A MODEL-BASED METHODOLOGY FOR ASSESSING MARKET RESPONSE FOR NEW INDUSTRIAL PRODUCTS

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ABSTRACT

Industrial marketers face the difficult problem of developing product designs and associated communication strategies for new products aimed at heterogeneous audiences. This paper details the structure of an operational model of industrial response to marketing strategy. Four submodels make up this structure—an awareness model, a feasibility model, an individual evaluation model, and a group interaction model. Methods of structuring and calibrating these submodels are discussed, as are the associated measurements. The use of the new methodology to develop industrial marketing strategy—including product design and positioning trade-offs as well as communication program development—are reviewed. The

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paper uses illustrations from applications of the methodology and concludes with a detailed example reviewing the assessment of the market potential for solar-powered industrial cooling systems.

1. INTRODUCTION: THE NEW INDUSTRIAL PRODUCT DEVELOPMENT PROBLEM

New products account for a significant portion of the sales volume of industrial companies. McGuire and Bailey (1970) indicate that for the majority of industrial companies, over 25 percent of sales volume is attributable to products introduced within the last five years. Several studies (de Simone, 1967; Booz, Allen and Hamilton, 1965, for example) also show the importance of new products in determining company growth.

However, new products are risky. The Booz, Allen and Hamilton study shows that over 70 percent of the money spent on new product activities is associated with products that are not commercial successes. A recent analysis of the success probabilities of new industrial products at different stages in their development by Mansfield and Wagner (1975) suggests that less than one-third of new industrial product projects become economic successes.

Mansfield and Rapoport (1975) report on the cost of new product development. The major components of this cost, across many industries, are associated with the development of a prototype plant, new tools, and manufacturing facilities. This suggests the importance of market analysis prior to that stage of development.

A number of attempts have been made to identify the causes of new industrial product failures (Briscoe, 1973; Rothwell et al., 1974; Cooper, 1975; Mansfield and Wagner, 1975). The results of these studies are quite consistent: more emphasis is needed on analysis of organizational purchasing behavior and on fostering a closer integration of market research with product development. As Levitt (1960) points out, and as is confirmed by careful empirical work by von Hippel (1977), the high rate of failure of many new industrial products is linked to the policy of selling what R&D can produce rather than of satisfying customer needs.

This paper presents a model-based methodology to assess short-run market response to a new industrial product. The methodology comprises a set of models that addresses the issues of new product awareness, organizational feasibility, decision participants' perceptions, and group choice. Although the structure has been developed to treat medium-priced capital equipment, the modularity of its submodels offers considerable flexibility. In a particular application of the methodology, any of its submodels can be adapted to account for the unique situation encountered by the new industrial product investigated.

Once the model components have been calibrated, the methodology provides a flexible decision aid for developing new industrial products. It provides key diagnostic information about areas of high potential for product redesign; areas of resistance to the new product concept among decision participants; and opportunities for developing differentiated communication strategies.

The methodology can therefore be used to assess design trade-offs, in terms of expected market response, and product profitability. The analysis of the buying behavior of organizations in the target market, on which the methodology rests, also allows a quantitative treatment of new industrial product positioning issues and communications programs development (including target audience definition and copy design).

The paper proceeds as follows: the next section briefly reviews the literature about organizational buying and identifies those variables and relationships that are essential to the new product adoption process. We then develop an operational model of market response and review the issues associated with designing the model components. A measurement methodology is then described which provides the necessary input to each of the model's components. The use of the procedure to aid the new industrial product development process is then reviewed, using a solar-powered cooling system for industrial use as a case example. That extended example shows: which design improvements in solar cooling will have most effect on potential demand; who (what job responsibilities) are the key decision influences in the market; how the market can be segmented according to the structure of the decision-making unit; and what types of communications programs (issues, media) are most likely to be cost effective in boosting the potential sales of the new product.

The time/cost and other implementation issues associated with the methodology are reviewed, along with a discussion of the situations which justify its