure definition, market segmentation, and product positioning and (2) establishing a methodological link between behavioral and normative segmentation approaches.

Chapter III presents the research questions and research design employed in this dissertation.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

This dissertation develops and tests a model of normative segmentation in an industrial context. The robustness of the conceptual model and methodological process is assessed in a consumer context. This chapter outlines the research design and methodology used in the dissertation.

The chapter begins with a general discussion of industrial versus consumer segmentation research and related problems. Then, the research objectives and questions are presented, and the resulting information requirements are detailed. Finally, the data collection process is outlined, followed by a description of the research instrument and sampling plan for each application.

I. INDUSTRIAL VERSUS CONSUMER SEGMENTATION

Segmentation in an industrial market is based on the same assumptions and criteria as segmentation in a consumer market (Plank 1985; deKluyver and Whitlark 1986; Wind 1978). There are two primary differences (McGlone 1990). First, the specific variables used in the model will differ. These differences were reviewed in Table 2.2. Industrial segmentation requires consideration of organizational characteristics and group decision-making factors. Measurement of these variables often presents data collection problems. Second, the diversity of end-users and product uses in industrial settings results in a multitude of potential segments and segmentation schemes that must be evaluated (deKluyver and Whitlark 1986), many of which are unknown to the firm.

Industrial markets have several distinguishing characteristics that impact the purchasing process (Kotler 1991): (1) a small number of large buyers, (2) long-standing supplier-buyer relationships, (3) geographically concentrated buyers, (4) inelastic derived demand, (5) highly volatile demand, (6) professional purchasing, and (7) multiple buying influences. As a result, several common problems arise in the conduct of industrial marketing research (Morris 1988; McGlone 1990). First, it is often difficult to identify who participates in the purchase decision and what each person's role and level of influence is (Kotler 1991). Some functions that individuals may perform in industrial buying situations are (Urban and Star 1991): specification, gatekeeping, budgeting, generation of alternatives, evaluation, selection, approval, and monitoring. Typically, people perform more than one function and more than one person is often involved at each functional step, thus compounding the respondent identification problem.

A second problem is concerned with the accessibility of industrial respondents. As noted, industrial markets are generally characterized by a small number of buyers. The variable accessibility of target respondents across firms may lead to incomplete and unrepresentative responses from one firm, and an inordinate number from another. Unbalanced response can have a significant biasing effect on the results in a small sample situation.

Thirdly, in a technical business-to-business industry, researchers and/or interviewers must be able to understand the technical terminology in sufficient detail to facilitate two-way communication. This is a critical issue for primary data collection, and to a lesser extent for the generation of secondary data.

II. RESEARCH OBJECTIVES AND RESEARCH QUESTIONS

A. Overview

This dissertation proposes a multi-stage, integrated methodology to test a model of normative segmentation. Figure 3.1 illustrates the proposed process. The four-stage process involves: (1) modeling product preferences at the individual level using conjoint analysis; (2) modeling product preferences at the segment level via cluster analysis; (3) designing optimal product line strategy at the segment level with SIMOPT (Green and Krieger 1991); and (4) designing optimal marketing strategy at the segment level using multiobjective integer programming.

The four stages of the model are interdependent and connected via inputs and outputs. Table 3.1 defines the objective, input, analysis, and output of each stage. The first stage involves the collection of conjoint data from customers in both the industrial and consumer applications. The subsequent stages of the model involve analyses that utilize the conjoint data and/or link conjoint results to data derived from secondary sources. This chapter outlines the research design and methodology employed in the development of the integral conjoint inputs for the industrial and consumer applications.

Figure 3.1
Model of Normative Segmentation

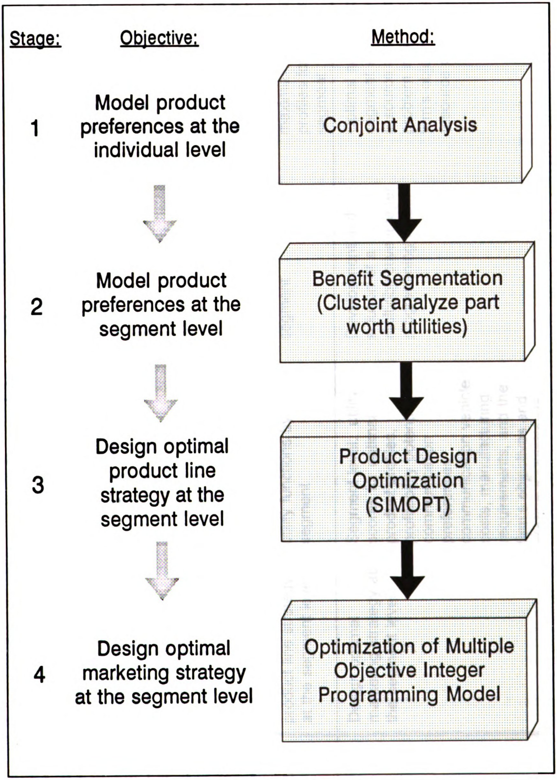

Table 3.1
Research Methodology

Stage	Objective	Inputs	Analysis	Output
Stage 1	Model product preferences at the individual level	Customer preferences for alternative product profiles	Conjoint analysis of choice data	Individual part-worth utility functions
Stage 2	Model product preferences at the segment level	Transformed (normalized) individual part-worth utilities	Cluster analysis using various algorithms	Homogeneous groups of customers with similar product preferences and corresponding segment level utility functions
Stage 3	Design optimal product line strategy at the segment level	Raw individual part-worth utility functions by segment	SIMOPT analysis by segment	Optimal (utility maximizing) product profiles for each market segment
Stage 4	Design optimal marketing strategy at the segment level	Segment level: utility scores for optimal product profiles, profitability potential, communication preferences, communication vehicle costs, manufacturing requirements, and the firm's objectives and resource constraints	Development and solution of a multiobjective integer programming model	Optimal solution to the segment selection and resource allocation problem in light of the firm's objectives and resource constraints

B. Research Objectives

This dissertation develops a model that simultaneously and rigorously treats segmentation and marketing strategy decisions in a normative benefit segmentation framework. The purpose of this research is to develop a normative segmentation approach that is considerably more applicable in practice than traditional approaches. The model is based on customer preferences, managerial input, and actionable attributes, therefore the results are highly relevant and implementable. Chapter II examined the conceptual integration necessary for model development and presented conjoint analytic techniques as a basis for methodological integration.

The specific research objectives of this dissertation are as follows:

(1) To establish a conceptual and methodological link between product-market structure definition, market segmentation and product positioning;

(2) To establish a conceptual and methodological link between normative and behavioral segmentation approaches;

(3) To develop a normative segmentation approach that facilitates consideration of all elements of the market mix;

(4) To develop a normative segmentation approach that simultaneously solves the segment selection and resource allocation problems in the context of the firm's objectives and constraints;

(5) To provide managers with a programmatic approach for devising and assessing segment level marketing strategy;

C. Research Questions

The primary study of this dissertation is the industrial application involving automotive front-end bumper systems. The purpose of the industrial study is to fully develop and test the proposed model of normative segmentation, as well as to demonstrate the link between product-market structure, definition, segmentation, and product positioning. The secondary study is conducted in a consumer product context on small portable entertainment units. The purpose of the consumer study is to validate the conceptual model and methodological process developed in the industrial study.

In order to achieve the objectives of this dissertation, research questions were developed from a synthesis of classic normative segmentation research (Chapter II) and the integrative conceptual framework of market behavior. The questions are organized around the research objectives outlined above. The specific questions for each application are outlined next.

C.1. Industrial Application

Based on the objectives set forth for this dissertation, the following seven research questions are pertinent to the industrial application:

1. What is the structure of the front-end bumper system product-market?
    - How can market structure be defined according to customer's preference-based choices?

2. What are the feasible product-market opportunities for front-end bumper system manufacturers?
    - How should homogeneous segments be formed?

3. What is the appropriate product portfolio for the firm?
    - How many and which segments should be selected?
    - What is the optimal product design in each segment?
    - What is the optimal mix of communication vehicles?
    - How should promotion and manufacturing resources be allocated?

4. How should the segment selection and resource allocation problem be modeled to include the firm's objectives and constraints?
    - How should segments be evaluated within a multiple objective programming model (MOIP)?

- How can each element of the marketing mix be included in the MOIP?
- What is the best formulation of the MOIP?
- What is the optimal solution to the MOIP?

5. What is the impact of the segmentation and product positioning strategy on profits?

6. What is the impact of the segmentation and product positioning strategy on customer satisfaction?

7. How effectively and efficiently is the resulting product portfolio communicated to each segment?

Research questions 1 through 3 jointly address the first research objective by establishing a conceptual and methodological link between product-market structure definition, market segmentation and product positioning. Research question 2 accomplishes the second objective by establishing a conceptual and methodological link between normative and behavioral segmentation approaches. Research question 4 realizes the third objective by facilitating consideration of all elements of the market mix. Research questions 4 through 7 jointly achieve the fourth objective by developing a normative segmentation approach that simultaneously solves the segment selection and resource allocation problems in the context of the firm's objectives and constraints. In total, the seven research questions satisfy the fifth objective by developing a programmatic approach for devising and assessing segment level marketing strategy.

C.2. Consumer Application

The purpose of the consumer application is to reexamine the approach developed for the industrial application in order to validate the overall process.

The consumer study provides an assessment of the transferability of the conceptual model and methodological process to a different context. Thus, the research questions pertinent to the consumer study are as follows:

1. Is the conceptual model and methodological process transferable to a consumer product-market?
2. Are there any differences in the application of the conceptual model or the methodological process to a consumer product-market?

III. INFORMATION NEEDS AND DATA SOURCES

A. Industrial Application

The research objectives and questions determine the information needs. Information is required from three sources to address the research questions: (1) the customers of automotive front-end bumper systems; (2) a supplier of automotive front-end bumper systems; and (3) secondary data on the cost of alternative communication vehicles. The relevant customers are the automotive OEMs, not the end-users (or consumers) of automobiles. Although there are generally multiple people involved in industrial buying situations, the focus here is on the function of specification of the technical properties of front-end bumper systems. Information on the preferences for various attributes and performance characteristics of front-end bumper systems is sought. The function most responsible for determining product specification is engineering. Thus, the specific customers of interest, or target respondents, are the bumper system engineers at the automotive OEMs.

The information required from the customer includes:

1. Preferences for different product profiles (defined in terms of technical attributes and benefits, as well as overall product cost);

2. Preferences for and usage patterns of different communication vehicles (trade press, exhibitions and trade shows, personal sales calls, and direct communications);

3. Preferences for and current practices of alternative forms of product delivery (in terms of the number of components delivered to the OEM's manufacturing plants by the supplier).

3. General information on the engineer (including demographics and risk preferences);

4. General information on the firm (including demographics and general business practices).

The information required from the supplier includes:

1. Relative cost data by attribute.

2. Pricing information.

3. Budget constraints on promotion (dollars).

4. Assembly capacity requirements for different forms of product delivery (manhour).

5. Capacity constraints on production (manhours).

6. Product-line constraints in terms of infeasible combinations of product profiles.

7. Identification of management's objectives and the relative ranks and weights among the objectives.

Additional information developed from secondary sources includes: industry specific average cost data for each communication vehicle, total market sales volume, and estimates of market shares for bumper system suppliers.

Information required from the bumper system engineers was collected in two phases. Phase I was an exploratory step necessary for generating a relevant and limited set of technological attributes and benefits. This data was collected through individual interviews with representative (but nonrandomly selected) respondents and industry experts. Phase II involved a large-scale conjoint-based survey of bumper system engineers in the automotive industry. Phase I and II are more completely described in the next section on Research Approaches. Information required from the bumper system supplier was collected in an on-going, interactive manner, throughout the course of model development and solution. This interactive process is described in greater detail in Chapter V.

B. Consumer Application

The consumer application requires the same type of information as the industrial study. That is, information is required from the customer's perspective, and a supplier's perspective. The target customers in the consumer application are college students who are users of small portable entertainment units. In lieu of actual data from a manufacturer of small portable entertainment units, industry participants and secondary sources were used to develop hypothetical, relevant data. Additional information is obtained from secondary sources includes: average cost data by media type, estimates of market share by brand, and estimates of total market sales.

The information required from the customer includes:

1. Preferences for different product profiles (defined in terms of features and benefits, as well as price);
2. Usage patterns of different promotional media (magazines, newspapers, television and radio);

3. Brand preferences and loyalties;

4. General information on the student (including demographics, socioeconomic data, and motivations);

The information that must be developed for the supplier perspective includes:

1. Relative cost data by attribute.

2. Pricing information.

3. Hypothetical budget constraints on promotion (dollars).

4. Estimates of capacity requirements for alternative product profiles (volume).

5. Hypothetical capacity constraints on production (volume).

6. Hypothetical product-line constraints in terms of infeasible combinations of product profiles.

7. Assumptions regarding management's objectives and the relative ranks and weights among the objectives.

Information required from the college students was also collected in two phases. Phase I generated the relevant attributes and levels. This data was collected through individual interviews with representative respondents. Phase II involved a large-scale conjoint-based survey of college students. Phase I and II for the consumer application are more completely described in the next section on Research Approaches.

IV. DATA COLLECTION PROCESS

This section describes the conjoint data collection process. There are six major steps involved in conjoint analysis (Green and Srinivasan 1990; Hair et al. 1992). Table 3.2 lists the steps and the alternatives for accomplishing each step.

Table 3.2
Conjoint Analysis Steps

STEP 1	Specify attributes and levels
STEP 2	Specify preference model form • Vector model, ideal-point model, part-worth function model, mixed model
STEP 3	Construction of stimulus-set: number and form • Number: factorial design, fractional factorial design • Form: verbal description (multiple-cue stimulus card), paragraph description, pictorial or three-dimensional model representation, physical products
STEP 4	Choose data-collection method • Full profile, two-attribute at a time (tradeoff)
STEP 5	Select preference measures • Rating scale, rank order, paired comparisons, constant-sum paired comparisons, graded paired comparisons, category assignment
STEP 6	Select estimation method • Metric methods (multiple regression), nonmetric methods (LINMAP, MONANOVA, PREFMAP, Johnson's tradeoff table algorithm), choice-probability-based methods (logit, probit)

[adapted from Green and Srinivasan 1990; and Hair et al. 1992]

The six steps were followed in both the industrial and consumer application. Each step is described in detail for the industrial study and summarized for the consumer study.

A. Industrial Application

Step 1. Specify attributes and levels. The appropriate attributes and levels were determined in the Phase I exploratory stage of the industrial study. Personal interviews with representative respondents and industry experts were conducted in order to generate a *relevant set* of attributes and levels. The goal of Phase I was to identify attributes and levels that met the following criteria: (1) determinant factors that are pivotal in the actual judgment decision, (2) the factors and levels should be actionable and not "fuzzy" characteristics, (3) the factors and levels should be easily communicable to the target respondents for a realistic evaluation (Hair et al. 1992; Churchill 1990).

The number of attributes directly affects the statistical efficiency and reliability of the conjoint model (Wittink, Krishnamurthi, and Reibstein 1990). As factors and levels are added, the number of parameters to be estimated increases. This requires either a larger number of stimuli or a reduction in the reliability of parameters. The problem cannot be solved by adding respondents because each respondent generates the required number of observations. Thus, Phase I sought to identify a *limited set* of attributes and levels. Table 3.3 presents the attributes identified for front-end automotive bumper systems.

Step 2. Specify preference model form. The appropriate preference model form is determined by the nature of the attributes and levels. Attributes and levels

Table 3.3
Industrial Study Attributes and Levels

(1). **WEIGHT** - the percent decrease in total weight from the current front-end bumper system (0%, 5%, 15%, 30%).

(2). **ENERGY MANAGEMENT** - the amount of energy absorption the front-end bumper can withstand (2.5 mph, 5 mph, 15 mph).

(3). **FASCIA FINISH** - the finish on the front-end bumper fascia (black, painted body color, molded-in color).

(4). **RECYCLED CONTENT** - the percent of total recycled material contained in the front-end bumper system (0%, 5% postconsumer, 20% regrind).

(5). **MANUFACTURING COMPLEXITY** - the number of parts delivered to the manufacturing plants incorporating the energy absorber, beam, and fascia (1 modular system, a 2 part combination, 3 separate parts).

(6). **SYSTEM COST** - the percent increase in total cost over the current front-end bumper system (0%, 5%, 10%).

can be either categorical or quantitative. Categorical models features require a part-worth function model. Specifically, an additive, main-effects part-worth model is employed. The additive model is based on the additive composition rule which assumes that individuals "add-up" individual part-worths over attributes and levels to calculate an overall or total utility score indicating preference. No interaction effects are modeled[1]. The additive part-worth model is the most general and widely applied conjoint preference model (Green and Srinivasan 1990).

Step 3. Construct stimulus set. The number of stimuli is dependent upon

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[1] Empirical evidence (Green 1984) indicates that modeling interaction terms often leads to *lower* predictive validity. That is, model realism may be improved by incorporating interaction terms, but it is achieved at the expense of predictive accuracy due to the addition of parameters (Green and Srinivasan 1990).

the experimental design, as well as the number of attributes and levels. The six attributes and their respective levels result in $4x3^5$ (or 972) possible combinations of product profiles. A subset of the product profile combinations was selected according to an asymmetric fractional factorial design. A fully orthogonal main-effects design was used, resulting in 25 profiles (Addleman 1962; Green 1974).

Fractional factorial designs trade-off the measurement of all possible interaction effects in order to obtain a smaller number of replicates to be estimated without confounding (Green 1974). Orthogonal arrays represent the most parsimonious set of design (in terms of the number of combinations) available for main-effect parameter estimation (Green 1974). Parsimony in the number of combinations is critical for enhancing industrial respondent participation. Each respondent was presented with all 25 stimuli and each factor was in each stimulus. The 25 stimuli were presented to the respondents in written form in a booklet. Each attribute was identified at a particular level for each profile.

Step 4. Choose data-collection method. The conjoint data was collected using the full-profile presentation method. The full-profile method performs well when there are only a moderate number (five to seven) of attributes (Green and Srinivasan 1990). One of its major advantages is that it allows for a realistic description of a product by defining levels of each factor. This facilitates an explicit portrayal of the trade-offs customers make among factors.

Using the full-profile method, the 25 stimuli were described and placed in a booklet. Each stimulus was a complete product profile consisting of one level of each attribute. The order in which the factors were listed in the stimulus booklets was randomly rotated across respondents to minimize order effects. Phase II of data collection involved a large-scale conjoint-based survey of bumper system engineers. The conjoint exercise was administered by mail. Detailed written instructions accompanied the booklets.

Step 5. Select preference measure. Respondents' preference for each profile was measured by a 6-point likelihood-of-selecting scale (Louviere 1988)[2]. A metric rating scale was chosen because it provided the form of data required for analysis. Metric ratings allow conjoint estimation to be performed using regression techniques. Furthermore, conjoint is more amenable to mail-administration when the preference measure involves a rating exercise rather than a ranking exercise.

Step 6. Select estimation method. Ordinary least squares multiple regression is employed for estimation of parameters. In practice, regression analysis has become the favored approach for parameter estimation (Green and Srinivasan 1990; Wittink and Cattin 1989). In OLS estimation, attribute levels are recoded into dummy variables and entered into a standard multiple-regression program that estimates part-worths for each level. The reliability of the OLS conjoint model can be assessed by testing the significance of the Pearson correlations between the actual and predicted preferences for each person (Green and Srinivasan 1990). The objective in assessing reliability is to ascertain how

[2] The 6-point forced scale is as follows: 1=definitely would select, 2=very likely would select, 3=probably would select, 4=probably would not select, 5=very likely would not select, and 6=definitely would select.

consistently the model predicts across the set of preference evaluations given by each person (Reibstein, Bateson, and Boulding 1988).

B. Consumer Application

The six step approach was applied in the consumer study. The Phase I exploratory stage involved two focus groups with representative college students to identify the appropriate attributes and levels. Table 3.4 presents the attributes and levels identified for the small portable entertainment units.

A part-worth, main-effects, additive preference model was employed for the consumer study[3]. The five attributes and respective levels result in $5 \times 3^2 \times 2 \times 4$ (or 360) possible combinations of product profiles, from which a subset of 25 product was selected according to an asymmetric fractional factorial design.

Using the full-profile presentation method, each of the 25 stimuli were completely described and placed in a booklet. The order in which the factors were listed in the stimulus booklets was randomly rotated across respondents to minimize order effects. Phase II of data collection involved a large-scale conjoint-based survey of college students. The conjoint exercise was administered as an in-class exercise in two separate classes. Oral instructions were given and visual aids were used to ensure clarity of explanation. The students were asked to rate their preferences for each profile on a 6-point likelihood-of-buying scale (the 6-points are the same as those defined for the industrial study).

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[3] Since price is a quantitative variable, the effect of modeling price with a linear (vector) preference function was assessed. Compared to the complete part-worth model, the mixed part-worth/vector model resulted in lower predictive accuracy. Since the purpose of conjoint analysis is to predict customer choices, the preference model with higher predictive validity was used (Green and Srinivasan 1990; Cattin and Punj 1984).

Table 3.4
Consumer Study Attributes and Levels

(1).	**BRAND** - the name brand (Aiwa, Panasonic, GPX, Sony, GE).
(2).	**FEATURES** - the capability of the unit to function as a radio, cassette player, and/or a CD player (AM/FM only, AM/FM + cassette, AM/FM + CD player, CD player only).
(3).	**SOUND SYSTEM** - the type of headphones that come with the unit (no headpiece with insert earpieces, Headpiece with insert earpieces, headpiece with external earpieces).
(4).	**STYLE** - the type of model (sport model or standard/non-sport model).
(5).	**PRICE** - the unit retail price ($25.99, $59.99, $89.99, $139.99).

V. RESEARCH INSTRUMENTS

Phase II of the data collection process involved a large-scale, conjoint-based survey. In each application, a formal, nondisguised survey consisting of the 25 product profiles and additional items was administered to each respondent by mail or in person. The questionnaire was designed to collect the conjoint data and additional information required for model development (see Appendix A). The questionnaire content and pretest are briefly discussed next for each application.

A. Industrial Application

Content. The questionnaire was mainly designed to identify customers' preferences for different front-end bumper system profiles. Other questions elicited preferences for and usage patterns of different communication vehicles, as well as preferences for and current practices of alternative forms of product delivery. Questions pertaining to the engineers' model assignment(s) and risk preferences were included. Finally, the questionnaire contained several items to gather general information on the firm, including general business practices, functional responsibilities, and current supplier practices and preferences.

The development of the conjoint profiles was described in a previous section. The Business Practices items were drawn from Narver and Slater's (1990) market orientation scale. The items measuring Risk were developed from the risk aversion factor in Craig and Ginter's (1975) innovativeness scale and from the risk preferences factor in Price and Ridgeway's (1983) use innovativeness scale. The functional responsibility matrix and questions regarding the effectiveness of various information sources were drawn from Choffray and Lilien (1978). The questions regarding the current and preferred number of suppliers and components were based on discussions with industry experts.

Pretest. The instrument was pretested on two independent industry experts. Based on their suggestions and questions, changes were made in the wording of certain questionnaire items and in the directions for the conjoint exercise. The revised questionnaire was pretested on several engineers at the supplier firm and revised again based on additional comments and problems.

B. Consumer Application

Content. As in the industrial application, the consumer study questionnaire was mainly designed to identify students' preferences for different small portable entertainment units (SPEU). In addition, various items were included to collect demographic data on the respondents; including current ownership of an SPEU, usage patterns of music products, sex, age, and socioeconomic data. Other questions elicited usage patterns of different promotional media. Materialistic attitudes and the degree of involvement with SPEUs were measured. Finally, student's ethnocentrism and country-of-origin perceptions were assessed.

The development of the conjoint profiles was described in a previous section. The materialism items were developed directly from Moschis and Churchill's (1978) materialistic attitudes scale. The product involvement measures were drawn from Traylor and Joseph's (1984) general scale of product involvement. The consumer ethnocentrism items were obtained from Shimp and Sharma's (1987) validation study of CETSCALE, and the measures of country-of-origin perceptions were developed from Pisharodi and Parmeswaran (1992).

Pretest. The instrument was pretested on five representative respondents. Based on questions and comments, changes were made in the wording of certain questionnaire items and in the instructions given for the conjoint exercise. The revised questionnaire was pretested on five different students and revised again based on additional comments.

VI. SAMPLING PLAN

A. Industrial Application

The target population for the industrial study is the bumper system engineers at the major automotive OEMs in the U.S. It is estimated that there are approximately 450 bumper system engineers in this population[4]. Balancing the cost of data collection against the need to obtain a sufficiently large sample for analysis purposes, a target sample size of 100 was set.

A purposive sampling approach was used to draw a quota sample of 100 bumper system engineers. Specifically, a snowball sample was generated from an initial list of 124 bumper system engineers obtained from an automotive industry consulting firm (Goodman 1961). The initial contacts were used as informants to identify additional contacts. The request for referrals was driven by the goal of obtaining responses for as many models as possible within each vehicle class. Also, every effort was made to balance the sample across OEMs.

Up to five attempts were made to contact each engineer by telephone. Upon making contact, participation in the research project was requested. A survey was promptly mailed to each engineer who agreed to participate. Each contact was asked for additional references. In total, 143 contacts were made and 140 surveys were mailed out. Up to three follow-up phone calls were made to the engineers who had been mailed a questionnaire until the quota of 100 surveys were returned (giving a response rate of 71.4%).

The sampling plan achieved a good distribution of responses across vehicle classes. However, the resulting sample was somewhat imbalanced in terms of OEM representation. Although the Japanese OEMs have manufacturing facilities in the U.S., a majority of the engineering and design work is done in

[4] There are 228 total domestic and import models in the passenger car and light truck classes (full-sized pickups, sport-utility, and vans are excluded). A reasonable estimate is that, on average, each model has two bumper system engineers assigned.

Japan, thus there was a smaller available population from which to sample. The remaining imbalance in the distribution of OEM representation is an artifact of snowball sampling (Biernacki and Waldorf 1981). A demographic summary of the respondents is as follows:

OEM	Frequency
GM	28
Ford	39
Chrysler	25
Japanese	8

Vehicle Class	Frequency
Small car	19
Midsize	17
Large car	14
Luxury	13
Truck/Sport Utility	17
Minivan	12

B. Consumer Application

The target population for the consumer study is college students. A nonrandom, convenience sample of undergraduate students enrolled in courses at Michigan State University was used for the consumer study. A target sample size of 200 was set in order to obtain a sufficiently large sample for analysis purposes. To achieve this sample size, two undergraduate classes were nonrandomly selected so as to preclude duplication. The survey was administered by the researcher during the course of a single class period in each class. In total, 216 questionnaires were completed, of which 209 were usable.

VII. SUMMARY

The stages of the multi-stage, integrated methodology proposed in this dissertation are interdependent and connected via inputs and outputs. This chapter outlined the research design and methodology employed in the development of the primary data upon which the model is built; the conjoint inputs. Specifically, the research objectives and questions were presented and linked to information requirements and data sources. The data collection process was outlined. Finally, the research instruments and sampling plans were reviewed for each application.

CHAPTER IV

CONJOINT SEGMENTATION AND PRODUCT DESIGN OPTIMIZATION: ANALYSIS AND RESULTS

This dissertation proposes a multi-stage model of normative segmentation. Figure 1.1 illustrates the model and proposed process. The four-stage process involves: (1) modeling product preferences at the individual level using conjoint analysis; (2) modeling product preferences at the segment level via cluster analysis; (3) designing optimal product line strategy at the segment level with SIMOPT (Green and Krieger 1991); and (4) designing optimal marketing strategy at the segment level using multiobjective integer programming. Table 1.2 illustrates the interdependent nature of the four-stages.

This chapter details the analysis and results involved in Stages 1 through 3 of the proposed model. The conjoint, cluster, and design optimization analyses involved in Stages 1 though 3 are highly interrelated due the dependency of each stage on conjoint inputs. For coherence, the results of Stages 1 through 3 are presented together in this chapter. Stage 4 involves a significantly different conceptualization, thus it is presented separately in Chapter V.

First, the conjoint and cluster analyses and results of Stages 1 and 2 are presented jointly in a conjoint segmentation framework. Then, the application and results of the design optimization SIMOPT are presented. The industrial study on front-end bumper systems is the focus of the discussion.

I. CONJOINT SEGMENTATION

Conjoint segmentation is the application of conjoint analysis and cluster analysis in tandem to identify needs of delineated market segments. Market segmentation can be realized by submitting the results of conjoint analysis to cluster analysis in an effort to delineate potential segments based on benefits sought. The resulting benefit segments represent groups of customers who seek similar benefits.

A. Conjoint Analysis

The objective of Stage 1 is to model product preferences at the individual level. Conjoint analysis provides a quantitative estimate of how each attribute level impacts customer choices. The resulting utility functions contain quantitative estimates for each attribute level for each individual. The utility function is the sum of the part-worth utility estimates for each attribute level.

The conjoint exercise described in Chapter III produced a vector of 25 product choice preferences for each respondent. The 100 vectors of product choice preferences served as input to conjoint analysis. Individual level part-worth utility functions were estimated using standard OLS multiple regression techniques with Bretton-Clark (1992) Conjoint Analyzer© software.

A.1. Utility Functions[1]

A utility function must be interpreted in a relative fashion. The impact of each attribute and level is measured relative to the impact of all other attributes

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[1] This discussion is drawn from Bretton-Clark's (1992) description of Conjoint Analyzer ©

and levels in a given study. For example, a negative utility for some attribute level does not mean that respondents dislike this level. It means that respondents like this level less than other levels in the attribute, and that this level leads to a lower average preference rating.

The utility function is measured in abstract units called "utiles". The procedures employed in Conjoint Analyzer© facilitate direct translation of utiles to the respondent's ratings. For example, a part-worth utility score of .3 utiles means that this particular attribute level has a positive impact of .3 rating points on the rating scale used in the study. Higher utilities indicate greater preference.

The part-worth utility model is easily interpreted. Each level of the attribute has an explicit utility. The part-worth utilities for the levels of a particular attribute are constrained to sum to zero. Appropriate interpretations of the part-worth utilities include: (1) differences between two part-worth utilities for the levels of a particular attribute, (2) differences between pairs of utilities for the levels of a particular attribute, and (3) percentage differences between pairs of utilities for the levels of a particular attribute. It is inappropriate to state that one utility is, for example, twice as large as another.

A.2. Aggregate Conjoint Results

Part-worth utility functions were calculated for each respondent. The part-worth utility functions consist of a part-worth utility score for all levels of each attribute for each individual. Table 4.1 reviews the attributes and levels used in the bumper system study that were described in Chapter III (Table 3.3).

Table 4.1
Attributes and Attribute Levels

ATTRIBUTES	ATTRIBUTE LEVELS 1	2	3	4
Weight	0% decrease	5% decrease	15% decrease	30% decrease
Energy	2.5 mph	5 mph	15 mph	
Finish	Black	Painted	Molded	
Recycled Content	0% recycled	5% recycled	20% recycled	
Mfg Complexity	3 parts	2 parts	1 part	
Cost	10% increase	5% increase	0% increase	

The aggregate, group utility function for all respondents is presented next to illustrate the results of the conjoint analysis. The aggregate utility scores for each attribute level are presented in Table 4.2. The group utility scores in Table 4.2 are averaged aggregates of the 100 individual part-worth utility functions. A matrix of data similar to that presented in Table 4.2 was calculated for each individual.

Table 4.2
Aggregate (Total Sample) Utility Scores

Attribute	Attribute Level 1	2	3	4
Weight	-0.435	0.253	0.019	0.162
Energy	-0.733	0.305	0.427	
Finish	-0.475	0.482	-0.008	
Recycled	-0.051	-0.029	0.081	
Mfg Comp	-0.057	-0.131	0.187	
Cost	-0.184	-0.044	0.229	

The average adjusted R^2 of the aggregate utility function is 0.706 (s.e. = .025), indicating that the model does a good job of fitting the data. The average adjusted R^2 indicates how well the utility function fits the respondents' data by measuring how much of the variance in the original data is captured by the utility function[2].

Table 4.3 presents the relative importances of each attribute for the total sample. The relative importance (RI) of an attribute is calculated from the range of utilities for the attribute[3]. Relative importances were calculated at the group level and the individual level. The difference between the individual and group relative importances can be examined in order to assess the degree of heterogeneity in the data. Table 4.3 reports the deviation of the group RIs from an "average" individual's RIs.

If the group and individual RIs are significantly different, this indicates that respondents are heterogenous in their preferences and that the group utility function is an inappropriate aggregation. For example, the group RI for Energy Absorption is 31.62% which is 3.23 standard deviations away from an "average" individual's RI for Energy Absorption. Table 4.3 indicates that four of the six attributes have group RIs that are more than two standard deviations away from the individual RIs; Energy, Finish, Recycled Content, and Manufacturing Complexity.

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[2] The R^2 statistic is biased in conjoint applications due to non-linearity (Haggerty and Srinivasan 1991). The adjusted R^2 corrects for bias using an arcsine transformation.

[3] $RI_i = (range_i * 100)/\sum_i range_i$; where RI is the relative importance of attribute i.

Table 4.3
Group RIs and Distribution of Preferred Levels

Attribute	Relative Importance (%) (Standard deviations between group and individual RI)	Distribution of Preferred Levels (%) 1	2	3	4
Weight	18.76 (1.03)	1.00	48.00	16.00	35.00
Energy	31.62 (3.23)	7.00	34.50	58.50	
Finish	26.09 (3.26)	11.00	66.00	23.00	
Recycled	3.60 (7.48)	36.83	29.33	33.83	
Mfg Comp	8.67 (2.94)	30.00	14.50	55.50	
Cost	11.26 (1.28)	23.33	17.33	59.33	

The degree of variation in the data can be assessed by examining the distribution of preferences across attribute levels. Table 4.3 also presents the distribution of preferred levels for the aggregate data. For each attribute, the table displays the percentage of respondents that "preferred" each of its levels; the sum of the percentages across each attribute is 100%. "Preferred" means that the respondent had greater utility for this level than any of the other levels of the attribute. The extent to which the percentages differ from 0% and 100% indicates the degree of heterogeneity in preferences.

The distribution of preferred levels indicates a considerable degree of heterogeneity in respondent preferences. The variation in preferred levels strongly suggests that distinct segments with different preferences exist, thus justifying the need for benefit segmentation analysis. This also suggests that it is more appropriate to aggregate and present utility scores at the segment level rather than at the total sample level. In order develop segment level utility functions, respondents must first be sorted into homogeneous groups. Cluster analysis facilitates the identification of benefit segments using the individual part-worth utility functions derived from the conjoint analysis.

B. Cluster Analysis

The objective of Stage 2 (Figure 1.1) is to model product preferences at the segment level. In the context of conjoint segmentation, the purpose of cluster analysis is to sort customers into groups that seek similar product benefits. Benefit segments are identified by sorting customers into segments according to their preferences for product attributes. The individual part-worth utility functions derived from the conjoint analysis in Stage 1 provide measures of individual product attribute preferences. Thus, the individual part-worth utility functions from Stage 1 are used as inputs to the cluster analysis in Stage 2.

A traditional step in cluster analysis is the selection of a cluster solution (i.e., the number of clusters) based on some variance criterion (e.g., scree plots or discriminant validity), difference of means tests, intuition, or visual inspection. This dissertation argues that normative segmentation theory compels simultaneous segment selection (how many and which segments to select) and resource allocation decisions within the context of the firm's objectives and constraints. Thus, cluster analysis is used to identify multiple benefit segment solutions consisting of k clusters each. The problem of segment selection (i.e., cluster solution selection) is left for Stage 4.

B.1. Clustering Method and Solution

There are few theoretical guidelines to guide the choice among clustering methods. The major works on comparative analysis of clustering methods are briefly reviewed next. The most comprehensive comparative analysis available in the literature was reported in related papers by Milligan (1980), Milligan et al. (1983), and Milligan and Cooper (1983). Milligan and associates compared fifteen clustering algorithms to determine the algorithms recovered the "right" number of clusters. The main results of their comparative analyses are as follows: (1) the K-means algorithm gave better results than hierarchical methods only when the starting partition was close to the final solution, (2) single-link method was only mildly affected by outliers but was strongly affected by errors in distance at levels having virtually no effect on other hierarchical algorithms, and (3) no one group of hierarchical algorithms was consistently superior to any other group.

The comparative analysis of clustering methods presents a continuing problem for research. Hartigan (1985) contends that there is no single "best" clustering algorithm for all purposes (also Klastorin 1983). It has been suggested that several alternative methods should be tried on a given data set (Funkhouser 1983). Fisher and Van Ness (1971) and Rubin (1967) suggest comparing clustering methods and solutions using a list of "admissibility criteria". The idea is to evaluate alternative clustering solutions according to a list of properties concerning cluster formation, data structure, and any *a priori* assumptions.

In this dissertation, three clustering algorithms were employed to analyze the transformed individual part-worth utilities[4]: a Ward's, k-means, and centroid algorithm. Multiple cluster solutions[5] were generated using each method, for a total of 15 cluster solutions. The solutions were individually evaluated for meaningfulness using several criteria to assess cluster solution validity.

Assessing cluster validity involves the evaluation of indices for the purpose of judging the merits of clustering structures in a quantitative and qualitative manner. The adequacy of a clustering structure refers to the degree to which the clustering structure provides true information about the data, or the ability of the recovered structure to reflect the intrinsic character of the data. The validity of a clustering structure can be expressed in terms of external criteria and internal criteria. External criteria measure performance by evaluating a cluster structure relative to *a priori* information concerning the data. This might include subjective comparisons of cluster solutions to *a priori* expectations regarding the number and

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[4] The part-worth utilities were standardized using a multinomial Luce transformation of the following type (McFadden 1976):

$$P_j^i = \left(e^{u_j^{(i)}}\right) / \sum_{j=1}^{n} e^{u_j^{(i)}}$$

Where $P_j^{(i)}$ denotes the transformed weight for level j (j = 1,2,..,n) of attribute i (i = 1,2,..,m), e=2.718... and $u_j^{(i)}$ is the part-worth utility associated with level j of attribute i. The transformation creates independent and comparable weights with computational advantage and which are invariant over an additive constant applied to each of the $u_j^{(i)}$ within any specific attribute (Green and DeSarbo 1978).

[5] Five cluster solutions were generated with each algorithm (k=6,5,4,3,2); i.e., a 6-cluster, 5-cluster, 4-cluster (and so on) solution was generated using Ward's, k-means, and centroid clustering methods.

distribution of clusters. Internal criteria assess the fit between the structure and the data using only the data itself. This includes tests of differences among the clusters on the clustering variables and on other important descriptor variables.

Four criteria were evaluated to assess the validity of the 15 cluster solutions: (1) differences within each cluster solution on attribute relative importance variables, (2) differences within each cluster solution on demographic variables, (3) the distribution of cluster sizes within each solution, and (4) the interpretability of each solution. Thus, the validity of each solution was assessed in four steps:

Table 4.4
Assessment of Cluster Validity

STEP	ANALYSIS
1	Test for differences in means on attribute RI scores;
2	Test for differences in means and frequencies on demographic variables;
3	Assess the distribution of cluster sizes using industry expert opinion;
4	Assess the interpretability of each solution using industry expert opinion.

The first step reflects an internal validity check on the legitimacy of each cluster solution. Recall, relative importances are derivations of part-worth utilities (footnote 3). A test of differences among clusters on relative importances assesses the between-group variance achieved by a particular cluster structure. If there are not significant differences on relative importances, then the cluster solution is not an acceptable split of the data into distinct benefit segments.

The second test reflects another internal validity check on the legitimacy of each cluster solution. Tests of differences among clusters on various demographic variables identify those solutions that reflect important distinctions in customer characteristics. The demographic variables tested include model and OEM classifications, respondents' market orientations, risk preferences, functional responsibilities, information source practices and preferences, and supplier practices and preferences.

After evaluating each cluster solution on the basis of the first two criteria, the third and fourth steps are applied as subjective external evaluations. The distribution of cluster sizes within the solution and the interpretability of each solution were considered. Alternative cluster solutions were evaluated relative to *a priori* expectations regarding segment size distributions and market structure. This evaluation was based on the insights and expectations of industry experts who were asked to examine the alternative cluster solutions and report on the appropriateness of each according to their knowledge of the market.

The application of the four steps led to the selection of three cluster solutions; a 5-cluster solution (Ward's), a 4-cluster solution (k-means), and a 3-cluster solution (Ward's). The three cluster solutions resulted in the identification of twelve benefit segments. The clusters are numbered consecutively x_1 through x_{12} and will be so referenced for the remainder of the dissertation. Note that the sum of the cluster sizes *within each solution* is 100, the total sample size.

The size of each segment is outlined below:

5-cluster Solution	4-cluster Solution	3-cluster Solution
$x_1 = 25$	$x_6 = 18$	$x_{10} = 40$
$x_2 = 17$	$x_7 = 41$	$x_{11} = 33$
$x_3 = 27$	$x_8 = 35$	$x_{12} = 27$
$x_4 = 15$	$x_9 = 6$	
$x_5 = 16$		

Table 4.5 presents the ANOVA tests of difference for the relative importance variables and various demographic variables for the three cluster solutions. The results indicate that there are significant differences within in each cluster solution for all of the relative importance variables. However, a majority of the Business Practice and Information Source variables are not important discriminators of cluster membership. The multiple range tests of differences in means are presented in Table B1.1 in Appendix B.

Table 4.6 contains the results of chi-square tests of independence between certain categorical demographic variables and each cluster solution. The chi-square tests indicate that there is a significant relationship between cluster membership and the respondent's classification according to OEM, model, and the number of suppliers used (current and preferred). Manufacturing complexity (i.e., the number of components delivered to the plant) does not have a significant association with cluster membership.

The result of the cluster analysis and evaluation process is a set of twelve clusters that represent feasible alternative sortings of the sample into groups of

Table 4.5
ANOVA Tests for Cluster Solutions

	Ward's 5-cluster	K-means 4-cluster	Ward's 3-cluster
Relative Importances[1]			
Weight	.0643	.0521	.0442
Energy Absorption	.0001	.0001	.0001
Finish	.0001	.0003	.0001
Recycled Content	.0004	.0015	.0001
Mfg Complexity	.0165	.0001	.0027
Cost	.0001	.0001	.0001
Business Practices			
Market Orientation	ns	.0480	.0521
Risk Preference	ns	ns	ns
Functional Responsibilities[2]	ns	ns	ns
Information Sources[3]			
Current - Trade Shows	.0365	.0420	.0592
Effectiveness - Trade Press	.0582	.0621	.0532

Table Notes:
[1] For each variable in this table, the significance of difference in means across clusters was tested using ANOVAs; the value entered in the columns for each cluster solution indicates the significance of the F-test.
[2] Functional Responsibilities includes scores on 5 activities and 6 functions (see the survey instrument in Appendix A for a complete list). Summary scores by activity (5 composite variables) and by function (6 composite variables) were calculated and tested for differences across clusters. There were no significant differences for any of the composite variables for any cluster solution at the .05 level or better.
[3] Information Sources includes ratings for the current usage of 4 sources of information and effectiveness scores for the 4 sources (see the survey instrument in Appendix A for a complete list). Only those sources with significant differences are listed in the Table.

Table 4.6
Chi-Square Tests for Cluster Solutions*

Variable	Ward's 5-cluster	K-means 4-cluster	Ward's 3-cluster
OEM	.032	.019	.038
Model	.040	.041	.022
Number of Suppliers:			
Current	.015	.006	.003
Preferred	.068	.059	.045
Number of Components:			
Current	ns	ns	ns
Preferred	ns	ns	ns

* Table entries are the significances of the X^2 test.

respondents with distinct preferences. In order to fully articulate the derived clusters as benefit segments, it is necessary to resubmit the individual part-worth utilities to conjoint analysis.

C. Conjoint Results by Segment

The aggregate conjoint results suggested the presence of distinct segments defined according to benefits sought. Cluster analysis was then used to sort respondents into homogeneous groups, or benefit segments, according to their preferences for product attribute. The objective of Stage 2 is to model the product preferences at the segment level. To achieve this objective, the individual part-worth utilities for each of the twelve segments are resubmitted to conjoint analysis in order to derive segment-level aggregate preferences. The conjoint results for each of the three cluster solutions are presented next.

Individual part-worth utility functions were calculated for each respondent in each segment. The segment-level part-worth utility functions for the 5-cluster solution are reported in Table 4.7. The part-worth utility scores and the relative importance of each attribute are presented for segments x_1 through x_5. The average adjusted R^2 for the segment-level utility functions ranged from 0.793 to 0.671 for segments in the 5-cluster solution. Tables 4.8 and 4.9 show the utility functions and relative importances for the 4-cluster and 3-cluster solutions, respectively. The average adjusted R^2 ranged from 0.741 to 0.651 for segments in the 4-cluster solution and from 0.743 to 0.617 in the 3-cluster solution.

Table 4.7
Part-Worth Utility Functions: 5-Cluster Solution

	Segment				
	X_1	X_2	X_3	X_4	X_5
Weight*	18.30%	14.56%	16.85%	24.75%	14.56%
0% decrease	-0.586	-0.218	-0.354	-0.545	-0.463
5% decrease	0.198	0.324	0.024	0.775	0.162
15% decrease	0.062	-0.029	0.061	-0.105	0.050
30% decrease	0.326	-0.076	0.269	-0.125	0.250
Energy Absorption	46.31%	36.39%	17.85%	33.50%	13.92%
2.5 mph	-1.211	-0.563	-0.404	-1.087	-0.390
5 mph	0.113	0.790	0.256	0.387	0.098
15 mph	1.097	-0.227	0.148	0.700	0.292
Finish	11.96%	27.85%	5.02%	23.87%	56.96%
Black	-0.305	-0.410	-0.049	-0.796	-1.225
Painted	0.291	0.625	-0.068	0.478	1.563
Molded	0.015	-0.216	0.117	0.318	-0.337
Recycled Content	5.22%	9.18%	13.84%	7.13%	7.66%
0% recycled	-0.139	0.186	-0.283	0.020	0.156
5% recycled	0.121	-0.008	0.054	0.180	0.063
20% recycled	0.017	-0.178	0.228	-0.200	-0.219
Manufacturing Complexity	8.27%	6.80%	16.75%	6.63%	2.17%
3 parts	-0.089	0.163	-0.230	0.020	-0.019
2 parts	-0.161	-0.073	-0.159	-0.187	-0.044
1 part	0.251	-0.090	0.389	0.167	0.063
Cost	9.95%	4.59%	26.69%	4.13%	4.73%
10% increase	-0.260	0.010	-0.523	0.116	0.019
5% increase	0.024	-0.090	-0.049	-0.011	-0.125
0% increase	0.236	0.080	0.573	-0.104	0.106

* The relative importance of each attribute is indicated in percentage form.

Table 4.8
Part-Worth Utility Functions: 4-Cluster Solution

	Segment			
	X_6	X_7	X_8	X_9
Weight	20.16%	16.94%	17.69%	16.50%
0% decrease	-0.472	-0.353	-0.527	-0.342
5% decrease	-0.072	0.315	0.364	0.158
15% decrease	0.183	-0.036	0.010	-0.042
30% decrease	0.361	0.074	0.153	0.225
Energy Absorption	15.86%	32.34%	43.31%	16.99%
2.5 mph	-0.396	-0.680	-1.143	0.289
5 mph	0.137	0.596	0.103	0.006
15 mph	0.259	0.084	1.040	-0.294
Finish	3.36%	34.57%	22.05%	10.68%
Black	-0.074	-0.605	-0.600	-0.056
Painted	0.009	0.759	0.511	-0.156
Molded	0.065	-0.154	0.089	0.211
Recycled Content	13.71%	7.17%	5.05%	6.31%
0% recycled	-0.326	0.127	-0.107	-0.122
5% recycled	0.085	0.029	0.148	0.028
20% recycled	0.241	-0.156	-0.041	0.094
Manufacturing Complexity	8.74%	4.45%	7.60%	42.72%
3 parts	-0.130	0.076	-0.088	-0.567
2 parts	-0.102	-0.099	-0.148	-0.333
1 part	0.231	0.023	0.235	0.900
Cost	38.17%	4.51%	4.31%	6.80%
10% increase	-0.733	-0.004	-0.129	-0.094
5% increase	-0.111	-0.087	0.040	-0.044
0% increase	0.844	0.091	0.089	0.139

Table 4.9
Part-Worth Utility Functions: 3-Cluster Solution

	Segment		
	X_{10}	X_{11}	X_{12}
Weight	20.57%	14.18%	16.85%
0% decrease	-0.571	-0.336	-0.354
5% decrease	0.414	0.245	0.024
15% decrease	-0.001	0.009	0.061
30% decrease	0.157	0.082	0.269
Energy Absorption	44.13%	22.75%	17.85%
2.5 mph	-1.164	-0.479	-0.404
5 mph	0.216	0.455	0.256
15 mph	0.948	0.024	0.148
Finish	17.75%	45.94%	5.02%
Black	-0.489	-0.805	-0.049
Painted	0.361	1.080	-0.068
Molded	0.128	-0.275	0.117
Recycled Content	4.65%	9.01%	13.84%
0% recycled	-0.079	0.172	-0.283
5% recycled	0.143	0.026	0.054
20% recycled	-0.064	-0.198	0.228
Manufacturing Complexity	8.15%	3.25%	16.75%
3 parts	-0.048	0.075	-0.230
2 parts	-0.171	-0.059	-0.159
1 part	0.219	-0.016	0.389
Cost	4.75%	4.87%	26.69%
10% increase	-0.119	0.014	-0.523
5% increase	0.011	-0.107	-0.049
0% increase	0.108	0.093	0.573

Figure 4.2 presents the conjoint results for the 4-cluster solution graphically (using the data in Table 4.8). Transformed part-worth utilities are plotted for each segment in order to graphically illustrate the part-worth utility functions for each segment[6]. Graphical representations of the 5-cluster and 3-cluster solutions are not shown due to the repetitive nature of the data. The information revealed by graphing the part-worth utilities can be inferred from the data in Tables 4.7 and 4.9. The graphs in Figure 4.2 indicate that there are four distinct benefit segments. The segments are effectively described by a dominant attribute: a Cost-Sensitive (x_6), Finish-Sensitive (x_7), Energy Absorption-Sensitive (x_8), and Manufacturing Complexity-Sensitive (x_9) segment.

The cluster solutions reflect alternative groupings of the same data set. The difference is in the degree of granularity to which the data is cut. In the 5-cluster solution, there are five distinct benefit segments: an Energy Absorption-Sensitive (x_1), Energy/Finish-Sensitive(x_2), Cost-Sensitive (x_3), Energy/Weight-Sensitive (x_4), and Finish-Sensitive (x_5) segment. The Energy Absorption attribute plays a more dominant role as a determinant variable in the 5-cluster solution than in the 4-cluster solution. Finally, there are three distinct benefit segments in the 3-cluster solution: an Energy Absorption-Sensitive (x_{10}), Finish-Sensitive (x_{11}), and Cost-Sensitive (x_{12}). The segments in the 3-cluster solution are much like those in the 4-cluster solution except that the small Manufacturing Complexity-Sensitive segment (X_9) is no longer separate.

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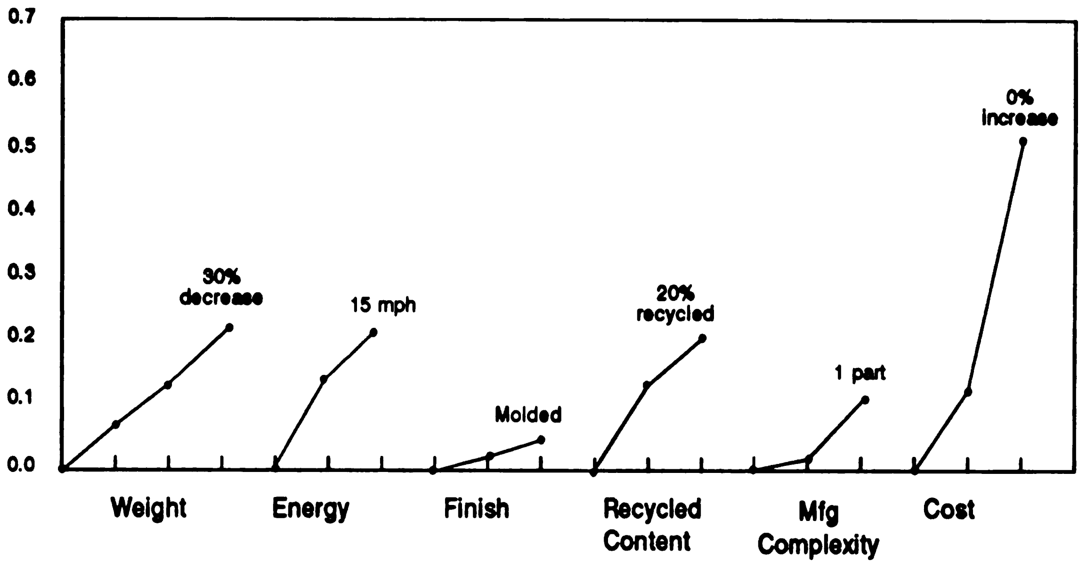
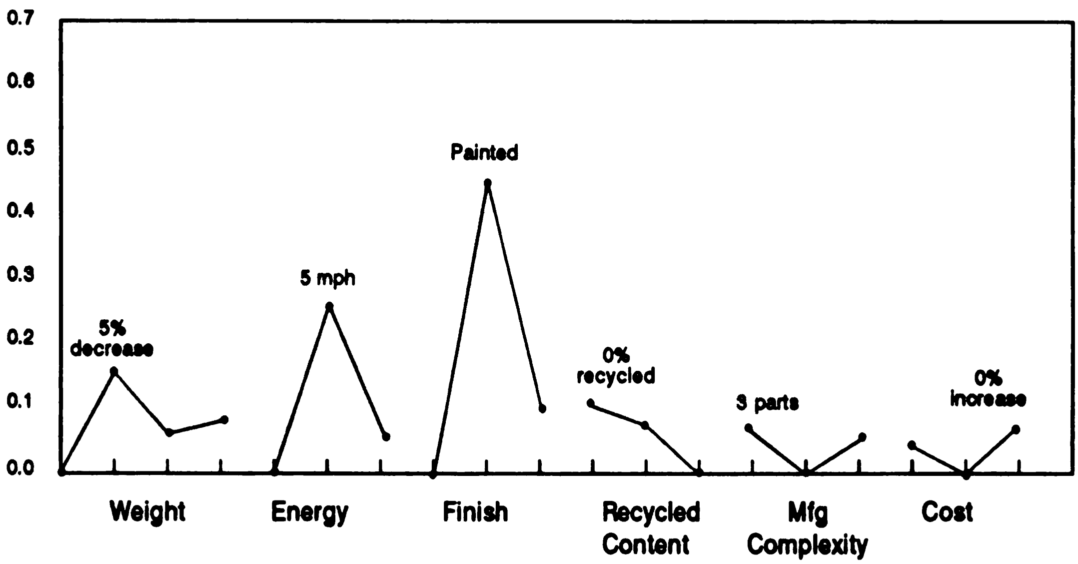
[6] The Luce transformation defined in footnote 4 was applied to the segment-level part-worth utilities. The transformed utilities reflect scaling and location changes to simplify the visual presentation of results.

Figure 4.2
Average Segment-Level Part-Worth Utility Functions (4-cluster Solution)

Segment x_6 *

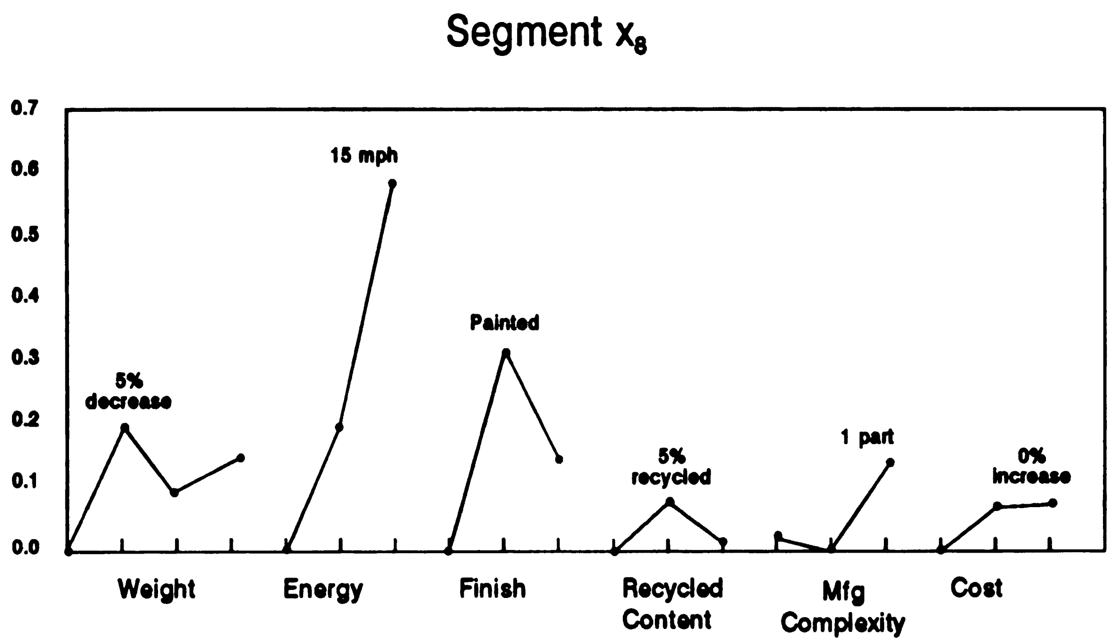


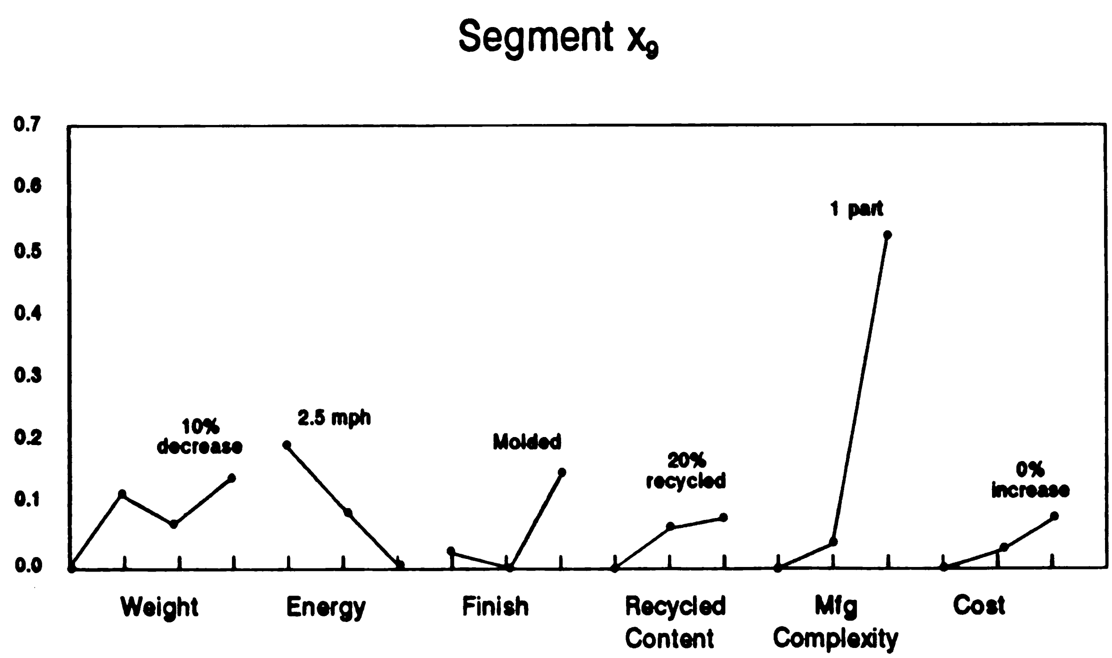
Segment x_7



* Only the most preferred attribute level is labeled.

Figure 4.2 (Continued)





Stages 1 and 2 of the proposed model were operationalized via conjoint segmentation. Product preferences were modeled at the individual and segment levels using conjoint and cluster analysis. Conjoint segmentation identified three feasible sortings of the sample into groups of respondents with similar preferences. The three cluster solutions represent alternative benefit segmentation schemes.

Chapter II defined effective segmentation schemes as those that result in segments meeting four conditions: (1) measurability, (2) substantiality, (3) accessibility, and (4) actionability. Using conjoint segmentation, Stages 1 and 2 have identified three segmentation schemes with measurable segments. Stage 3 will develop actionable information regarding optimal product design for each segment using a design optimization simulation. The twelve benefit segments and the respective part-worth utility functions developed in the conjoint segmentation analysis are the inputs to Stage 3. The substantiality and accessibility conditions drive segment selection. These conditions are addressed by Stage 4 of the model in Chapter V.

II. DESIGN OPTIMIZATION SIMULATION

The objective of Stage 3 in the proposed model is to design optimal product line strategy at the segment level. This is achieved by matching optimal product designs to given market segments. Green and Krieger's (1991, 1993) SIMOPT routine, described in Table 4.10, is employed to develop an optimal product design for each of the twelve benefit segments identified in Stage 2. Only

Table 4.10
SIMOPT Program Characteristics

Input	Analysis	Output
Individual part-worths file	For any set of competitive profiles, the program computes share/return for each supplier	Market share/return for each supplier
Individual importance weights file	All shares/returns are automatically adjusted to base-case conditions	Individual supplier selection file
Demographic (background) file	Sensitivity analyses can be performed at the individual attribute-level	Optimal product description for total market or selected segment
Each suppliers' profile	Optimization can be Carried out by supplier or for groups of suppliers' attribute levels can be fixed for conditional optimization	Sensitivity analysis results, by level within attribute
Value of alpha and demographic attribute weights	Analyses can be conducted at the total market or selected target segment level	Pareto-optimal frontier
Control parameters for optimization		
Attribute-level cost/return data		

(Source: Green and Krieger 1991)

a few select functions of SIMOPT's array of capabilities were applied in this dissertation. The description of SIMOPT that follows is based on Green and Krieger (1989; 1991; 1993).

Design optimization models extend the traditional conjoint exercise from a search for the best product profile in a small set of simulated alternatives to a search for the best profile in all possible attribute combinations. SIMOPT systematically searches for the "best" product profile for each segment, where "best" is defined as the customer utility maximizing product profile. SIMOPT uses a general choice rule, based on share of utility, called the alpha rule. The alpha rule is capable of mimicking the more traditional Bradley-Terry-Luce (BTL), logit, or max-utility choice rules. The alpha rule states that the probability of buyer k selecting brand s is given by:

$$\pi_{ks} = U_{ks}^{\alpha} / \sum_{s=1}^{S} U_{ks}^{\alpha}$$

where, U_{ks} is the utility of buyer k for brand s, α is an exponent chosen by the researcher, and S is the number of competitors. If alpha equals 1.0, the model mimics the BTL share-of-utility rule. As alpha goes to infinity, the model mimics the max-utility rule. Since SIMOPT is being used to determine the utility maximizing product profiles for each segment, larger values of alpha were used. By trial-and-error sensitivity analysis, it was determined that an alpha value of 10.0 was appropriate for the objective of utility maximization.

SIMOPT employs a divide-and-conquer heuristic to optimize product design (Green and Krieger 1987). Basically, the program starts with a subset of attributes for a given segment and finds their best combination (via complete enumeration), conditioned on fixed levels for the remaining attributes. Then, the next subset of attributes is conditionally optimized, and so on, until all such subsets are analyzed. The program continues this process of subset analysis until there is no change in the objective function (maximize utility).

Individual part-worth utility functions were analyzed using SIMOPT on a segment-by-segment basis. For each segment, SIMOPT identified an optimal (utility maximizing) product profile. The results are presented in Table 4.11. Each

Table 4.11
Design Optimization Simulation (SIMOPT) Results

	X_1	X_2	X_3	X_4
Weight	30% decrease	5% decrease	30% decrease	5% decrease
Energy	15 mph	5 mph	5 mph	5 mph
Finish	Painted	Painted	Molded	Painted
Recycled	5% recycled	0% recycled	20% recycled	5% recycled
Mfg Comp	1 part	3 parts	1 part	1 part
Cost	5% increase	0% increase	5% increase	10% increase

	X_5	X_6	X_7	X_8
Weight	30% decrease	30% decrease	5% decrease	5% decrease
Energy	15 mph	15 mph	5 mph	15 mph
Finish	Painted	Molded	Painted	Painted
Recycled	0% recycled	20% recycled	0% recycled	5% recycled
Mfg Comp	1 part	1 part	3 parts	1 part
Cost	5% increase	5% increase	0% increase	0% increase

	X_9	X_{10}	X_{11}	X_{12}
Weight	30% decrease	5% decrease	5% decrease	30% decrease
Energy	2.5 mph	15 mph	5 mph	5 mph
Finish	Molded	Painted	Painted	Molded
Recycled	20% recycled	5% recycled	0% recycled	20% recycled
Mfg Comp	1 part	1 part	3 parts	1 part
Cost	5% increase	0% increase	0% increase	5% increase

optimal product profile identified by SIMOPT has a corresponding utility score. The utility score is calculated from the segment-level part-worth utility functions. For example, the utility score for the optimal product profile for segment x_1 is 2.322. This is calculated by summing the part-worth utilities (shown in Table 4.7) for the appropriate attribute levels. To illustrate, the calculation of the utility score for x_1 would be: 0.326 (30% decrease in weight) + 1.097 (15 mph energy absorption) + 0.291 (painted fascia finish) + 0.121 (5% recycled content) + 0.251 (1 delivered component) + 0.236 (0% cost increase).

The objective of Stage 3 was to design optimal product line strategy at the segment level. This was achieved by matching optimal product designs to each of the twelve benefit segments identified in the conjoint segmentation analysis (Stages 1 and 2). The resulting product-market matches are feasible segmentation and positioning strategies from among which the firm must choose and then allocate its resources accordingly. The product-market combinations, and the associated utility scores for the optimal product designs, are key inputs to Stage 4 of the proposed model. Stage 4 is discussed in detail in Chapter V.

III. VALIDATION STUDY

The purpose of the validation study was to assess the robustness of the proposed conceptual and methodological model (Figure 1.1) in a different context. Specifically, the validation study was undertaken to demonstrate the *repeatability of the process* at each stage of the model, with different subjects. It was not the objective of the validation study to repeat the results from the industrial application. The consumer application required more assumptions than the industrial application due to the lack of supplier input. The results of Stages 1 through 3 will be briefly described next.

A. Stage 1 - Conjoint Analysis

The conjoint exercise described in Chapter III elicited choice preferences for 25 small portable entertainment unit (SPEU) profiles. The conjoint exercise resulted in 209 vectors of product choice preferences. Individual level part-worth utility functions were estimated for each respondent. The aggregate utility scores for each attribute level for all respondents are presented in Table B1.2 (Appendix B). The group utility scores in Table B1.2 are averaged aggregates of all 209 individual part-worth utility functions. A matrix of data similar to that presented in Table B1.2 was calculated for each individual.

The relative importances (RIs) of each attribute indicate that the Feature attribute is a dominant determinant of customer preference (Table B1.3, Appendix B). The deviations of the group RIs from an "average" individual's RIs and the distribution of preferred levels reveal a considerable degree of heterogeneity in respondent preferences. The variation in preferred levels and the RI deviations suggest that distinct segments with different preferences exist.

Stage 1 effectively modeled individual-level product preferences. In order to develop segment level utility functions, cluster analysis is applied to the 209 part-worth utility functions in Stage 2.

B. Stage 2 - Cluster Analysis

In the consumer study, Ward's, k-means, and centroid clustering algorithms were applied to the analysis of the transformed individual part-worth utilities. Multiple cluster solutions (k=6,5,4,3,2) were generated using each method, for a total of 15 cluster solutions. The solutions were individually evaluated for meaningfulness using four criteria to assess cluster solution validity: (1) differences among the clusters on attribute relative importance variables, (2) differences among the clusters on demographic variables, (3) the distribution of cluster sizes within each solution, and (4) the interpretability of each solution.

The application of the four criteria led to the selection of four cluster solutions: a 6-cluster, 5-cluster, 4-cluster, and a 3-cluster solution. The four cluster solutions resulted in the identification of eighteen benefit segments that represent feasible alternative sortings of the sample into groups of respondents with distinct preferences. The sizes of segments x_1 through x_{18} are presented in Table B1.4 (Appendix B).

In order to model the product preferences at the segment level, the individual part-worth utilities for each of the eighteen clusters were resubmitted to conjoint analysis. Individual part-worth utility functions were calculated for each respondent in each segment. To illustrate, the segment-level part-worth utility functions for the 4-cluster solution (x_{12} through x_{15}) are reported in Table B1.5 (Appendix B). The 6-cluster, 5-cluster, 4-cluster, and 3-cluster solutions reflect alternative groupings of the same data set. The difference is in the degree of granularity to which the data is cut. In each solution, the Features attribute is consistently important in each segment. The Brand and Price attributes are the key discriminators among segments.

Stages 1 and 2 were operationalized via conjoint segmentation. Product preferences were modeled at the individual and segment levels using conjoint and cluster analysis. Conjoint segmentation identified feasible sortings of the sample into alternative benefit segmentation schemes. The eighteen benefit segments and the respective part-worth utility functions are the inputs to Stage 3.

C. Stage 3 - Product Design Optimization

Stage 3 designed optimal product line strategy at the segment level by matching optimal product designs to given market segments. Individual part-worth utility functions were analyzed using SIMOPT on a segment-by-segment basis. For each segment, SIMOPT identified the utility maximizing product profile. To illustrate, the results for the 4-cluster solution are presented in Table B1.6.

Optimal product profiles similar to those presented in Table B1.6 (Appendix B) were developed for each of the eighteen benefit segments. In general, the dominant attribute levels were: Sony brand, AM/FM + CD player features, headpiece with insert earpiece sound systems, sport style, and $25.99 price. The product-market matches are feasible segmentation and positioning strategies from among which the firm must choose and then allocate its resources accordingly. The product-market combinations, and the associated utility scores for the optimal product designs, are key inputs to Stage 4.

IV. SUMMARY

Each stage of the proposed model results in valuable and useful information and tools for managerial decision-making. Conjoint segmentation

(Stages 1 and 2) helps managers understand and make sense of the underlying market structure in terms of customers' preferences and choices. Conjoint segmentation was used to classify customers into groups with similar product preferences, thus effectively identifying meaningful benefit segmentation strategies for the firm. SIMOPT (Stage 3) was employed to design optimal product line strategy for each alternative segmentation scheme.

In this chapter, the results of the conjoint segmentation analysis and design optimization simulation were presented. Conjoint analysis modeled product preferences at the individual level, thus achieving the objective of Stage 1. Cluster analysis and conjoint analysis were jointly applied to model product preferences at the segment level, thus achieving the objective of Stage 2. Finally, SIMOPT identified optimal product profiles for each segment. For each segmentation scheme, SIMOPT effectively designed product line strategy at the segment level, thereby achieving the objective of Stage 3.

In sum, three alternative, viable segmentation strategies were identified and optimal product line strategy was designed at the segment level for each segmentation scheme. According to the model of normative segmentation proposed in this dissertation, segment selection and resource allocation decisions should be made simultaneously within the context of the firm's objectives and constraints. To this end, a multiple objective programming model is developed in Stage 4 of the proposed model. Stage 4 is presented in Chapter V.

CHAPTER V

MULTIPLE OBJECTIVE INTEGER PROGRAMMING: MODEL DEVELOPMENT AND SOLUTION

This dissertation employs a multi-stage methodology to test the proposed model of normative segmentation. Figure 4.1 illustrated the proposed model and methodological process. Chapter IV presented the analysis and results for Stages 1 through 3. This chapter outlines the development and solution of the multiple objective integer programming (MOIP) model for Stage 4 of the research.

The objective of Stage 4 of the research is to determine the optimal marketing strategy at the segment level. This is achieved by simultaneously solving the segment selection and resource allocation problems. The ensuing discussion describes the formation of the model objectives and constraints, as well as the calculation of the model coefficients. Alternative model formulations are presented and the implications of these alternative approaches are discussed. Finally, solutions to the proposed models are reported and interpreted.

I. MODEL DEVELOPMENT

A well-structured math programming model must meet several criteria (Markland and Sweigart 1987): (1) it must be described in terms of numerical variables, scalar and vector quantities; (2) the goals to be attained must be specified in terms of a well-defined objective function; (3) there must be computational routines that permit the solution to be found and stated in actual numerical terms.

The purpose of Stage 4 is to develop a normative segmentation model that results in a meaningful benefit segmentation strategy for the bumper system supplier. The goal in model development was to achieve a MOIP model with four primary characteristics:

(1). Simultaneous optimization of the firm's and customers' objectives;

(2). Simultaneous solution of the segment selection and resource allocation problems;

(3). Incorporation of key constraints facing the firm that act as restrictions on segment selection and resource allocation;

(4). Incorporation of measures of segment attractiveness in the segment selection process.

Each of these characteristics had to result in well-defined, numerical representations and the resulting formulation had to be computationally solvable.

The first characteristic pertains to the objective function of the MOIP model. It is an objective of this dissertation to establish a methodological link between the normative and behavioral segmentation approaches. Simultaneous optimization of the firm's and customers' objectives extends the bounds of the traditional normative segmentation model objective from strict profit maximization (or cost minimization) to include additional objectives, such as maximizing customer satisfaction and communication effectiveness. A multiobjective objective function facilitates integration of the underlying goals of normative and behavioral segmentation approaches into a single model.

The second characteristic requires that segment selection and resource allocation decisions be linked. The purpose of this requirement is to couple the consideration of segment resource requirements with segment selection. In combination with the third characteristic, this integration overcomes the shortcomings of traditional segmentation models by explicitly linking the resource requirements of each segment to the resource constraints facing the firm.

The final model characteristic is related to the second and third in that it attempts to incorporate measures of segment attractiveness in the segment selection process. In an effort to develop a model that results in a meaningful benefit segmentation strategy[1], measures of segment profitability and the cost of serving each segment (in terms of promotion costs and manufacturing costs) are included as indicators of segment substantiality. Measures of communication effectiveness are included to reflect the accessibility of each segment.

In the following sections, the development of the model objectives constraints, and parameter coefficients is described.

A. Model Objectives

The multiple objective model developed in this dissertation is characterized by three objectives: (O1) profit maximization, (O2) customer utility maximization, and (O3) communication effectiveness maximization. Each of these objectives

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[1] Meaningful segments were defined previously as segments that meet measurability, substantiality, accessibility, and actionability criteria.

functions is operationalized as follows;

(O1) $$\text{Max } Z = \sum_{i=1}^{12} M_i \ x_i \qquad \text{(for } i = 1, \ldots, 12)$$

(O2) $$\text{Max } Z = \sum_{i=1}^{12} U_i \ x_i \qquad \text{(for } i = 1, \ldots, 12)$$

(O3) $$\text{Max } Z = \sum_{i=1}^{12} \sum_{j=1}^{4} A_{ij} \ y_{ii} \qquad \text{(for } i = 1, \ldots, 12;\ j = 1, \ldots, 4)$$

where

x_i = 1 if product-market i is selected,
0 otherwise

y_{ij} = 1 if communication vehicle j is selected for product-market i,
0 otherwise

M_i = expected profit associated with product-market i

U_i = customer utility associated with product-market i

A_{ij} = effectiveness of communication vehicle j for product-market i.

The decision variables (x_i and y_{ij}) are all binary (0,1) integer variables. The x_i decision variables are the link between Stage 3 and Stage 4 of the research methodology. Specifically, the x_i represent the twelve segments determined by the conjoint segmentation and SIMOPT analyses described in Chapter IV. The y_{ij} represent the four types of communication vehicles available to each segment: trade shows, trade publications, personal sales calls, and direct communication with the vendor. Considered jointly, the decision variables represent the segment selection and resource allocation problems.

Objective (O1) reflects the ever-important goal of maximizing profit. This objective is consistent with classical normative segmentation models. Objective (O2) incorporates customer satisfaction as a decision criterion in the segment selection process. The competitive reality is that customer satisfaction is a necessary consideration in the product design and positioning processes. Managers make decisions based on their understanding of the market and customer preferences. This compels the inclusion of customer satisfaction as an objective in the MOIP model. For a true optimum in segment selection, neither profits nor customer satisfaction can be ignored[2]. In this dissertation, customer utility is used as a surrogate for customer satisfaction[3]. Customer utility provides a measure of the degree of satisfaction achieved by the product designs matched to each benefit segment.

Objective (O3) reflects the notion that achieving a desired level of customer satisfaction and profit requires effectively communicating the firm's capabilities and product offerings to the target audience. Objective (O3) is consistent with classical normative segmentation models in that it introduces a promotion-related element to the model. However, objective (O3) is a departure from tradition in an important way: it is not based on response elasticities.

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[2] Joint consideration of profit and customer satisfaction does not require equal weighting of the two objectives. The role of objective weighting will be addressed in a later section.

[3] Customer satisfaction can be defined with regard to a number of characteristics of the firm, including the product and/or service offering. Here, satisfaction with the product offering is inferred from the level of utility achieved by the optimal product profile associated with each segment.

Traditional normative segmentation models have used the number of exposures and the subsequent sales response as a measure of communication effectiveness. Herein lies the information problem associated with the implementation of traditional normative segmentation models: accurate measurement of exposure and the related sales response at the individual or segment level is extremely difficult. Alternative, and perhaps more appropriate, measures of communication effectiveness are based on media preferences, media usage, and product characteristics (Galper and Lilien 1982; Hartley and Patti 1988; Korgaonkar, Bellenger, and Smith 1986; Schurr 1982).

Objective (O3) is formulated as a media selection problem in that it results in the selection of a combination of communication vehicles for each segment. It optimally matches communication vehicles with segments based on segment-level effectiveness ratings (Sissors 1971). The measure of communication effectiveness adopted in this dissertation does not aim to predict sales response. Instead, customer preferences for alternative communication vehicles are utilized to make macro-level decisions on communication vehicle selection. The basic idea is to match communication vehicles to segments according to the segment's communication preferences and perceptions of effectiveness. The development of a complete media planning model is outside the scope of this research.

Objectives (O2) and (O3) explicitly incorporate customer preferences into the model. In concert with objective (O1), the three objectives create a link between the normative and behavioral segmentation approaches. The resulting MOIP model simultaneously optimizes the firm's and customers' objectives, it simultaneously solves the segment selection and resource allocation problems, and it incorporates measures of segment attractiveness in the segment selection process.

B. Model Constraints

The model constraints facilitate incorporation of the bounds within which the firm operates. The objectives (O1-O3) are subject to four constraints: (C1) a communication budget, (C2) an assembly capacity limit, (C3) a conditional relationship between the x_i and y_{ij}, and (C4) a constraint preventing cluster overlap in the final solution. These constraint functions are operationalized as follows;

(C1) $$\sum_{i=1}^{12} \sum_{j=1}^{4} c_{ij} \; y_{ii} \leq B$$ (for i = 1, ... ,12; j = 1, ..., 4)

(C2) $$\sum_{i=1}^{12} h_i \; x_i \leq H$$ (for i = 1, ... ,12)

(C3) $$y_{ij} \leq x_i$$ (for i = 1, ... ,12; j = 1, ..., 4)

(C4) $$\sum_{i=1}^{n} x_i \leq 1$$ (for i = 1, ... , n)

where

c_{ij} = cost of communication vehicle j for product-market i

h_i = assembly capacity requirements in manhours for product-market i

H = plant assembly capacity in manhours

B = communication budget

n = the subset of x_i that are overlapping cluster solutions.

Constraint (C1) associates a cost with each communication vehicle and constrains the sum of the costs of the selected communication vehicle mix for all product-markets to be less than or equal to the annual budget. The c_{ij} provide an indirect measure of segment attractiveness because they reflect the cost of serving each market in terms of communication.

A promotion or communication budget constraint (or multiple variants of it) is the only constraint in traditional normative segmentation model. Just as profit maximization is not the only relevant objective to be modeled, the promotion budget constraint is not the only constraint of interest in segment selection and resource allocation. This is particularly true in industrial markets where communication and promotion decisions are often not as critical or limiting as various product development and manufacturing issues.

Constraint (C2) was developed in order to represent the manufacturing constraint on segment selection. Constraint (C2) assigns an assembly capacity requirement to each segment's preferred form of distribution (1 part delivered, 2 parts delivered, 3 or more parts delivered) and constrains the sum of the assembly requirements for the selected segments to be less than or equal to the annual assembly capacity. The h_i also provide an indirect measure of segment attractiveness because they reflect the cost of serving each market in terms of manufacturing requirements. Other manufacturing constraints that could be modeled include restrictions on the number or mix of product-markets selected, or inventory holding capacity limits. Such restrictions were not relevant to the bumper system study, so they are not included here.

Constraint (C3) is a restriction that creates a conditional relationship between the x_i and y_{ij}. The conditional relationships ensures that the mix of communication vehicles are not selected for a segment unless that segment has already been selected. The constraint may be stated, in words, as follows: if segment x_i is selected (x_i=1) then, and only then, the respective communication vehicles can be selected ($y_{ij} \leq 1$).

Finally, constraint (C4) is a multiple choice constraint that prohibits the selection of overlapping clusters. Recall that the three cluster solutions developed in Stage 2 reflect alternative groupings of the same data set. That is, x_1 through x_5 represent groupings of customers for the 5-cluster solution, x_6 through x_9 represent an alternative grouping of customers for the 4-cluster solution, and x_{10} through x_{12} represent a third grouping of customers for the 3-cluster solution. This means that the 100 respondents are represented in the set of x_i a total of three times. Constraint (C4) prevents certain x_i combinations from being selected in order to minimize cluster overlap in the final solution. Five multiple choice constraints were employed; e.g., ($x_1 + x_8 + x_{10} \leq 1$) and ($x_2 + x_7 + x_{11} \leq 1$).

C. Coefficient Development

Objectives (O1-O3) and constraints (C1) and (C2) required the development of numerical coefficients. Table 5.1 lists the coefficients developed for each parameter. The utility scores (U_i) for each segment were developed from the results of Stage 3, as described in Chapter III. The profit coefficients (M_i) were developed in three steps: (1) relative cost per attribute was obtained from

Table 5.1
Parameter Coefficients

	U	M	A_1	A_2	A_3	A_4
x_1	2.322	1662.5	13.00	13.00	21.40	52.56
x_2	2.168	1377.0	11.65	16.88	15.59	55.29
x_3	1.832	2038.5	12.88	15.48	21.04	50.60
x_4	2.103	1192.5	15.71	23.93	17.14	43.21
x_5	2.430	1072.0	9.13	14.38	23.75	52.75
x_6	2.001	1197.0	10.41	14.53	20.65	54.41
x_7	1.964	3321.0	10.92	16.28	20.38	52.41
x_8	2.387	2467.5	15.09	16.91	19.86	47.83
x_9	1.858	456.0	13.33	15.00	17.50	54.17
x_{10}	2.193	2820.0	13.97	16.92	19.87	49.21
x_{11}	2.120	2673.0	10.42	15.67	19.55	54.06
x_{12}	1.832	2038.5	12.88	15.48	21.04	50.06

	c_1	c_2	c_3	c_4	h
x_1	7200	10000	8493.00	7222.5	497949
x_2	7200	5000	5775.24	4911.3	275677
x_3	7200	10000	9172.44	7800.3	454936
x_4	7200	5000	5095.80	4333.5	278900
x_5	7200	5000	5435.52	4622.4	304359
x_6	7200	5000	6114.96	5200.2	287454
x_7	7200	10000	13928.52	11844.9	729265
x_8	7200	10000	11890.20	10111.5	679753
x_9	7200	5000	2038.20	1733.4	113400
x_{10}	7200	10000	13588.80	11556.0	775878
x_{11}	7200	10000	11210.76	9533.7	582911
x_{12}	7200	10000	9172.44	7800.3	454937

the participating supplier firm and industry experts[4]; (2) contribution margin per unit was calculated by subtracting the cost of the product profile for each x_i from the firm's average selling price[5]; and (3) total potential profit was calculated by multiplying the per unit contribution by segment size[6]. The profit coefficients provide an implicit measure of segment attractiveness because they reflect the potential value of serving each segment.

The communication effectiveness (A_{ij}) coefficients were derived from respondents' answers to question 3 in the 'General' section of the survey (see Appendix A). Respondents were asked to indicate how effective four different communication methods (vehicles) were as sources of information by rating each method on a scale of 0 to 100. The ratings were summarized to obtain mean communication effectiveness scores for each vehicle in each segment.

The cost of the communication vehicle for each segment (c_{ij}) was

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[4] The plant manager and operations manager at the supplying firm, as well as an independent industry expert were asked to assign costs to each attribute level. They were instructed to identify the most costly attribute and assign it a cost of 100. They then assigned relative costs to the remaining attribute levels. Discrepancies were resolved through an iterative process until all three were in agreement.

[5] The cost of the product profile represented by each x_i was determined by summing up the cost of the appropriate attribute levels. The supplying firm defined their average selling price per bumper system to be $100.

[6] Using information provided by the respondents (specifically, model and OEM data), the potential sales volume represented by each segment was calculated and multiplied by the CM per unit in an effort to capture an actual measure of potential segment profitability. Generally speaking, these calculations resulted in numbers that differed primarily in order of magnitude from those based on segment size. This result is likely due to the wide mix of models and OEMs present in each segment. Since segment size was deemed to be an appropriate proxy for segment volume, it was used in the profit calculation.

developed from industry-specific secondary data. The supplier firm reported that their typical annual communication budget (B) is \$100,000[7]. For the auto industry, the customers with whom a bumper system manufacturer needs to communicate can be reached in a variety of ways. This dissertation considered four methods: trade shows, trade publications, personal sales calls, and direct communication (phone calls, faxes, and direct mailings). The costs for each method were developed based on segment size when appropriate in order to capture the implicit cost of serving each segment.

Defining a cost for the trade show coefficient requires determining which and how many shows to consider (Gopalakrishna and Lilien 1995; Kerin and Cron 1987; Swandby 1982, 1984). The trade show that would be relevant for the product under study is the annual Society of Automotive Engineers International Congress & Exposition. The cost for renting a small booth space plus all related expenses is approximately \$5,000[8]. To staff the booth for the required number of days results in an additional estimated cost of \$2,200[9], for a total cost of \$7,200. The assumption is that either the supplier firm will participate in the trade show at this cost, or it will not. The size of the segment is not relevant to the cost calculation, therefore, a constant cost coefficient was used.

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7 This figure is consistent with the average marketing outlays for all industrial businesses in the PIMS database (Kijewski 1991).

8 Costs were developed from the SAE-96 Exhibitor Service Manual. The costs include display rental and other likely fees related to utilities and exhibit services.

9 For the booth size and expected number of contacts, a staffing requirement of 2.5 people is assumed (Swandby 1982). The dollar figure is based on the average daily salary for a product engineer (multiplied by 3 days and 2.5 people).

The development of the trade publication cost coefficient was similar that of the trade show cost. Five trade publications are relevant for the target population (SRDS 1995). For these publications, the average rate for a 1/2-page, color ad with 2 insertions was calculated to be approximately $5000. For segments smaller than 20, $5,000 was used as the cost coefficient. For segments larger than 20, a $10,000 cost was assigned to reflect the cost of advertising to a larger market.

The cost for personal sales calls per segment was based on average sales call data for the motor vehicle parts industry (Dartnell's... 1994). For the industry, the average cost per sales call is $113.24 and the average number of sales calls required to close a sale is 3.0. These figures were multiplied by segment size to determine a cost coefficient for each segment. The cost of direct communication was estimated in a similar fashion, but using an average engineer's salary (rather than average sales person salary). In addition, data on the average cost of direct mail and other direct communications (Statistical ... 1993) was developed. The direct communication cost coefficients reflect segment size.

Finally, the assembly capacity requirements for each segment (h_i) were derived from respondents' preferences for alternative delivery forms (1, 2, or 3 parts delivered to their plants), data provided by the supplier firm regarding assembly time requirements for each delivery form, and expected segment volume[10]. Customer preferences for the different delivery forms were identified

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[10] The size of each segment was used as a proxy for percent of total market volume share. Total market volume was weighted to reflect the supplier firm's achievable market share. Using segment size and the weighted total market volume, segment volumes (in units) were estimated.

for each segment and used to split the segment volume; e.g., 52% of segment x_1 preferred 1 part delivered, 24% preferred 2-parts delivered, and 24% preferred 3-parts delivered. The supplier firm calculated the assembly time requirements (in manhours) on a per-unit basis for each delivered form. The assembly time requirements for each segment (h_i) were then calculated by summing the total manhour requirement for each delivered form. The total annual assembly time capacity (H) was calculated by the supplier firm to be 1,680,000 manhours.

D. Alternative Approaches to Model Solution

In traditional normative segmentation models, a single objective is maximized or minimized subject to constraints. In reality, there are often several objectives that a firm is trying to achieve or several criteria involved in making segmentation and marketing strategy decisions. There are four approaches to solving a system of multiple objectives and constraints (Bierman, Bonini and Hausman 1986; Keeney and Raiffa 1976; Zeleny 1982; Zionts 1980): (1) model a single objective in the objective function and include all other objectives as constraints, (2) develop a goal programming model wherein the objective is to minimize the deviations from a series of goals (simultaneously or sequentially), (3) prioritize the objectives and solve them sequentially so that each subsequent solution is constrained to the previous solution, and (4) develop a single multiobjective function consisting of all objectives so that simultaneous optimization is achieved.

The first approach does not offer any significant advantages over traditional single objective approaches because it still assumes that management makes decisions on the basis of a single overriding criterion. This approach results in local rather than global optimization and thus may lead to dominated solutions. The second approach involves modifying the problem formulation to be a goal programming model. Rather than minimizing or maximizing various objective functions, goal programming is concerned with achieving prespecified targets or goals. Goal programming requires the specification of concrete targets for each objective; e.g., the achievement of $10M profit, 20 utiles of customer utility, and/or 130 units of communication effectiveness. The objective of goal programming is to achieve these targets as closely as possible by minimizing the deviations from the prespecified goals (Zeleny 1982). For the problem in this dissertation, management of the supplier firm did not have (and did not want to state) prespecified target levels for each objective.

Approach (2) was deemed inappropriate for the problem in this dissertation, so it is not considered further. Approach (1) involves standard single objective math programming techniques, so it is not discussed further. Approach (3) is a sequential approach to multiple criteria decision-making; thus, it reflects the nature of traditional normative segmentation models. Approach (4) achieves the research objectives set forth in this dissertation: it results in a multidimensional normative benefit segmentation model that simultaneously treats segmentation and resource allocation decision given the constraints facing the firm.

The remainder of this chapter is concerned with approaches (3) and (4). The discussion centers on establishing multiobjective programming (approach 4) as the most suitable approach to modeling normative segmentation decisions by demonstrating the suboptimality of priority programming for this problem. The impact of approaches (3) and (4) on model formulation is discussed next.

D.1. Priority Programming

Priority (or preemptive) programming involves prioritization of the objectives and then solving them sequentially, constraining each subsequent solution to the previous solution. This multi-staged approach is based on the "lexicographic" ordering of objectives according their importance to management (Zeleny 1982). For this study, the following rank ordering of the three objectives was obtained from management of the supplier firm: (1) profit maximization, (2) utility maximization, and (3) communication effectiveness maximization.

Using the rank ordering provided by management, solution of a fully preemptive, priority-based model would proceed in three stages. In the first stage, the profit maximization problem would be solved:

(O1) $$\text{Max } Z = \sum_{i=1}^{12} M_i \; x_i \qquad \text{(for } i = 1, \ldots, 12)$$

subject to:

(C2) $$\sum_{i=1}^{12} h_i \; x_i \leq H \qquad \text{(for } i = 1, \ldots, 12).$$

(C4) $$\sum_{i=1}^{n} x_i \leq 1 \qquad \text{(for } i = 1, \ldots, n)$$

Constraints (C1) and (C3) are not included in the first stage because they are not relevant to the achievement of the maximize profit objective (i.e., the y_{ij} do not enter the first stage decision). The optimization of the first stage results in the selection of N product-markets (x_i) with total profit Z.

In the second stage, the utility maximization problem would be constrained to the previous solution and then solved. That is, utility is maximized subject to an additional hard constraint that sets the profit objective function equal to its solution value in the first stage. The second stage is modeled as follows:

(O2) $\text{Max } Z = \sum_{i=1}^{12} U_i \; x_i$ (for i = 1, ... ,12)

subject to:

(C2) $\sum_{i=1}^{12} h_i \; x_i \leq H$ (for i = 1, ... ,12).

(C4) $\sum_{i=1}^{n} x_i \leq 1$ (for i = 1, ... , n)

(CP1) $\sum_{i=1}^{12} M_i \; x_i = \text{OFV}(1)$ (for i = 1, ... ,12).

Constraints (C1) and (C3) are not included in the second stage because they are not relevant to the achievement of maximize utility objective. Constraint (CP1) is the profit objective function modeled as a hard constraint, where OFV(1) is the objective function value for the first stage. The optimization of the second stage results in the selection of N product-markets (x_i) with total customer utility Z.

In the third and final stage, the communication effectiveness problem is constrained to the solutions from the first and second stages and solved. That is, communication effectiveness is maximized subject to a hard constraint that sets the profit objective function equal to its solution value in the first stage, and a hard constraint that sets the utility objective function equal to its solution value in the second stage. The third stage is modeled as follows:

(O3) $\text{Max } Z = \sum_{i=1}^{12} \sum_{j=1}^{4} A_{ij} \; y_{ii}$ (for i = 1,... ,12; j = 1,..., 4)

subject to:

(C2) $\sum_{i=1}^{12} \sum_{j=1}^{4} c_{ij} \; y_{ii} \leq B$ (for i = 1,... ,12; j = 1,..., 4)

(C3) $y_{ij} \leq x_i$ (for i = 1,... ,12; j = 1,..., 4)

(C4) $\sum_{i=1}^{n} x_i \leq 1$ (for i = 1, ... , n)

(CP1) $\sum_{i=1}^{12} M_i \; x_i = OFV\,(1)$ (for i = 1, ... ,12).

(CP2) $\sum_{i=1}^{12} U_i \; x_i = OFV\,(2)$ (for i = 1, ... ,12).

Here, constraint (C1) is not relevant to the achievement of objective (O3). Constraint (CP1) is the profit objective function modeled as a hard constraint, where OFV(1) is the objective function value for the first stage. Constraint (CP2) is the customer utility objective function modeled as a hard constraint, where OFV(2) is the objective function value for the second stage. The optimization of third stage results in the selection of m communication vehicles (y_{ij}) for each of the selected N product-markets (x_i) with a total communication effectiveness Z.

Although it may be argued that there are efficiencies achieved by limiting the decision set at each subsequent stage, a decision made on the basis of priority ordering is generally deemed incompatible with utility theory (Keeney and Raiffa 1976). As a consequence, a fully preemptive priority programming solution is not likely to be accepted as optimal by decision makers because it does not accurately reflect the decision-making process (Zeleny 1982; Zionts 1980). Rather than a fully preemptive, three-stage priority programming approach, a more reasonable representation of the problem (and the decision-making process) would be a two-stage priority approach.

In a two-stage model, the first stage would involve jointly maximizing profit and utility. The second stage would then maximize communication effectiveness subject to a hard constraint that set the joint profit-utility objective function equal to its solution value in the first stage. The first stage is modeled as a linear combination of objectives (O1) and (O2) as follows:

(O1+O2) $$\text{Max } Z = \sum_{i=1}^{12} M_i \ x_i + \sum_{i=1}^{12} U_i \ x_i$$

(for i = 1, ... ,12)

subject to:

(C2) $$\sum_{i=1}^{12} h_i \ x_i \leq H$$ (for i = 1, ... ,12).

(C4) $$\sum_{i=1}^{n} x_i \leq 1$$ (for i = 1, ... , n)

The second stage is formulated the same as the third stage of the fully preemptive priority program delineated above except that the (CP) constraint is combined as follows:

(CP1+2) $$\sum_{i=1}^{12} M_i \ x_i + \sum_{i=1}^{12} U_i \ x_i = OFV(1+2)$$

A two-stage approach overcomes some of the criticisms of a fully preemptive priority approach. However, since the two-stage approach solves the media vehicle selection and resource allocation decision sequentially, it is subject to some of the same criticisms noted for the three-stage approach. The implications and underlying assumptions of the two-stage model are discussed in the next section.

D.2. Multiple Objective Programming

Simultaneous multiobjective programming entails the development of a single objective function consisting of all relevant objectives. The main purpose of multiobjective programming is to find all nondominated solutions for a set of objectives. The nondominated set of solutions can be further reduced by assigning different weights of importance to each objective (e.g., Steuer and Schuler 1978; Zionts and Wallenius 1983).

Multiple objective programming reflects the reality that management decides upon the allocation of scarce resources with reference to several (sometimes conflicting) goals rather than to a single goal. Thus, multiple objective programming overcomes the shortcomings of priority programming by simultaneously optimizing the system of multiple objectives and constraints. Priority programs may result in dominated solutions in that a true optimum may not be achieved by the priority ordering of objectives selected by management. The "optimal" solution to a multiple objective model is the efficient (nondominated) solution preferred by the decision-maker (Shapiro 1984). Multiple objective programming models require that the decision-maker(s) play a central role in the solution search. The MOIP model is formulated as follows:

(O1+O2+O3)

$$\text{Max } Z = \pi_k \sum_{i=1}^{12} M_i \; x_i \quad + \quad \pi_k \sum_{i=1}^{12} U_i \; x_i \quad + \quad \pi_k \sum_{i=1}^{12} \sum_{j=1}^{4} A_{ij} \; y_{ii}$$

subject to

(C1) $\sum_{i=1}^{12} \sum_{j=1}^{4} c_{ij} \; y_{ii} \leq B$ (for i = 1, ... ,12; j = 1, ..., 4)

(C2) $\sum_{i=1}^{12} h_i \; x_i \leq H$ (for i = 1, ... ,12)

(C3) $y_{ij} \leq x_i$ (for i = 1, ... ,12; j = 1, ..., 4)

(C4) $\sum_{i=1}^{n} x_i \leq 1$ (for i = 1, ... , n)

The π_k represent the weight (if any) assigned to objective k (for k=1,2,3). All other variables are defined as before. In this form, the joint objective function can be construed as total value of a given solution to the firm, as determined by the degree of profit, customer utility, and communication effectiveness achieved.

This formulation of the objective function implies several assumptions regarding the relationship among the parameters, M_i, U_i and A_{ij}. First, the additive nature of the objective function assumes constant, linear returns from each objective. Second, it assumes the parameters are independent. Third, it assumes that the parameter coefficients are commensurable. Each assumption will be briefly addressed.

First, the multiple objective function assumes that profit, customer utility, and communication effectiveness have constant returns to firm value over the range of possible solutions. In a traditional normative segmentation model where the decision variables are media exposures, this assumption would certainly be unreasonable; there are generally decreasing returns to profit and promotion effectiveness as exposures increase. However, the decision variables in the model presented in this dissertation are (0,1) selection variables. If the decision variables are independent, as they are, there is no reason to assume that the value added to the firm from the selection of additional segments is not at least piece-wise linear over the entire range of solutions. This does not imply that the three objectives are necessarily equally *important* to the firm. Varying degrees of importance of each objectives can be incorporated by assigning appropriate weights (π_i).

The appropriateness of the first assumption will be assessed by enumerating and comparing solutions to the alternative formulations presented here. Specifically, solutions from the three-stage priority approach, the two-stage priority approach, and the weighted multiobjective approach will be compared. This comparative analysis will provide a basis for evaluating the impact of an additive, multiobjective function on the final solutions[11].

The second assumption concerns the independence of the model parameters. The A_{ij} were derived completely independently from the M_i and U_i coefficients. The M_i and U_i were both derived in part from the part-worth utility functions resulting from Stage 1. The correlations among the M_i, U_i, and A_{ij} were calculated to assess the degree of relationship between the parameters. The

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[11] The comparisons will be conducted interactively with the supplier firm in order to determine the "optimal" global solution (where "optimal" may ultimately be defined as a satisfactory, compromise solution).

correlation coefficients ranged between -.06 and .19 (all non-significant)[12], suggesting that there is not significant linear dependency among the parameters. Thus, independence may be reasonably assumed.

The third assumption regarding commensurability of parameter coefficients reflects the primary challenge in developing a MOIP model. There are two approaches to overcoming this difficulty: trade-off analysis and objective coefficient norming. Trade-off analysis involves specifying the trade-offs among the objectives (in terms of utility to the firm) so that a common metric is achieved (Keeney and Raiffa 1976); e.g., one would specify how much a unit of profit is worth, how much a unit of customer utility is worth, and how much a unit of communication effectiveness is worth, all in terms of utility to the firm. By this process, the total net benefit with respect to firm utility could be maximized. Although intuitively appealing, the problem with this approach is that it is a very time-consuming process requiring substantial input from the firm, and the resulting trade-offs are highly subjective.

Objective coefficient norming is more straightforward in that it involves standardizing the coefficients rather than developing a new common metric (Bitran 1980; Charnes and Cooper 1961; Hannan 1984; Steuer and Schuler 1978; Zionts and Wallenius 1983). Zeleny (1982) argues that it is not necessary to express all dimensions in common units. Objective coefficient norming effectively rescales the parameter coefficients to the "unit-cube" (Charnes and Cooper 1961). This approach assumes constant returns among the objectives. The most commonly

[12] The correlation between the M_i and U_i was particularly low (r=.02).

used scalar is the Euclidean norm $\|c^i\| = [(c^i)' c^i]^{1/2}$, where c^i denotes the ith objective coefficient vector (c_{i1}, ..., c_{in}). Since constant returns are assumed for the MOIP model proposed in this dissertation, objective coefficient norming is employed to achieve parameter commensurability. Table 5.2 lists the relevant Euclidean normed coefficients.

Table 5.2
Euclidean Normed Coefficients for A_{ij}, U_i, and M_i

	A1	A2	A3	A4	U	M
x_1	.0637	.0637	.1048	.2574	.3176	.2365
x_2	.0570	.0827	.0763	.2707	.2957	.1959
x_3	.0631	.0758	.1030	.2478	.2506	.2900
x_4	.0769	.1172	.0839	.2116	.2877	.1697
x_5	.0447	.0704	.1163	.2583	.3324	.1525
x_6	.0510	.0712	.1011	.2664	.2737	.1703
x_7	.0535	.0798	.0998	.2566	.2687	.4725
x_8	.0739	.0828	.0973	.2342	.3265	.3511
x_9	.0653	.0735	.0857	.2653	.2542	.0649
x_{10}	.0684	.0829	.0973	.2410	.3000	.4012
x_{11}	.0510	.0767	.0957	.2647	.2900	.3803
x_{12}	.0631	.0758	.1030	.2451	.2506	.2900

The final issue involved in the formulation of a MOIP model is the development of the weights (π_i) to reflect the varying degrees of importance attached to each objective. There are two primary methods for the articulation of objective weights: *a priori* articulation and progressive articulation (Steuer and Schuler 1978; Zeleny 1982; Zionts and Wallenius 1983). A priori articulation of weights assumes that all necessary information about a decision maker's preferences can be extracted prior to actually solving the problem, independently of a given decision situation. This method implies that preferences are relatively fixed and consistent; i.e., there is no significant learning process. The progressive articulation method assumes that the decision makers' preferences form and evolve in connection with a particular problem. This method implies that preferences are situation-dependent and evolving; i.e., there is a learning process that must be taken into account.

For this dissertation, interactive procedures were used to progressively articulate the "best" weighting structure for the objective function. To start, management of the supplier firm was asked to allocate 100 points among the three objectives to indicate the importance of each objective[13]. The elicited weighting structure and a number of alternative weighting schemes were applied to the problem in order to assess the impact of the weights on the solution. The solutions were shown to management and preferences for the alternative solutions were elicited. This interactive process led to the identification of the "best" weighting scheme and the "optimal" solution (as defined by the firm).

II. MODEL SOLUTION

Before presenting the model solutions, some preliminary information concerning data analysis is required. An algebraic modeling language for mathematical programming (AMPL) was used for model generation (Fourer, Gay

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[13] Management assigned the following weights to the three objectives: π_M=.60, π_U=.30, and π_A=.10.

and Kernighan 1993). Each model was formulated as binary integer and solved using CPLEX Mixed Integer Optimizer software (CPLEX 1992). Sample input and model formulation using AMPL and CPLEX is illustrated in Appendix C (Part I).

The CPLEX Mixed Integer Optimizer software employs the branch and bound procedure for solution of integer problems[14]. This procedure is briefly described. When a problem is required to have an integer solution, this means that there are a finite number of possible solution points. While it is theoretically possible to enumerate and evaluate every possible solution to find the optimum, in many cases it is computationally inefficient. The branch and bound technique facilitates the implicit consideration of all feasible solutions without explicit enumeration. The general idea is to divide the set of all feasible solutions for a problem into smaller subsets (branches). Bounds on the value of the best solution in each subset are computed and infeasible subsets are eliminated. Each remaining subproblem is solved using the simplex method (or sensitivity analysis techniques) and an upper bound is computed for each subproblem. Each subproblem is analyzed to determine if further branching is necessary. The branching continues until all subproblems are eliminated or have integer feasible solutions.

The remainder of this section presents solutions for the three-stage priority program, the two-stage priority program, and the single-stage multiobjective program. The impact of the solution approach on the results is examined.

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[14] The description of the branch and bound procedure that follows is drawn from Bierman, Bonini and Hausman (1986), Markland and Sweigart (1987), and Shapiro (1984).

A. Three-Stage Priority Program Solution

Using the priority-ordering of objectives provided by management, the three-stage priority programming model resulted in the selection of four segments; x_4, x_8, x_9, and x_{11}. The complete solution is presented in Table 5.3. Sensitivity analysis shows that the solution to the profit maximization problem is quite sensitive to changes in the capacity constraint. The sensitivity analysis is as follows[15]:

Run	Capacity	Max M Obj. Value	x_i selected
1	1,680,000	6789.0	x_4, x_8, x_9, x_{11}
2	1,200,000	5359.5	x_3, x_7
3	1,800,000	7624.0	x_3, x_4, x_7
4	2,000,000	8371.5	x_4, x_8, x_{11}, x_{12}

The selection of segments appears to be quite variable and highly dependent upon the level of the capacity constraint. This is an important point because the assembly capacity limit is a key constraint for the firm; it is the primary bottleneck in production. In estimating the assembly capacity (H=1,680,000), some additional labor force and machinery that is not currently in place (but is in the process of being secured) was considered. In order to relax this constraint, the firm would need to make a substantial additional investment.

[15] The calculation of current assembly capacity (1.68M manhours) was based on the manhours generated by two shifts at the plant, where the first shift operates at capacity (in terms of number of employees) and the new second shift functions with a minimal, skeleton staff. Management stated that the most likely decrease in capacity would come from a decision to eliminate the second shift entirely, thus resulting in a 28^{+}% decrease in manhours (to 1.2M). Increases would come from additions to the second shift workforce. Management indicated that they would likely hire additional employees in either small or moderate increments to achieve 1.8M or 2M manhour capacity levels.

Table 5.3
Three-Stage Priority Program - Solution One[1]

	(Max M_i) Stage 1	(Max U_i) Stage 2	(Max A_{ij})[2] Stage 3			
			y_{i1}	y_{i2}	y_{i3}	y_{i4}
x_1	0	0	0	0	0	0
x_2	0	0	0	0	0	0
x_3	0	0	0	0	0	0
x_4	1	1	1	1	1	1
x_5	0	0	0	0	0	0
x_6	0	0	0	0	0	0
x_7	0	0	0	0	0	0
x_8	1	1	1	1	1	1
x_9	1	1	1	1	1	1
x_{10}	0	0	0	0	0	0
x_{11}	1	1	0	0	1	1
x_{12}	0	0	0	0	0	0
Objective						
Z	6789	8.468	373.29			
Slack[3]						
B	n/a	n/a	2452.82			
H	25036	25036	n/a			

Table Notes:

[1] The solution required 129 simplex iterations and 53 branch-and-bound nodes for Stage 1; 5 simplex iterations for Stage 2; and 65 simplex iterations and 31 branch-and-bound nodes for Stage 3.

[2] The A_{ij} are as follows: (j=1) trade shows, (j=2) trade publications, (j=3) personal sales calls, and (j=4) direct communication with vendor.

[3] This solution is based on a budget of $100,000 and assembly capacity of 1,680,000 manhours.

Although adding capacity is feasible in the long-run, discussions with management indicated that a 1.68 million manhour limit is the most appropriate value for the capacity constraint since it reflects a projection into the near-term future. Thus, the solution to run 1 was used to constrain the second stage.

The second stage resulted in the selection of the same four segments as the first stage. The effect of the capacity constraint on this stage was limited to reductions in capacity[16]. The objective value could not be improved by adding capacity and different x_i could not enter the solution due to the constrained nature of the priority program. In the third stage, all but two of the available communication vehicles (A_{ij}) were selected for the four segments. Changes in the communication budget did not have a major effect on the solution. A $10,000 decrease in the budget (B = $90,000) caused the use of trade publications for segment x_8 to drop from the solution and a $10,000 increase in the budget (B = $110,000) caused the use of trade publications for x_{11} to enter the solution.

In sum, the three-stage priority program resulted in the selection of four segments of varying size including a total of 89 respondents. The "optimality" of this solution is questionable in light of the previous discussion regarding the problems with fully preemptive priority programming. In an effort to understand the impact of the prioritization of objectives on the solution, the program was reanalyzed with a different priority order: (1) customer utility maximization, (2) profit maximization, (3) communication effectiveness maximization. The revised three-stage priority programming model resulted in the selection of five segments

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[16] Reducing capacity to 1.2 million manhours caused x_{11} to drop from the solution.

(x_1, x_2, x_4, x_5 and x_6) of varying size including a total of 91 respondents. The complete solution is presented in Table 5.4.

There are three important points to note in comparing the two solutions to the three-stage priority program. First, the x_i in the final solution depends greatly on the order of the objectives; only x_4 is common between the solutions. Second, objective ordering has a notable influence on the objective function values; (1) $Z_{Max\ M}$ is higher when Max M is given first priority, (2) $Z_{Max\ U}$ is higher when Max U is given first priority and (3) $Z_{Max\ A}$ is higher when Max U is given first priority. Third, the degree of market coverage differs according to the order of the objectives; n_1=89 versus n_2=91. These results gave rise to considerable managerial anxiety. Management did not want to choose one objective (and hence solution) over the other. Furthermore, it was not clear how to evaluate the differences.

B. Two-Stage Priority Program Solution

The two-stage priority program overcomes some of the shortcomings associated with the fully preemptive priority program. The two-stage formulation simultaneously maximizes profit and customer utility in the first stage[17], and then maximizes communication effectiveness in the second stage. This formulation required the articulation of weights for the profit and customer utility objectives.

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[17] Euclidean normed coefficients for the M_i and U_i were used.

Table 5.4
Three-Stage Priority Program - Solution Two[1]

	(Max U_i) Stage 1	(Max M_i) Stage 2	(Max A_{ij})[2] Stage 3			
			y_{i1}	y_{i2}	y_{i3}	y_{i4}
x_1	1	1	1	0	1	1
x_2	1	1	1	1	1	1
x_3	0	0	0	0	0	0
x_4	1	1	1	1	1	1
x_5	1	1	0	1	1	1
x_6	1	1	0	1	1	1
x_7	0	0	0	0	0	0
x_8	0	0	0	0	0	0
x_9	0	0	0	0	0	0
x_{10}	0	0	0	0	0	0
x_{11}	0	0	0	0	0	0
x_{12}	0	0	0	0	0	0
Objective						
Z	11.024	6501	466.83			
Slack[3]						
B	n/a	n/a	1195.58			
H	35661	35661	n/a			

Table Notes:

[1] The solution required 24 simplex iterations and 7 branch-and-bound nodes for Stage 1; 6 simplex iterations for Stage 2; and 106 simplex iterations and 90 branch-and-bound nodes for Stage 3.

[2] The A_{ij} are as follows: (j=1) trade shows, (j=2) trade publications, (j=3) personal sales calls, and (j=4) direct communication with vendor.

[3] This solution is based on a budget of $100,000 and assembly capacity of 1,680,000 manhours.

Five weighting schemes were tested:

Run	U_i Weight (π_U)	M_i Weight (π_M)
1	.50	.50
2	.05	.95
3	.95	.05
4	.25	.75
5	.75	.25

The results of the five runs are presented in Table 5.5. The weighting schemes for runs 2 and 3 will provide a validity check on the use of the Euclidean normed coefficients and on the linear combination of the two objectives. Specifically, run 2 should result in the same solution as the three-stage priority program with Max M as the first stage and run 3 should give the solution as the three-stage program with Max U as the first stage.

The purpose of testing several weighting schemes was to assess the impact of objective weighting on the solution. Depending on the weighting of the two objectives, the two-stage priority program had three basic solutions: a profit maximization solution (run 2), a profit dominant solution (run 4), and the balanced weight solution (run 1). Greater emphasis on customer utility (runs 3 and 5) gave the same result as the balanced weight solution. Specifically, at weights π_M=.52, and π_U=.48, the solution became stable (x_1, x_2, x_4, x_5, x_6) and did not change with additional increases in π_U. The results clearly indicate that the customer utility objective has the greatest impact on the objective function value[18].

[18] The Z value for run 3 with π_U=.95 was the largest Z across all five runs.

Table 5.5
Two-Stage Priority Program Solution[1]

Run[2]	Stage 1 Solution[3]	Z	Stage 2 Solution[4]	Z
1	$x_1\ x_2\ x_4\ x_5\ x_6$	1.216	All y_{ij} =1 except $y_{12} = y_{51} = y_{61} = 0$	466.83
	$slack_H$ = 35661		$slack_B$ = 1195.58	
2	$x_4\ x_8\ x_9\ x_{11}$	0.976	All y_{ij} =1 except $y_{11,1} = y_{11,2} = 0$	373.29
	$slack_H$ = 25036		$slack_B$ = 2452.82	
3	$x_1\ x_2\ x_4\ x_5\ x_6$	1.479	All y_{ij} =1 except $y_{12} = y_{51} = y_{61} = 0$	466.83
	$slack_H$ = 35661		$slack_B$ = 1195.58	
4	$x_2\ x_4\ x_5\ x_8\ x_9$	1.075	All y_{ij} =1 except $y_{21} = y_{31} = y_{42} = 0$	461.41
	$slack_H$ = 27911		$slack_B$ = 2436.28	
5	$x_1\ x_2\ x_4\ x_5\ x_6$	1.362	All y_{ij} =1 except $y_{12} = y_{51} = y_{61} = 0$	466.83
	$slack_H$ = 35661		$slack_B$ = 1195.58	

Table Notes:
[1] The solution requirements were as follows,
Run 1: 71 simplex iterations and 37 branch-and-bound nodes;
Run 2: 159 simplex iterations and 67 branch-and-bound nodes;
Run 3: 28 simplex iterations and 7 branch-and-bound nodes;
Run 4: 61 simplex iterations and 22 branch-and-bound nodes;
Run 5: 56 simplex iterations and 21 branch-and-bound nodes.
[2] Each solution is based on a budget of $100,000 and assembly capacity of 1,680,000 manhours.
[3] Stage 1 = (Max $U_i + M_i$); Stage 2 = (Max A_{ij}) constrained to stage 1 solution value.
[4] The A_{ij} are the same as defined previously.

The results suggests that run 3 (π_M=.05, π_U=.95) represents the "optimal" weighting of the two objectives since this is the solution with the highest objective value Z. However, since the "optimal" solution is that which is most preferred by the decision makers (Shapiro 1984), the selection of the "optimal" weighting scheme (and hence solution) for the two-stage programming model was determined interactively with management.

The results of the five runs were shown to management. Management preferred the solution with equal weights on the two objectives (run 1) for three reasons: (1) it reflects their balance of emphasis on the two objectives, (2) it provides for efficient utilization of the firm's resources, and (3) it results in better market coverage than any profit dominant weighting scheme. The firm expressed that a 50/50 weighting of the profit and customer utility objectives was the best representation of reality. Furthermore, although the objective value improves as greater weight is placed on customer utility, the final solution (in terms of the x_i and y_{ij}) does not change. The balanced weighting scheme, as well as those that stressed customer utility, utilized capacity more efficiently and achieved greater market coverage than the profit dominant weighting schemes[19]. Also, the balanced and customer utility-dominant weighting scheme resulted in higher

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[19] Runs 1, 3, and 5 result in a total market coverage of n=91 while runs 2 and 4 result in a total market coverage of n=89. Thus, greater market coverage is achieved by a balanced or customer utility-dominant weighting scheme than by profit-dominant weighting schemes. An evaluation of the capacity slack in the final solutions suggests that capacity is utilized most efficiently by the balanced weighting scheme and those that emphasize customer utility. This is inferred from the result that the balanced and customer utility-dominant solutions achieve more market coverage with fewer resources ($slack^H_{1,3,5} > slack^H_{2,4}$ while $n_{1,3,5} > n_{2,4}$).

communication effectiveness objective values and greater utilization of the communication budget[20].

As expected, run 2 (π_M=.95, π_U=.05) and run 3 (π_M=.05, π_U=.95) returned the exact same solution as the three-stage priority programs with Max M and Max U as the first stage, respectively. This provides empirical support for the use of the rescaled coefficients in the linear combination of the profit and customer utility objectives. Using Euclidean normed coefficients impacted the magnitude of the objective value, but not the final solutions. That is, the linear combination of the two objectives did not alter the solution. It was the *weight* applied to each objective that impacted the results.

The two-stage priority program resulted in considerably more stable results than the three-stage priority programs. However, the media vehicle selection and resource allocation decisions are solved sequentially, thus the solution is potentially suboptimal. In order to fully incorporate segment evaluation into the segment selection decision, the cost of serving each segment must be assessed in a single stage. This requires simultaneously solution of the three objectives, as described in the next section.

C. Multiple Objective Program Solution

The final formulation involves a single multiobjective function that simultaneously maximizes profit, customer utility, and communication effectiveness. Weights for each objective were elicited from management and a number of alternative weighting schemes were applied to the problem in order to

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20 $Z^A_{1,3,5} > Z^A_{2,4}$ and $slack^B_{1,3,5} < slack^B_{2,4}$.

assess the impact of the weights on the solution. Specifically, five types of weighting schemes were evaluated: (1) even weights across all objectives, (2) a single dominant objective, (3) a dominant objective with half of the total weight and then balanced weights on the remaining two objectives, (4) two dominant evenly weighted objectives, and (5) ordered weights. The five types of weighting schemes resulted in the following thirteen runs for the multiobjective programming model:

Type	Run	Max M Weight (π_1)	Max U Weight (π_2)	Max A Weight (π_3)
1	1	.33	.33	.33
2	2	.98	.01	.01
	3	.01	.98	.01
	4	.01	.01	.98
3	5	.50	.25	.25
	6	.25	.50	.25
	7	.25	.25	.50
4	8	.40	.40	.20
	9	.20	.40	.40
	10	.40	.20	.40
5	11	.60	.30	.10
	12	.10	.60	.30
	13	.30	.10	.60

Summary results from the thirteen runs were shown to management and preferences for the alternative solutions were elicited. From this interactive process, run 8 was identified as the "best" weighting scheme and the "optimal" solution from the firm's perspective (π_M=π_U=.40, π_A=.20). The complete solution for run 8 is presented in Table 5.6. Management preferred an equal balance of

Table 5.6
Multiple Objective Program Solution - Run 8 [1,2]

	x_{ij}	y_{i1}	y_{i2}	y_{i3}	y_{i4}
x_1	1	1	0	1	1
x_2	1	1	1	1	1
x_3	0	0	0	0	0
x_4	1	1	1	1	1
x_5	1	0	1	1	1
x_6	1	0	1	1	1
x_7	0	0	0	0	0
x_8	0	0	0	0	0
x_9	0	0	0	0	0
x_{10}	0	0	0	0	0
x_{11}	0	0	0	0	0
x_{12}	0	0	0	0	0
Objective					
Z	1.4303				
Slack[3]					
B	1195.58				
H	35661				

Table Notes:

[1] The solution required 1171 simplex iterations and 255 branch-and-bound nodes.

[2] The y_{ij} are as follows: (j=1) trade shows, (j=2) trade publications, (j=3) personal sales calls, and (j=4) direct communication with vendor.

[3] This solution is based on a budget of $100,000 and assembly capacity of 1,680,000 manhours.

weight on the profit and customer utility objectives for the reasons previously identified: (1) it reflects their emphasis profit and customer satisfaction relative to communication effectiveness, (2) it provides for efficient utilization of the firm's resources, and (3) it results in better market coverage than the profit-dominant or communication-dominant weighting schemes. The solution to run 8 is the same as the optimal solution identified in the two-stage priority programming model. The stability of the solution across different model formulations and across a variety of weighting schemes suggests that a MOIP model is a valid representation of the problem.

A summary of all thirteen runs is presented in Table 5.7. The type 2 weighting scheme with a single dominant objective resulted in three distinct solutions: a profit dominant solution (run 2), a customer utility dominant solution (run 3), and a communication effectiveness dominant solution (run 4). The results of all other runs with more balanced weighting schemes (run 1, runs 5-13) were identical to the customer utility dominant solution. This provides support for the selection of the weighting scheme and solution for run 8 as "optimal". It is an efficient, nondominated, and highly stable solution that accurately reflects management's decision-making criteria.

Each run resulted in a unique objective function value (Z). Placing greater weight on communication effectiveness resulted in higher objective function values. This effect is caused by the number of decision variables involved in the communication effectiveness objective compared to the profit and customer utility

Table 5.7
Multiple Objective Program Solutions - 13 Runs [1,2]

Run	Solution[3] x_i	y_{ij}	Z	$slack_H$, $slack_B$	n
Type 1					
1	x_1 x_2 x_4 x_5 x_6	$y_{12}=y_{51}=y_{61}=0$	1.557	35661, 1195.58	91
Type 2					
2	x_4 x_8 x_9 x_{11}	$y_{11,1}=y_{11,2}=0$	0.976	25036, 2452.82	89
3	x_1 x_2 x_4 x_5 x_6	$y_{12}=y_{51}=y_{61}=0$	1.510	35661, 1195.58	91
4	x_1 x_2 x_4 x_5 x_9	$y_{12}=y_{51}=0$	2.313	209715, 1539.02	79
Type 3					
5	x_1 x_2 x_4 x_5 x_6	$y_{12}=y_{51}=y_{61}=0$	1.411	35661, 1195.58	91
6	x_1 x_2 x_4 x_5 x_6	$y_{12}=y_{51}=y_{61}=0$	1.557	35661, 1195.58	91
7	x_1 x_2 x_4 x_5 x_6	$y_{12}=y_{51}=y_{61}=0$	1.751	35661, 1195.58	91
Type 4					
8	x_1 x_2 x_4 x_5 x_6	$y_{12}=y_{51}=y_{61}=0$	1.430	35661, 1195.58	91
9	x_1 x_2 x_4 x_5 x_6	$y_{12}=y_{51}=y_{61}=0$	1.703	35661, 1195.58	91
10	x_1 x_2 x_4 x_5 x_6	$y_{12}=y_{51}=y_{61}=0$	1.586	35661, 1195.58	91
Type 5					
11	x_1 x_2 x_4 x_5 x_6	$y_{12}=y_{51}=y_{61}=0$	1.236	35661, 1195.58	91
12	x_1 x_2 x_4 x_5 x_6	$y_{12}=y_{51}=y_{61}=0$	1.683	35661, 1195.58	91
13	x_1 x_2 x_4 x_5 x_6	$y_{12}=y_{51}=y_{61}=0$	1.800	35661, 1195.58	91

Table Notes:

[1] Each solution is based on a budget of $100,000 and assembly capacity of 1,680,000 manhours.

[2] The n reflects the degree of market coverage achieved by the solution; i.e., the number of respondents included in the selected segments.

[3] All $y_{ij}=1$ for the selected segments unless noted otherwise in the table. The A_{ij} are the same as previously defined.

objectives[21]. The customer utility dominant solution (x_1 x_2 x_4 x_5 x_6) is stable across all weighting schemes except the profit dominant (run 3) and the communication dominant (run 4) weighting schemes. In general, improvements in the objective value do not improve this solution[22]. The stability of the customer utility dominant solution over a variety of weighting schemes instills confidence in the selection of this solution as "optimal".

As expected, runs 2, 3 and 4 returned the exact same solution as the respective two and three-stage priority programs. This again provides support for the use of the rescaled coefficients in the linear combination and solution of the multiobjective function. In general, the solutions to the multiobjective programming model are consistent with the two and three-stage priority programming model. The primary difference is in the computer time required to solve the alternative formulations[23]. These results indicate that simultaneous solution of the multiple objectives is an appropriate and efficient formulation of the problem at hand.

A brief interpretation of the final "optimal" solution is warranted. The purpose of a normative segmentation model is to provide managers with a programmatic approach for devising and assessing segment level marketing

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[21] There are 48 y_{ij} versus only 12 x_i decision variables.

[22] The profit dominant solution results in the lowest Z_2=0.976 and less market coverage (n_2=89). The communication effectiveness solution results in the highest Z_4=2.313 but at significant sacrifice in market coverage (n_4=79).

[23] A comparison of the number of simplex iterations and branch-and-bound nodes required to solve each formulation indicates that the MOIP model is the most computationally demanding.

strategy. The MOIP solution designs optimal product portfolios for the firm by determining optimal product positioning and market coverage. Table 5.8 illustrates normative advice inferred from the MOIP "optimal" solution for the bumper system supplier. The normative advice offered in Table 5.8 includes recommendations for the degree of market coverage, optimal product line strategy, optimal communication vehicle mix, the optimal mix of delivery forms, and optimal product-line pricing structure. The MOIP model also provides information on expected profits, assembly capacity requirements, and communication costs.

III. VALIDATION STUDY

The purpose of the consumer application was to reexamine the approach developed for the industrial application in order to validate the overall process. In the validation study, the purpose of Stage 4 was to develop a normative segmentation model that resulted in a meaningful benefit segmentation strategy for a hypothetical small portable entertainment unit (SPEU) supplier. The multiple objective integer programming (MOIP) model developed for the consumer application was very similar in nature to the MOIP model developed in the industrial application. Three objectives were maximized: (1) profit, (2) customer utility, and (3) target audience accessibility.

The profit maximization and customer utility maximization objectives for the consumer application are defined in the same manner as in the industrial application. Target audience accessibility refers to the degree of opportunity the

Table 5.8
Normative Implications of MOIP Model Solution

Target Markets
Select 5 markets (sizes are in parentheses) to achieve a high percentage of market coverage (n_{total}=91):

x_1 (n_1 =25), x_2 (n_2=17), x_4 (n_4=15), x_5 (n_5=16), x_6 (n_6=18)

Optimal Product-line Strategy (optimal product profile indicated for each segment)

	X_1	X_2	X_4	X_5	X_6
Weight	30% decrease	5% decrease	5% decrease	30% decrease	30% decrease
Energy	15 mph	5 mph	5 mph	15 mph	15 mph
Finish	Painted	Painted	Painted	Painted	Molded
Recycled	5% recycled	0% recycled	5% recycled	0% recycled	20% recycled
Mfg	1 part	3 parts	1 part	1 part	1 part
Cost	5% increase	0% increase	10% increase	5% increase	5% increase

Optimal Communication Vehicle Mix (level and cost indicated for each vehicle)

	X_1	X_2	X_4	X_5	X_6
Trade shows	1 show $7200	1 show $7200	1 show $7200	Not Used	Not Used
Trade[24] press	2 ads $10000	1 ad $5000	1 ad $5000	1 ad $5000	1 ad $5000
Personal sales	75 calls $8493	51 calls $5775	45 calls $5096	48 calls $5436	54 calls $6115
Direct comm.	75 contacts $7223	51 contacts $4911	45 contacts $4334	48 contacts $4622	54 contacts $5200
SEGMENT COMM. COST	$32916	$22886	$21630	$15058	$16315

[24] An advertisement was previously defined as 1/2-page, color with 2 insertions. The number in the table indicates how many ads of this type should be placed.

Table 5.8 (cont'd)

Optimal Mix of Delivery Forms (mix of preferences and manhour requirements indicated for each segment)

	X_1	X_2	X_4	X_5	X_6
1 part	55%	27%	46%	44%	27%
2 parts	25%	33%	23%	44%	27%
3 parts	20%	40%	31%	12%	46%
Segment Assembly Req'mts (manhours)	597949	275677	278900	304359	287454

Optimal Product-line Pricing Structure[25]

	X_1	X_2	X_4	X_5	X_6
PRICE:	$105	$100	$110	$105	$105
MFG COST:	$33.5	$19.0	$20.5	$33.0	$33.5
PER UNIT MARGIN:	$71.5	$81.0	$89.5	$72.0	$71.5

Summary Expected Totals

Profit:	$37.9M
Assembly Requirements:	1,644,339 manhours
Communication Costs:	$98,804

[25] Optimal pricing is inferred from the preferences for the "Cost Increase" attribute in the optimal product profiles. The percent change is calculated from the current average selling price of $100.

firm has to reach the target audience through a variety of advertising media. As in the industrial application, the accessibility objective was formulated as a media selection problem in that it results in the selection of a combination of advertising media vehicles for each segment. It optimally matches media vehicles with segments based on segment-level accessibility scores for each media. The measure of accessibility adopted for the consumer study does not aim to measure exposure or to predict sales response.

The objectives were subject to four constraints: (1) an advertising budget, (2) an production capacity limit, (3) a conditional relationship between the x_i and y_{ij}, and (4) constraints preventing cluster overlap in the final solution. The full model is presented in Table B1.7 in Appendix B. An example of the input and model formulation using AMPL and CPLEX is illustrated in Appendix C (Part II).

A variety of weighting schemes were applied to the three objectives in order to assess the impact of alternative weights on the final solution. An examination of the solution results indicated that weighting schemes with two dominant evenly weighted objectives (e.g., π_M=π_U=.40, π_A=.20) and ordered weights (e.g, π_M=.50, π_U=.30, π_A=.20) returned the exact same solution. The "optimal" weighting scheme was selected by assuming that profit and customer utility objectives are equally important to a SPEU supplier (i.e., π_M=π_U=.40, π_A=.20). Since the solution to the MOIP is stable over a broad range of dominant-evenly-weighted and ordered weighting schemes, selection of the π_M=π_U=.40, π_A=.20 weighting scheme is reasonable. Table B8 in Appendix B presents the complete solution and sensitivity analysis.

Table B1.8 indicates that the production capacity constraint has significant influence on the final solution. In general, the solution was quite stable across all sensitivity analyses. When the production capacity constraint was tightened (Runs 2 and 3), the MOIP model returned a solution consisting of five rather than six segments, thereby achieving less market coverage.

IV. SUMMARY

Multiobjective integer programming is a very important tool for normative segmentation analysis. Normative segmentation involves decision-making using multiple criteria in the context of multiple constraints. Specifically, optimal segment selection requires segment evaluation according to multiple criteria while simultaneously considering the firm's resource constraints.

This chapter outlined the development and solution of a MOIP model for Stage 4 of the research. The objective of Stage 4 was to design optimal marketing strategy at the segment level. This was achieved by simultaneously solving the segment selection and resource allocation problems in the context of a MOIP model. The MOIP model developed in this chapter resulted in a multidimensional normative benefit segmentation model that simultaneously treats segmentation and resource allocation decision given the constraints facing the firm.

This chapter formulated and compared solutions to several alternative approaches to multiple objective programming. The convergence of solutions lends confidence to the choice of a multiobjective formulation as a valid and efficient approach to normative segmentation. The multiobjective integer program resulted in meaningful optimization, where meaningful is defined in two senses. First, the final segmentation scheme identified in the solution was meaningful according to the criteria of effective segmentation (measurability, actionability, accessibility, and substantiality). Second, the final solution was deemed "optimal" by management in that it appropriately reflected and incorporated the firm's objectives and constraints.

CHAPTER VI

CONCLUSIONS

This dissertation proposed a model that simultaneously and rigorously treats segmentation and marketing strategy decisions in a normative benefit segmentation framework. The results of the industrial application were presented in detail in Chapters IV and V. The process developed in the industrial study was reexamined in a consumer context and the results were briefly reported. This chapter summarizes both applications. Conclusions are drawn, limitations of the research are discussed, and directions for future research are presented.

I. APPLICATION SUMMARIES

A. Industrial Application

The purpose of the industrial study was to develop and test the proposed model. This was achieved via a four-stage integrated methodology. Customer preferences and choices provided a different perspective on market definition and revealed an alternative market structure than has been traditionally assumed in the bumper system industry. Customer preferences and choices were used to clearly define product-market opportunities and design optimal product portfolio responses for the participating bumper system supplier.

The industrial study found that vehicle class was not the most appropriate discriminator of bumper system preferences, the classic segment descriptor in this industry. The results suggest that preferences for specific characteristics are benefit driven rather than vehicle class driven. That is, meaningful segmentation in the bumper system industry is based on customer preferences for weight reduction, performance improvements, cost reduction, manufacturing improvements, recyclability, and styling.

The results of the industrial study have important implications for the bumper system industry. Conventional wisdom among bumper system industry participants holds that the bumper system market is appropriately segmented along traditional vehicle classification lines. This assumption has implicitly driven a number of organizational design decisions; e.g., the organization of the bumper system engineers and buyers at the OEMs and the sales forces at the suppliers. The organization of the bumper system engineers at the OEMs is understandable; the bumper system is not the OEMs primary component or business. This dissertation suggests that the validity of the mirror organizational structure at bumper system suppliers is debatable. The results of the industrial study revealed the potential for significant efficiency and synergy gains throughout the supplier's organization (e.g., in the sales organization, engineering design efforts, and production scheduling).

B. Validation Study

The purpose of the consumer application was to reexamine the approach developed for the industrial application in order to validate the overall process. The consumer study provides an assessment of the transferability of the conceptual model and methodological process to a different context with different subjects. Given the assumptions and available data, the consumer application effectively demonstrated the transferability of the process at each stage of analysis. The results of the consumer study were not surprising in any manner. That is, an unexpected market structure or segmentation scheme was not uncovered. This is a function of the application, not the model. The repeatability of the process at each stage of the proposed model was solidly established, thus validating the conceptual and methodological model proposed in this dissertation.

C. Summary of Applications

This dissertation developed a model that simultaneously and rigorously treated segmentation and marketing strategy decisions in a normative benefit segmentation framework. The model conceptually and methodologically integrated several of the core concepts of marketing. Since the information requirements for the model are behaviorally based and commonly used in practice, the result is a normative segmentation approach that is considerably more applicable in practice than traditional models. The model was developed using managerial and customer inputs, thus the results that are highly relevant and implementable. All elements of the marketing mix were incorporated in the model and the firm's objectives and resource constraints were simultaneously considered.

The proposed model of normative segmentation was developed and tested in an industrial context using a multi-stage methodology, encompassing a conjoint experiment, cluster analysis, a design optimization simulation, and multiobjective integer programming. The process developed in the industrial study was successfully validated in the consumer application.

II. RESEARCH QUESTIONS ADDRESSED

A model of normative segmentation was developed and tested in an industrial context in order to address the following research questions:

RQ1. What is the structure of the front-end bumper system product-market?
- How can market structure be defined according to customer's preference-based choices?

RQ2. What are the feasible product-market opportunities for front-end bumper system manufacturers?
- How should homogeneous segments be formed?

RQ3. What is the appropriate product portfolio for the firm?
- How many and which segments should be selected?
- What is the optimal product design in each segment?
- What is the optimal mix of communication vehicles?
- How should promotion and manufacturing resources be allocated?

RQ4. How should the segment selection and resource allocation problem be modeled to include the firm's objectives and constraints?
- How should segments be evaluated within a multiple objective programming model (MOIP)?
- How can each element of the marketing mix be included in the MOIP?
- What is the best formulation of the MOIP?
- What is the optimal solution to the MOIP?

RQ5. What is the impact of the segmentation and product positioning strategy on profits?

RQ6. What is the impact of the segmentation and product positioning strategy on customer satisfaction?

RQ7. How effectively and efficiently is the resulting product portfolio communicated to each segment?

Application of the four-stage methodology effectively addressed all seven research questions by: (1) modeling product preferences at the individual level using conjoint analysis; (2) modeling product preferences at the segment level via cluster analysis; (3) designing optimal product line strategy at the segment level with SIMOPT; and (4) designing optimal marketing strategy at the segment level using multiobjective integer programming. The research steps and questions effectively addressed the objectives of this dissertation.

The approach developed for the industrial application was reexamined in a consumer context in order to validate the overall process. The purpose of the consumer study was to assess the transferability of the conceptual model and methodological process to a different context with different subjects. The following two research questions were relevant to the consumer application in the validation study:

RQ8. Is the conceptual model and methodological process transferable to a consumer product-market?

RQ9. Are there any differences in the application of the conceptual model or the methodological process to a consumer product-market?

The research questions were effectively addressed in the validation study by reapplying the four-stage methodology. The conceptual and methodological process was demonstrated to be wholly transferrable to the consumer application. The differences were in the values of the coefficients and the specific results obtained, as was expected given the divergent nature of the two applications.

III. LIMITATIONS OF THE RESEARCH

There are several limitations of the research conducted in this dissertation. First, any math programming model output is only as reliable as the data from which it is constructed. In some instances, practices of an industry may result in inadequate or unreliable data for use in model evaluation. In the industrial application, relative costs were used as a basis for the profit calculations. In the consumer application, hypothetical data was used for a number of coefficients for lack of input from an actual supplier. Assumptions concerning these coefficients were made, thus potentially impacting the quality of the output. In the development of any model, assumptions must be made in order to resolve these issues. These assumptions, of course, then become the limits of the model.

Second, segment stability is not addressed by the model proposed in this dissertation. The impact of time on the structure of the market and on the proposed model is uncertain. Although the MOIP model cannot be considered dynamic in the framework set forth, it can be used in dynamic situations in two ways. First, new output can be computed with different inputs if conditions have changed sufficiently to warrant recalculation of the inputs. Second, numerous outputs could be calculated each with different inputs to reflect change within predetermined acceptable ranges. The matrix of results that best approximates the actual situation at hand can be selected and utilized.

Third, the nature of the consumer study did not permit examination of distribution preferences. In order to expand the consumer application to include all elements of the marketing mix, additional data is required and objectives and/or constraints would need to be added to the MOIP model. In addition, the consumer sample was a nonrandom, convenience sample of students. Although students were the appropriate target population for the product under study, additional random samples would need to be examined to generalize the results.

Finally, the snowball sampling procedure in the industrial application resulted in an imbalanced distribution of OEMs in the final sample. This may have biased the results toward the dominant OEMs preferences. In order to confidently generalize the results to the entire market, samples from the underrepresented OEMS (especially the Japanese) need to be examined.

IV. CONTRIBUTIONS

This dissertation offers several theoretical and practical contributions to the segmentation area. Specifically, this research presents five primary contributions:

(1) It establishes a conceptual and methodological link between product-market structure definition, market segmentation and product positioning;

(2) It establishes a conceptual and methodological link between normative and behavioral segmentation approaches;

(3) It develops a normative segmentation approach that facilitates consideration of all elements of the market mix;

(4) It develops a normative segmentation approach that simultaneously solves the segment selection and resource allocation problems in the context of the firm's objectives and constraints;

(5) It provides managers with a programmatic approach for devising and assessing segment level marketing strategy.

This dissertation integrates three core concepts of marketing in a conceptual framework of market behavior. The research demonstrates that conjoint analytic techniques coupled with multiobjective integer programming facilitate methodologically integration of product-market structure definition, market segmentation, and product positioning decisions.

The model integrates aspects of the behavioral school into a normative segmentation approach, thereby extending the value of normative segmentation as a managerial tool useful for identifying product-market opportunities and designing optimal product portfolio responses. The model proposed a normative segmentation approach using a behavioral basis of segmentation. The behavioral segmentation basis overcomes the information and data constraints associated with traditional normative segmentation models. This significantly improves the applicability of traditional normative segmentation models.

The model developed in this dissertation facilitates consideration of all elements of the market mix, thereby extending the focus of traditional normative segmentation models. The optimal marketing mix is simultaneously determined for each selected segment while considering resource constraints. The product profile and promotion mix are directly determined and the distribution and price factors are indirectly determined by the model.

The model simultaneously solves the segment evaluation and selection problems with the resource allocation problem. This addresses a gap in the traditional normative segmentation model wherein segment selection is not considered. Segment selection and resource allocation decisions are modeled within the context of the firms objectives and resource constraints. An important contribution of the model in this dissertation is that it recognizes objectives in addition to profit maximization; specifically, customer satisfaction and communication effectiveness. It also models important manufacturing constraints on marketing strategy decisions.

Finally, the model of normative segmentation results in a programmatic approach that facilitates the development of marketing strategy in a segmentation framework. This dissertation presents empirical research pinpointing effective segmentation and positioning strategies for the purpose of influencing customers. Furthermore, the MOIP model offers a mechanism by which alternative market segmentation and positioning strategies can be evaluated in the context of the organizational and resource constraints facing a firm. The proposed model presents a method by which operational marketing strategies may be developed from segmentation findings, thereby overcoming the significant implementation problem that plagues most normative segmentation models.

V. DIRECTIONS FOR FUTURE RESEARCH

There are several areas for future research, including extensions to the applications in this dissertation and extensions of the model in general. First, additional parameters could be incorporated in the model to reflect other decisions, constraints, and/or objectives relevant to the firm. For example, a sales force management problem, a warehouse facility location problem, or an inventory management problem could be incorporated in the normative segmentation model.

Second, trade-off analysis could be employed to achieve commensurability among the parameter coefficients. Objective coefficient norming was used in this research. Trade-off analysis involves specifying the trade-offs among the objectives (in terms of utility to the firm) so that a common metric is achieved. The trade-offs permit maximizing the total net benefit with respect to firm utility. It would be of interest to examine the effect of trade-off coefficients on the MOIP model results. Trade-off analysis was not applied in this dissertation due to lack of the degree of participation necessary to achieve reliable data.

A third issue that could be addressed is the concept of product-market boundaries and its role in the conceptual framework of market behavior. Product-market boundaries were assumed known in this dissertation. Future research could examine the link between customers' consideration sets and their preferences for alternative product offerings. In addition, the link between producers' product portfolios (in terms of product positioning and market coverage) and customer perceptions (consideration sets) could be examined by measuring response to the marketing strategies implemented by the firm.

Fourth, a more explicit link between customer preferences/choices for alternative product profiles and design characteristics could be established. This requires linking each attribute to a corresponding design specification. The attributes used in the industrial application were not of this nature. Percentage levels rather than actual design specifications were used in order to encourage participation. Establishing links between the attributes and design specifications would improve the actionability of the results of this research for the supplier.

A fifth area for future research involves modeling the competitive dynamics involved in any given product-market. The model developed in this dissertation assumed no competitive response. SIMOPT (Green and Krieger 1993) is capable of modeling a number of competitive dynamics with regard to optimal product design. Future research is needed to incorporate dynamism in the MOIP model.

A sixth important area for future research is assessing the impact of product-market conditions on the proposed model. Specifically, does the applicability of the model, the interpretability of the solution, and/or the value of the model to management change according to the product-market conditions? Some conditions might include product-market newness, stability, and competitiveness. Newness refers to the innovativeness and novelty of the product-market to the industry (not the firm). Stability refers to the rate of change of the product-market in terms of technology, preferences, or geography. One might hypothesize that the application and interpretation of the proposed model would be more difficult in new, highly unstable, competitive product-markets because determination of the coefficients would be quite burdensome and by design, non-dynamic. This suggests, that such applications would be of little value to management unless product-market conditions were in some fashion incorporated in the model.

Finally, another area of future research involves extending the application of the model to alternative contexts. For example, the model of normative market segmentation developed in this dissertation could be modified and used as an international market selection tool. The appropriate modifications would include the development of objectives, constraints, and parameters pertinent to international market entry decisions. An international market selection model based on the normative segmentation approach could incorporate the product adaptation/standardization issue via the conjoint methodology. The normative segmentation approach would facilitate systematic evaluation of international market attractiveness.

VI. SUMMARY

This chapter reviewed the contributions, limitations and future directions for the research. The dissertation developed and tested a model that simultaneously and rigorously treats segmentation and marketing strategy decisions in a normative benefit segmentation framework. The proposed model developed a normative segmentation approach that is considerably more applicable in practice than traditional models. The model is based on managerial and customer input, therefore the results are highly relevant and implementable.

There has been little development of normative segmentation models since their inception, in spite of the potential value to managers. The research proposed in this dissertation contributes to the advancement of the theory, method and application of normative segmentation models. This is achieved by conceptually and methodologically integrating several of the core concepts of marketing. This research should help narrow the gap between academic research on normative segmentation and managerial application of the normative segmentation approach.

APPENDICES

APPENDIX A

SURVEY INSTRUMENTS

APPENDIX A

SURVEY INSTRUMENTS

A. INDSUTRIAL APPLICATION

Instructions

Please take the time to answer all of the following questions with regard to the model you currently work on. If you work on multiple models/platforms, please *choose one* and answer from that perspective.

Model/Platform ____

On the following pages there are 25 profiles of *front-end bumper systems*. Each front-end bumper system is described by six characteristics:

(1). **Weight** - the percent decrease in total weight from the current front-end bumper system (0%, 5%, 15%, 30%).
(2). **Energy Management Function** - the amount of energy absorption the front-end bumper can withstand (2.5 mph, 5 mph, 15 mph).
(3). **Fascia Finish** - the finish on the front-end bumper fascia (black, painted body color, molded-in color).
(4). **Recycled Content** - the percent of total recycled material contained in the front-end bumper system (0%, 5% postconsumer, 20% regrind).
(5). **Manufacturing Complexity** - the number of parts delivered to the manufacturing plants incorporating the energy absorber, beam, and fascia (1 modular front-end bumper system, a 2 part combination, 3 separate parts).
(6). **System Cost** - the percent increase in total cost over the current front-end bumper system (0%, 5%, 10%).

Please consider each profile individually and consider the trade-offs among the characteristics. For each profile, please rate the likelihood that you would select the described front-end bumper system ***in the next design cycle*** for the model you currently work on, using the following scale:

Rating Scale

1 = Definitely would select
2 = Very likely would select
3 = Probably would select
4 = Probably would not select
5 = Very likely would not select
6 = Definitely would not select

Rating 1 ______

Weight
5% decrease from current system

Energy Management Function
2.5 mph energy absorption

Fascia Finish
Black

Recycled Content
5% recycled postconsumer material

Manufacturing Complexity - # Parts Delivered
3 separate parts - EA, beam, fascia

System Cost
10% increase over current system

Rating 2 ______

Weight
15% decrease from current system

Energy Management Function
15 mph energy absorption

Fascia Finish
Black

Recycled Content
20% recycled regrind material

Manufacturing Complexity - # Parts Delivered
2 part combination of EA, beam, and fascia

System Cost
0% increase over current system

Rating 3 ______

Weight
0% change from current system

Energy Management Function
5 mph energy absorption

Fascia Finish
Molded-in color

Recycled Content
5% recycled postconsumer material

Manufacturing Complexity - # Parts Delivered
2 part combination of EA, beam, and fascia

System Cost
10% increase over current system

Rating 4 ______

Weight
5% decrease from current system

Energy Management Function
5 mph energy absorption

Fascia Finish
Painted body color

Recycled Content
0% recycled material

Manufacturing Complexity - # Parts Delivered
3 separate parts - EA, beam, fascia

System Cost
0% increase over current system

Rating 5

Weight
30% decrease from current system

Energy Management Function
15 mph energy absorption

Fascia Finish
Molded-in color

Recycled Content
5% recycled postconsumer material

Manufacturing Complexity - # Parts Delivered
3 separate parts - EA, beam, fascia

System Cost
5% increase over current system

Rating

For each profile, please rate the likelihood that you would select the described bumper system with a score of 1 to 6 using the following scale:

1 = Definitely would select
2 = Very likely would select
3 = Probably would select
4 = Probably would not select
5 = Very likely would not select
6 = Definitely would not select

Rating 6

Weight
5% decrease from current system

Energy Management Function
5 mph energy absorption

Fascia Finish
Molded-in color

Recycled Content
20% recycled regrind material

Manufacturing Complexity - # Parts Delivered
2 part combination of EA, beam, and fascia

System Cost
10% increase over current system

Rating 7

Weight
30% decrease from current system

Energy Management Function
5 mph energy absorption

Fascia Finish
Black

Recycled Content
5% recycled postconsumer material

Manufacturing Complexity - # Parts Delivered
1 modular bumper system

System Cost
0% increase over current system

Rating 8

Weight
30% decrease from current system

Energy Management Function
5 mph energy absorption

Fascia Finish
Black

Recycled Content
20% recycled regrind material

Manufacturing Complexity - # Parts Delivered
3 separate parts - EA, fascia, beam

System Cost
0% increase over current system

Rating 9

Weight
30% decrease from current system

Energy Management Function
5 mph energy absorption

Fascia Finish
Painted body color

Recycled Content
5% recycled postconsumer material

Manufacturing Complexity - # Parts Delivered
2 part combination of EA, beam, and fascia

System Cost
10% increase over current system

Rating 10

Weight
30% decrease from current system

Energy Management Function
2.5 mph energy absorption

Fascia Finish
Black

Recycled Content
0% recycled material

Manufacturing Complexity - # Parts Delivered
1 modular bumper system

System Cost
10% increase over current system

Rating 11

Weight
15% decrease from current system

Energy Management Function
5 mph energy absorption

Fascia Finish
Molded-in color

Recycled Content
0% recycled material

Manufacturing Complexity - # Parts Delivered
3 separate parts - EA, beam, fascia

System Cost
5% increase over current system

Rating ______ 12

Weight
30% decrease from current system

Energy Management Function
15 mph energy absorption

Fascia Finish
Painted body color

Recycled Content
0% recycled material

Manufacturing Complexity - # Parts Delivered
3 separate parts - EA, beam, fascia

System Cost
10% increase over current system

Rating

For each profile, please rate the likelihood that you would select the described bumper system with a score of 1 to 6 using the following scale:

1 = Definitely would select
2 = Very likely would select
3 = Probably would select
4 = Probably would not select
5 = Very likely would not select
6 = Definitely would not select

Rating ______ 13

Weight
30% decrease from current system

Energy Management Function
2.5 mph energy absorption

Fascia Finish
Molded-in color

Recycled Content
0% recycled material

Manufacturing Complexity - # Parts Delivered
2 part combination of EA, beam, and fascia

System Cost
0% increase over current system

Rating ______ 14

Weight
15% decrease from current system

Energy Management Function
2.5 mph energy absorption

Fascia Finish
Black

Recycled Content
5% recycled postconsumer material

Manufacturing Complexity - # Parts Delivered
2 part combination of EA, beam, and fascia

System Cost
10% increase over current system

Rating ______ 15

Weight
30% decrease from current system

Energy Management Function
2.5 mph energy absorption

Fascia Finish
Molded-in color

Recycled Content
20% recycled regrind material

Manufacturing Complexity - # Parts Delivered
3 separate parts - EA, beam, fascia

System Cost
10% increase over current system

Rating ______ 16

Weight
30% decrease from current system

Energy Management Function
2.5 mph energy absorption

Fascia Finish
Molded-in color

Recycled Content
0% recycled material

Manufacturing Complexity - # Parts Delivered
2 part combination of EA, beam, and fascia

System Cost
0% increase over current system

Rating ______ 17

Weight
0% change from current system

Energy Management Function
2.5 mph energy absorption

Fascia Finish
Molded-in color

Recycled Content
5% recycled postconsumer material

Manufacturing Complexity - # Parts Delivered
3 separate parts - EA, beam, fascia

System Cost
0% increase over current system

Rating ______ 18

Weight
15% decrease from current system

Energy Management Function
2.5 mph energy absorption

Fascia Finish
Painted body color

Recycled Content
5% recycled postconsumer material

Manufacturing Complexity - # Parts Delivered
2 part combination of EA, beam and fascia

System Cost
0% increase over current system

Rating ______ 19

Weight
0% change from current system

Energy Management Function
5 mph energy absorption

Fascia Finish
Black

Recycled Content
0% recycled material

Manufacturing Complexity - # Parts Delivered
3 separate parts - EA, beam, fascia

System Cost
0% increase over current system

Rating

For each profile, please rate the likelihood that you would select the described bumper system with a score of 1 to 6 using the following scale:

1 = Definitely would select
2 = Very likely would select
3 = Probably would select
4 = Probably would not select
5 = Very likely would not select
6 = Definitely would not select

Rating ______ 20

Weight
0% change from current system

Energy Management Function
2.5 mph energy absorption

Fascia Finish
Painted body color

Recycled Content
20% recycled regrind material

Manufacturing Complexity - # Parts Delivered
1 modular bumper system

System Cost
5% increase over current system

Rating ______ 21

Weight
5% decrease from current system

Energy Management Function
15 mph energy absorption

Fascia Finish
Molded-in color

Recycled Content
5% recycled postconsumer material

Manufacturing Complexity - # Parts Delivered
1 modular bumper system

System Cost
0% increase over current system

Rating ______ 22

Weight
15% decrease from current system

Energy Management Function
5 mph energy absorption

Fascia Finish
Molded-in color

Recycled Content
0% recycled material

Manufacturing Complexity - # Parts Delivered
1 modular bumper system

System Cost
10% increase over current system

Rating ______ 23

Weight
0% change from current system

Energy Management Function
15 mph energy absorption

Fascia Finish
Black

Recycled Content
0% recycled material

Manufacturing Complexity - # Parts Delivered
2 part combination of EA, beam, and fascia

System Cost
10% increase over current system

Rating ______ 24

Weight
30% decrease from current system

Energy Management Function
5 mph energy absorption

Fascia Finish
Black

Recycled Content
5% recycled postconsumer material

Manufacturing Complexity - # Parts Delivered
2 part combination of EA, beam, and fascia

System Cost
5% increase over current system

Rating ______ 25

Weight
5% decrease from current system

Energy Management Function
2.5 mph energy absorption

Fascia Finish
Black

Recycled Content
0% recycled material

Manufacturing Complexity - # Parts Delivered
2 part combination of EA, beam and fascia

System Cost
5% increase over current system

BUSINESS PRACTICES

In answering the following questions regarding your business unit's practices, use the following response scale. Place the most appropriate number in the blank space to the left of each statement. Please respond to each statement.

Not at all	*To a very slight extent*	*To a small extent*	*To a moderate extent*	*To a considerable extent*	*To a great extent*	*To an extreme extent*
1	*2*	*3*	*4*	*5*	*6*	*7*

___ Our objectives are driven primarily by customer satisfaction.
___ We constantly monitor our commitment and orientation to serving customer needs.
___ We freely communicate information about our successful and unsuccessful customer experiences across all business functions.
___ Our bumper systems are based on our understanding of customer needs.
___ All of our business functions (e.g., marketing/sales, manufacturing, engineering, etc.) are integrated in serving the needs of our target markets.
___ Our strategies are driven by our beliefs about how we can create greater value for customers.
___ We measure customer satisfaction systematically and frequently.
___ Our managers understand how everyone in our business can contribute to creating customer value.

RISK

How well do the following statements fit your personal views? (Please CIRCLE ONE number for each item using the scale below).

		Not at All Well	Not Very Well	Fairly Well	Very Well	Extremely Well
1.	When it comes to taking chances, I'd rather be safe than sorry.	1	2	3	4	5
2.	I believe in leaving well enough alone.	1	2	3	4	5
3.	I like to experiment with new ways of doing things.	1	2	3	4	5
4.	I'm uncomfortable working on projects different from types I'm accustomed to.	1	2	3	4	5
5.	I like to try and apply new technologies to old problems.	1	2	3	4	5
6.	Designing a new component that has not yet been proven is usually a waste of time and money.	1	2	3	4	5
7.	I like to preempt and create change.	1	2	3	4	5

GENERAL

1. Please indicate which functional areas are involved in the various activities of purchasing a bumper system component? Indicate the extent of involvement of each functional area by assigning a percentage of total responsibility.

	FUNCTION					
<u>ACTIVITY</u>	Corporate Policy & Planning	Administration	Engineering	Production	R&D	Purchasing
Determines materials						
Determines specifications						
Chooses suppliers to submit bids						
Evaluates bids against specifications						
Chooses final supplier(s)						

2. How often do you *currently* obtain information from the following sources? *(Circle one number for each item).*

	Never	Rarely	Sometimes	Often	Regularly
Exhibitions and trade shows	1	2	3	4	5
Trade and technical press	1	2	3	4	5
Personal sales calls	1	2	3	4	5
Direct communication with vendor (including faxes, phone calls, mail)	1	2	3	4	5

3. Please assign ***0 - 100 points*** to each of the following items to indicate how ***effective*** each one is as a source of information for you.

____ Exhibitions and trade shows
____ Trade and technical press
____ Personal sales calls
____ Direct communication with vendor

4. Which of the following best describes how your company ***currently*** purchases front-end bumper systems in terms of: (1) the number of suppliers, and (2) the number of components delivered to the plant?

Number of Suppliers (Check One)	Number of Components Delivered (Check One)
__ Single Supplier	__ 1 modular bumper system
__ Multiple Suppliers	__ 2 major components (some combination of the EA, beam, & fascia)
	__ 3 major components (the beam, EA, & fascia)
	__ More than three components

5. Which of the following best describes your company's ***preferred*** number of suppliers and number of delivered components?

Number of Suppliers (Check One)	Number of Components Delivered (Check One)
__ Single Supplier	__ 1 modular bumper system
__ Multiple Suppliers	__ 2 major components (some combination of the EA, beam, & fascia)
	__ 3 major components (the beam, EA, & fascia)
	__ More than three components

Why is this preferred? ____

____

6. What is your title? ____

7. Do you work on any other models/platforms? __ Yes __ No

If yes:

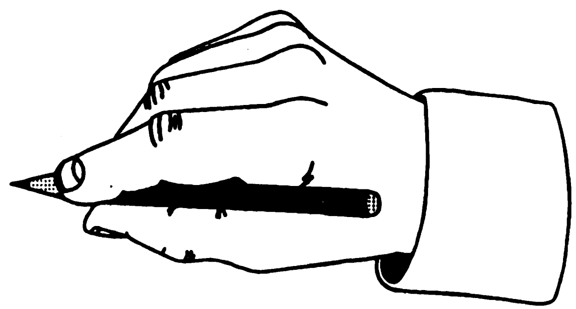
(a) Which one(s)? ____

(b) Would the answers to this survey be significantly different for the other model(s)? __ Yes __ No

8. Comments?

B. CONSUMER APPLICATION

Product Design Study:
<u>Portable Personal Entertainment Units</u>



Name: ______________________

Student ID: ______________________

Michigan State University

Rating 1

Brand
Aiwa

Features
AM/FM + cassette

Sound System
No headpiece with insert earpieces

Style
Standard model (not sport)

Price
$139.99

Rating 2

Brand
Panasonic

Features
CD player only

Sound System
No headpiece with insert earpieces

Style
Sport model

Price
$25.99

Rating 3

Brand
GPX

Features
AM/FM only

Sound System
No headpiece with insert earpieces

Style
Sport model

Price
$89.99

Rating 4

Brand
Sony

Features
AM/FM + CD player

Sound System
No headpiece with insert earpieces

Style
Sport model

Price
$139.99

Rating

For each profile, please rate the likelihood that you would buy the described brand with a score of 1 to 6 using the following scale:

1 = Definitely would buy
2 = Very likely would buy
3 = Probably would buy
4 = Probably would not buy
5 = Very likely would not buy
6 = Definitely would not buy

Rating 5

Brand
GE

Features
AM/FM + cassette

Sound System
No headpiece with insert earpieces

Style
Standard model (not sport)

Price
$59.99

Rating 6

Brand
Sony

Features
CD player only

Sound System
Headpiece with insert earpieces

Style
Standard model (not sport)

Price
$89.99

Rating 7

Brand
GE

Features
AM/FM only

Sound System
Headpiece with insert earpieces

Style
Sport model

Price
$139.99

Rating 8

Brand
Aiwa

Features
AM/FM + CD player

Sound System
Headpiece with insert earpieces

Style
Sport model

Price
$59.99

Rating

For each profile, please rate the likelihood that you would buy the described brand with a score of 1 to 6 using the following scale:

1 = Definitely would buy
2 = Very likely would buy
3 = Probably would buy
4 = Probably would not buy
5 = Very likely would not buy
6 = Definitely would not buy

Card	Brand	Features	Sound System	Style	Price	Rating
9	Panasonic	AM/FM + cassette	Headpiece with insert earpieces	Sport model	$139.99	____
10	GPX	AM/FM + cassette	Headpiece with insert earpieces	Standard model (not sport)	$25.99	____
11	Panasonic	AM/FM only	Headpiece with external earpieces	Standard model (not sport)	$89.99	____
12	GPX	AM/FM + CD player	Headpiece with external earpieces	Sport model	$139.99	____

Rating

For each profile, please rate the likelihood that you would buy the described brand with a score of 1 to 6 using the following scale:

1 = Definitely would buy
2 = Very likely would buy
3 = Probably would buy
4 = Probably would not buy
5 = Very likely would not buy
6 = Definitely would not buy

Card	Brand	Features	Sound System	Style	Price	Rating
13	Sony	AM/FM + cassette	Headpiece with external earpieces	Sport model	$25.99	____
14	GE	AM/FM + cassette	Headpiece with external earpieces	Sport model	$89.99	____
15	Aiwa	CD player	Headpiece with external earpieces	Standard model (not sport)	$139.99	____
16	GE	AM/FM + CD player	Headpiece with external earpieces	Standard model (not sport)	$25.99	____

Rating

For each profile, please rate the likelihood that you would buy the described brand with a score of 1 to 6 using the following scale:

1 = Definitely would buy
2 = Very likely would buy
3 = Probably would buy
4 = Probably would not buy
5 = Very likely would not buy
6 = Definitely would not buy

Rating 17

Brand
Aiwa

Features
AM/FM + cassette

Sound System
Headpiece with external earpieces

Style
Sport model

Price
$89.99

Rating 18

Brand
Panasonic

Features
AM/FM + cassette

Sound System
Headpiece with external earpieces

Style
Sport model

Price
$139.99

Rating 19

Brand
GPX

Features
CD player

Sound System
Headpiece with external earpieces

Style
Sport model

Price
$59.99

Rating 20

Brand
Sony

Features
AM/FM only

Sound System
Headpiece with external earpieces

Style
Standard model (not sport)

Price
$139.99

Rating

For each profile, please rate the likelihood that you would buy the described brand with a score of 1 to 6 using the following scale:

1 = Definitely would buy
2 = Very likely would buy
3 = Probably would buy
4 = Probably would not buy
5 = Very likely would not buy
6 = Definitely would not buy

Rating 21

Brand
GPX

Features
AM/FM + cassette

Sound System
No headpiece with insert earpieces

Style
Standard model (not sport)

Price
$139.99

Rating 22

Brand
Sony

Features
AM/FM + cassette

Sound System
No headpiece with insert earpieces

Style
Sport model

Price
$59.99

Rating 23

Brand
GE

Features
CD player

Sound System
No headpiece with insert earpieces

Style
Sport model

Price
$139.99

Rating 24

Brand
Aiwa

Features
AM/FM only

Sound System
No headpiece with insert earpieces

Style
Sport model

Price
$25.99

Rating

For each profile, please rate the likelihood that you would buy the described brand with a score of 1 to 6 using the following scale:

1 = Definitely would buy
2 = Very likely would buy
3 = Probably would buy
4 = Probably would not buy
5 = Very likely would not buy
6 = Definitely would not buy

Rating ______ 25

Brand
Panasonic

Features
AM/FM + CD player

Sound System
No headpiece with insert earpieces

Style
Standard model (not sport)

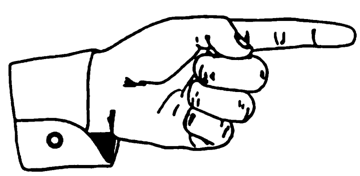
Price
$89.99

Rating

For each profile, please rate the likelihood that you would buy the described brand with a score of 1 to 6 using the following scale:

1 = Definitely would buy
2 = Very likely would buy
3 = Probably would buy
4 = Probably would not buy
5 = Very likely would not buy
6 = Definitely would not buy

Please Continue



Please indicate how much you agree or disagree with the following statements by circling the appropriate number.

		Strongly Agree						Strongly Disagree
1.	It is really true that money can buy happiness.	1	2	3	4	5	6	7
2.	My dream in life is to be able to own expensive things.	1	2	3	4	5	6	7
3.	People judge others by the things they own.	1	2	3	4	5	6	7
4.	I buy some things that I secretly hope will impress other people.	1	2	3	4	5	6	7
5.	Money is the most important thing to consider in choosing a job.	1	2	3	4	5	6	7
6.	I think others judge me as a person by the kinds of products and brands I use.	1	2	3	4	5	6	7
7.	If someone saw me using a portable personal entertainment unit, they would form an opinion of me.	1	2	3	4	5	6	7
8.	You can tell a lot about a person by seeing what brand of portable personal entertainment unit he/she uses.	1	2	3	4	5	6	7
9.	A portable personal entertainment unit helps me express who I am.	1	2	3	4	5	6	7
10.	Seeing somebody else use a personal portable entertainment unit tells me a lot about that person.	1	2	3	4	5	6	7
11.	When I use a portable personal entertainment unit, others see me the way I want them to see me.	1	2	3	4	5	6	7
12.	My portable personal entertainment unit is "me" in every sense.	1	2	3	4	5	6	7

Please answer the following questions by ***placing a check "√" on the appropriate line.***

---

1. Do you currently own a portable entertainment unit (e.g, a Walkman)?

___ yes ====> IF YES: ___ I bought it myself
___ no ___ It was a gift

2. How many CDs and tapes do you currently own *(check one)*?:

___ 0-10 total ___ 26-40 total
___ 11-25 total ___ more than 40 total

3. How often do you listen to tapes or CDs *(check one)*?

___ Never ___ Once a day
___ Rarely ___ 3 to 4 times per day
___ 1 to 2 times per month ___ More than 5 times per day
___ 1 to 2 times per week

4. Sex: ___ Male ___ Female

5. Age: ___ 18-21 ___ 22-25 ___ 26-30 ___ over 30

6. Total FAMILY household income *(check one)*:

___ $10,001 - 25,000 ___ $25,001 - 40,000
___ $40,001 - 55,000 ___ over $55,001

7. Which of the following newspapers have you read within the last 7 days *(check "√" all that apply)* and how often did you read them *(circle one number for each paper)*:

	Daily	Several times per week	Weekends Only
___ Wall Street Journal	1	2	3
___ Lansing State Journal	1	2	3
___ Detroit News/Free Press	1	2	3
___ USA Today	1	2	3
___ MSU State Journal	1	2	3

Other (list all): ____________________

8. How much time did you spend listening to the radio yesterday? Please try your best to remember and estimate all the time you spent.

STATION	TOTAL TIME SPENT *(hours)*
________________	________
________________	________
________________	________
________________	________
________________	________
________________	________
Time spent listening to the radio but to "no particular station"	________

9. How much time did you spend watching TV yesterday? Please try to your best to remember and estimate your time spent.

PROGRAM	TOTAL TIME SPENT *(hours)*
________________	________
________________	________
________________	________
________________	________
________________	________
________________	________
Time spent watching TV but "no particular program"	________
Other regular programs you watch *(list all)*.	________________________________

10. Which magazines have you read or looked at in the past month and how often do you read them? Please try your best to recall all of the magazines you read or looked at.

Title	How often do you read this magazine *(circle one)*?					Subscribe *(circle one)*	
	Very regularly				Rarely		
________________	1	2	3	4	5	Yes	No
________________	1	2	3	4	5	Yes	No
________________	1	2	3	4	5	Yes	No
________________	1	2	3	4	5	Yes	No
________________	1	2	3	4	5	Yes	No

How favorable are your feelings toward personally buying and using foreign-made products?

Very Unfavorable Feelings											Very Favorable Feelings
0	1	2	3	4	5	6	7	8	9	10	11

If you were to purchase a new portable personal entertainment unit within the next year or so, what brands would you seriously consider purchasing? *(Please list as many as you would consider).*

1. ____________________ 3. ____________________

2. ____________________ 4. ____________________

Are you a U.S. citizen? __ Yes __ No

What is your nationality or ethnic origin? *(Please circle one)*

African American   Native American   Asian American   Anglo-American

Other *(Please specify)* ____________________

Please indicate how appropriate each of the following characteristics are in describing products made in the U.S., Japan, and Korea. *(Circle one number for each country)*

	U.S.	JAPAN	KOREA
	Not at all Very	Not at all Very	Not at all Very
Unreasonably expensive	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
Usually imitations	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
Not attractive	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
Frequent repairs	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
Cheaply put together	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
Sold in many countries	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
Intensely advertised	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
Easily available	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
Long lasting	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
Good value	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
Prestigious products	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10

APPENDIX B

ADDITIONAL TABLES

APPENDIX B

ADDITIONAL TABLES

Table B1.1
Multiple Range Tests of Difference[1]

	Ward's 5-cluster	K-means 4-cluster	Ward's 3-cluster
Relative Importances[2]			
Weight	4-5,3-2	2-4	1-2
Energy Absorption	3-5,5-2,3-4	4-1,4-3,4-2	3-1,3-2
Finish	3-2,3-4,3-5,3-1, 2-4	2-1,1-3	3-2,3-1
Recycled Content	5-2,5-4,5-1,5-3, 2-1,2-3,4-3	2-1,1-3,1-4	2-1,2-3
Mfg Complexity	1-3,1-5,4-5,2-3, 2-5	3-2,3-4,3-1, 2-1	1-2,1-3
Cost	4-5	2-3	1-2
Business Practices			
Market Orientation	ns	4-2,2-1	3-1,3-2
Information Sources			
Current - Trade Shows	3-4,1-4,4-2	4-2,4-3	3-2
Effectiveness - Trade Press	4-1,4-3,4-5	4-2	3-2

Table Notes:

[1] Only those variables with significant differences across clusters are included in this Table. This explains why some rows included in Table 4.4 are missing from this table.
[2] Table entries indicate which cluster means are significantly different (at p=.05 or better) based on Scheffe's multiple range test. The numbers represent the cluster number in the particular cluster solution; e.g., an entry of 5-2 indicates that the mean of cluster 5 is significantly greater than the mean of cluster 2 for this variable.

Table B1.2
Aggregate Utility Scores - Consumer Study

Attribute	Attribute Level 1	2	3	4	5
Brand	GPX -0.361	GE -0.133	AIWA 0.010	Panasonic 0.065	Sony 0.420
Features	AM/FM only -1.173	AM/FM+cassette -0.180	CD player 0.375	AM/FM+CD 0.978	
Sound System	No headpiece -0.043	Headpiece + external -0.075	Headpiece + inserts 0.119		
Style	Standard -0.136	Sport 0.136			
Price	$139.99 -0.621	$89.99 -0.077	$59.99 0.175	$25.99 0.523	

Table B1.3
Group RIs and Distribution of Preferred Levels - Consumer Study

Attribute	RIs (%) (Standard deviations)	Distribution of Preferred Levels (%) 1	2	3	4	5
Brand	17.19 (4.63)	4.86	9.41	19.06	20.57	46.09
Features	47.36 (11.98)	0.00	5.98	14.11	79.90	
Sound	4.27 (13.02)	33.97	25.60	40.43		
Style	5.98 (0.38)	22.49	77.51			
Price	25.20 (0.81)	4.31	13.48	24.00	58.21	

Table B1.4
Cluster Sizes - Consumer Study

6-cluster	5-cluster	4-cluster	3-cluster
$x_1 = 10$	$x_7 = 10$	$x_{12} = 53$	$x_{16} = 53$
$x_2 = 45$	$x_8 = 45$	$x_{13} = 45$	$x_{17} = 74$
$x_3 = 43$	$x_9 = 43$	$x_{14} = 82$	$x_{18} = 82$
$x_4 = 63$	$x_{10} = 82$	$x_{15} = 29$	
$x_5 = 29$	$x_{11} = 29$		
$x_6 = 19$			

Table B1.5
Part-Worth Utility Functions: 4-Cluster Solution (Consumer Study)

	X_{12}	X_{13}	X_{14}	X_{15}
Brand	13.19%	19.25%	12.26%	31.47%
GPX	-0.258	-0.394	-0.298	-0.677
GE	-0.043	-0.212	-0.108	-0.250
Aiwa	-0.028	0.122	-0.005	-0.050
Panasonic	0.010	0.282	-0.020	0.068
Sony	0.319	0.202	0.431	0.909
Features	46.90%	64.34%	39.56%	31.61%
AM/FM only	-1.235	-1.167	-1.220	-0.953
AM/FM + cassette	0.359	-0.556	-0.417	0.089
CD player only	0.059	0.633	0.504	0.189
AM/FM + CD player	0.817	1.091	1.133	0.658
Sound System	14.87%	7.35%	4.84%	17.38%
No headpiece	-0.370	0.084	-0.061	0.407
Headpiece w/external	0.281	-0.171	-0.113	-0.469
Headpiece w/inserts	0.090	0.087	0.174	0.062
Style	11.63%	1.08%	4.63%	3.81%
Standard	-0.254	-0.019	-0.138	-0.096
Sport	0.254	0.019	0.138	0.096
Price	13.41%	7.98%	38.72%	15.74%
$139.99	-0.367	-0.198	-1.103	-0.381
$89.99	0.061	0.082	-0.323	0.122
$59.99	0.087	0.033	0.225	0.412
$25.99	0.219	0.082	1.201	-0.153

Table B1.6
Illustrative SIMOPT Results: 4-cluster solution (Consumer Study)

	X_{12}	X_{13}	X_{14}	X_{15}
Brand	Sony	Panasonic	Sony	Sony
Features	AM/FM + CD	AM/FM + CD	AM/FM + CD	AM/FM + CD
Sound	Headpiece w/external	Headpiece w/insert	Headpiece w/insert	No Headpiece
Style	Sport	Sport	Sport	Sport
Price	$25.99	$89.99	$25.99	$59.99

Table B1.7
MOIP Model for Consumer Study

$$\text{Max } Z = \pi_k \sum_{i=1}^{12} M_i \ x_i \quad + \quad \pi_k \sum_{i=1}^{12} U_i \ x_i \quad + \quad \pi_k \sum_{i=1}^{12} \sum_{j=1}^{4} A_{ij} \ y_{ii}$$

subject to

$$\sum_{i=1}^{12} \sum_{j=1}^{4} c_{ij} \ y_{ii} \leq B \qquad \text{(for i = 1, ... ,12; j = 1, ..., 4)}$$

$$\sum_{i=1}^{12} v_i \ x_i \leq V \qquad \text{(for i = 1, ... ,12)}$$

$$y_{ij} \leq x_i \qquad \text{(for i = 1, ... ,12; j = 1, ..., 4)}$$

$$\sum_{i=1}^{n} x_i \leq 1 \qquad \text{(for i = 1, ... , n)}$$

where

- x_i = 1 if product-market i is selected, 0 otherwise
- y_{ij} = 1 if media j is selected for product-market i, 0 otherwise
- M_i = expected profit associated with product-market i
- U_i = customer utility associated with product-market i
- A_{ij} = accessiblity of product-market i with advertising media j
- c_{ij} = cost of communication vehicle j for product-market i
- v_i = volume (unit) requirements for product-market i
- V = plant production capacity in volume (units)
- B = advertising budget
- n = the subset of x_i that are overlapping cluster solutions
- π_k = the weight assigned to objective k (for k=1,2,3).

Table B1.8
Multiple Objective Program Solution - Consumer Study [1,2,3]

Run	x_i	y_{ij}	Z	$slack_V$	$slack_B$	n
Original Values[4]						
1	$x_1\ x_2\ x_4\ x_5\ x_6\ x_9$	$y_{23} = 0$	1.426	0	1371	209
Sensitivity Analysis						
2	$x_1\ x_4\ x_6\ x_9\ x_{15}$	$y_{42} = 0$	1.231	61124	43088	164
3	$x_1\ x_4\ x_5\ x_6\ x_9$	$y_{43} = 0$	1.225	61124	2508	164
4	$x_1\ x_3\ x_4\ x_5\ x_6\ x_{13}$	$y_{42}=y_{43}=y_{13,3}=0$	1.426	25000	1371	209
5	$x_1\ x_3\ x_4\ x_5\ x_6\ x_{13}$	$y_{32}=y_{42}=y_{13,2}=0$	1.439	25000	14289	209

Table Notes:

1 Each solution is based on the $\pi_M=\pi_U=.40$, $\pi_A=.20$ weighting scheme.
2 All $y_{ij}=1$ for the selected segments unless noted otherwise in the table.
3 The y_{ij} are as follows: (j=1) newspapers, (j=2) radio, (j=3) television, and (j=4) magazines.
4 Values (OOOs) of Budget and Volume constrains for each run: (1) B=\$600, V=400; (2) B=\$600, V=375; (3) B=\$550, V=375; (4) B=\$600, V=425; (5) B=\$650, V=425.

APPENDIX C

SAMPLE CPLEX AND AMPL PROGRAMS

APPENDIX C

SAMPLE CPLEX AND AMPL PROGRAMS

INDUSTRIAL APPLICATION

A. Multiobjective Programming Model

```
set MARKETS := 1 .. 12;
set MEDIA := 1 .. 4;
param a {MARKETS, MEDIA} >= 0;
param c {MARKETS, MEDIA} >= 0;
param h {MARKETS} >= 0;
param u {MARKETS} >= 0;
param m {MARKETS} >= 0;
param budget >= 0;
param capacity >= 0;
var X {MARKETS} binary;
var Y {MARKETS, MEDIA} binary;
maximize Obj: sum {i in MARKETS} .60*(m[i]*X[i]) + sum {i in MARKETS}
        .40*(u[i]*X[i]) + sum {i in MARKETS, j in MEDIA} .20*(a[i,j]*Y[i,j]);
subject to Budget:  sum {i in MARKETS, j in MEDIA} c[i, j]*Y[i, j] <= budget;
subject to Capacity:  sum {i in MARKETS} h[i]*X[i] <= capacity;
subject to Clearance {i in MARKETS, j in MEDIA}: Y[i, j] - X[i] <= 0;
subject to Cluster1: X[1] + X[8] + X[10] <= 1;
subject to Cluster2: X[2] + X[7] + X[11] <= 1;
subject to Cluster3: X[3] + X[6] + X[9] + X[12] <= 1;
subject to Cluster4: X[4] + X[10] <= 1;
subject to Cluster5: X[5] + X[11] <= 1;
```

B.1. Stage 1 of the Three-stage Priority Program

```
set MARKETS := 1 .. 12;
set MEDIA := 1 .. 4;
param a {MARKETS, MEDIA} >= 0;
param c {MARKETS, MEDIA} >= 0;
param h {MARKETS} >= 0;
param u {MARKETS} >= 0;
param m {MARKETS} >= 0;
param budget >= 0;
param capacity >= 0;
var X {MARKETS} binary;
var Y {MARKETS, MEDIA} binary;
maximize Obj: sum {i in MARKETS} m[i]*X[i];
subject to Budget: sum {i in MARKETS, j in MEDIA} c[i, j]*Y[i, j] <= budget;
subject to Capacity:  sum {i in MARKETS} h[i]*X[i] <= capacity;
subject to Clearance {i in MARKETS, j in MEDIA}: Y[i, j] - X[i] <= 0;
subject to Cluster1: X[1] + X[8] + X[10] <= 1;
subject to Cluster2: X[2] + X[7] + X[11] <= 1;
subject to Cluster3: X[3] + X[6] + X[9] + X[12] <= 1;
subject to Cluster4: X[4] + X[10] <= 1;
subject to Cluster5: X[5] + X[11] <= 1;
```

B.2. Stage 2 of the Three-stage Priority Program

```
set MARKETS := 1 .. 12;
set MEDIA := 1 .. 4;
param a {MARKETS, MEDIA} >= 0;
param c {MARKETS, MEDIA} >= 0;
param h {MARKETS} >= 0;
param u {MARKETS} >= 0;
param m {MARKETS} >= 0;
param budget >= 0;
param capacity >= 0;
var X {MARKETS} binary;
var Y {MARKETS, MEDIA} binary;
maximize Obj: sum {i in MARKETS} u[i]*X[i];
subject to Budget: sum {i in MARKETS, j in MEDIA} c[i, j]*Y[i, j] <= budget;
subject to Capacity:  sum {i in MARKETS} h[i]*X[i] <= capacity;
subject to Clearance {i in MARKETS, j in MEDIA}: Y[i, j] - X[i] <= 0;
subject to ZM: sum {i in MARKETS} m[i]*X[i] = 6789;
subject to Cluster1: X[1] + X[8] + X[10] <= 1;
subject to Cluster2: X[2] + X[7] + X[11] <= 1;
subject to Cluster3: X[3] + X[6] + X[9] + X[12] <= 1;
subject to Cluster4: X[4] + X[10] <= 1;
subject to Cluster5: X[5] + X[11] <= 1;
```

B.3. Stage 3 of the Three-stage Priority Program

```
set MARKETS := 1 .. 12;
set MEDIA := 1 .. 4;
param a {MARKETS, MEDIA} >= 0;
param c {MARKETS, MEDIA} >= 0;
param h {MARKETS} >= 0;
param u {MARKETS} >= 0;
param m {MARKETS} >= 0;
param budget >= 0;
param capacity >= 0;
var X {MARKETS} binary;
var Y {MARKETS, MEDIA} binary;
maximize Obj: sum {i in MARKETS, j in MEDIA} a[i, j]*Y[i, j];
subject to Budget:  sum {i in MARKETS, j in MEDIA} c[i, j]*Y[i, j] <= budget;
subject to Capacity:  sum {i in MARKETS} h[i]*X[i] <= capacity;
subject to Clearance {i in MARKETS, j in MEDIA}: Y[i, j] - X[i] <= 0;
subject to ZM: sum {i in MARKETS} m[i]*X[i] = 6789;
subject to ZU: sum {i in MARKETS} u[i]*X[i] = 8.468;
subject to Cluster1: X[1] + X[8] + X[10] <= 1;
subject to Cluster2: X[2] + X[7] + X[11] <= 1;
subject to Cluster3: X[3] + X[6] + X[9] + X[12] <= 1;
subject to Cluster4: X[4] + X[10] <= 1;
subject to Cluster5: X[5] + X[11] <= 1;
```

C.1. Stage 1 of the Two-stage Priority Program

```
set MARKETS := 1 .. 12;  set MEDIA := 1 .. 4;
param a {MARKETS, MEDIA} >= 0;
param c {MARKETS, MEDIA} >= 0;
param h {MARKETS} >= 0;
param u {MARKETS} >= 0;
param m {MARKETS} >= 0;
param budget >= 0;
param capacity >= 0;
var X {MARKETS} binary;
var Y {MARKETS, MEDIA} binary;
maximize Obj: sum {i in MARKETS} .50*(m[i]*X[i]) + sum {i in MARKETS}
        .50*(u[i]*X[i]);
subject to Budget: sum {i in MARKETS, j in MEDIA} c[i, j]*Y[i, j] <= budget;
subject to Capacity:  sum {i in MARKETS} h[i]*X[i] <= capacity;
subject to Clearance {i in MARKETS, j in MEDIA}: Y[i, j] - X[i] <= 0;
subject to Cluster1: X[1] + X[8] + X[10] <= 1;
subject to Cluster2: X[2] + X[7] + X[11] <= 1;
subject to Cluster3: X[3] + X[6] + X[9] + X[12] <= 1;
subject to Cluster4: X[4] + X[10] <= 1;
subject to Cluster5: X[5] + X[11] <= 1;
```

C.2. Stage 2 of the Two-stage Priority Program

```
set MARKETS := 1 .. 12;  set MEDIA := 1 .. 4;
param a {MARKETS, MEDIA} >= 0;
param c {MARKETS, MEDIA} >= 0;
param h {MARKETS} >= 0;
param u {MARKETS} >= 0;
param m {MARKETS} >= 0;
param budget >= 0;  param capacity >= 0;
var X {MARKETS} binary;  var Y {MARKETS, MEDIA} binary;
maximize Obj: sum {i in MARKETS, j in MEDIA} a[i, j]*Y[i, j];
subject to Budget:  sum {i in MARKETS, j in MEDIA} c[i, j]*Y[i, j] <= budget;
subject to Capacity:  sum {i in MARKETS} h[i]*X[i] <= capacity;
subject to Clearance {i in MARKETS, j in MEDIA}: Y[i, j] - X[i] <= 0;
subject to ZMU: sum {i in MARKETS} .50*(m[i]*X[i]) + sum {i in MARKETS}
        .50*(u[i]*X[i]) = 1.21647;
subject to Cluster1: X[1] + X[8] + X[10] <= 1;
subject to Cluster2: X[2] + X[7] + X[11] <= 1;
subject to Cluster3: X[3] + X[6] + X[9] + X[12] <= 1;
subject to Cluster4: X[4] + X[10] <= 1;
subject to Cluster5: X[5] + X[11] <= 1;
```

<u>CONSUMER APPLICATION</u>

Multiobjective Programming Model

```
set MARKETS := 1 .. 18;  set MEDIA := 1 .. 4;
param a {MARKETS, MEDIA} >= 0;
param c {MARKETS, MEDIA} >= 0;
param v {MARKETS} >= 0;
param u {MARKETS} >= 0;
param m {MARKETS} >= 0;
param budget >= 0;
param volume >= 0;
var X {MARKETS} binary;  var Y {MARKETS, MEDIA} binary;
maximize Obj: sum {i in MARKETS} .40*(m[i]*X[i]) + sum {i in MARKETS}
        .40*(u[i]*X[i]) + sum {i in MARKETS, j in MEDIA} .20*(a[i,j]*Y[i,j]);
subject to Budget:  sum {i in MARKETS, j in MEDIA} c[i, j]*Y[i, j] <= budget;
subject to Volume:  sum {i in MARKETS} v[i]*X[i] <= volume;
subject to Clearance {i in MARKETS, j in MEDIA}: Y[i, j] - X[i] <= 0;
subject to Cluster1: X[1] + X[7] + X[12] + X[16] <= 1;
subject to Cluster2: X[2] + X[8] + X[13] + X[12] <= 1;
subject to Cluster3: X[3] + X[9] <= 1;
subject to Cluster4: X[4] + X[10] + X[14] + X[18] <= 1;
subject to Cluster5: X[5] + X[11] + X[15] + X[17] <= 1;
subject to Cluster6: X[6] + X[10] +  X[14] + X[18] <= 1;
```

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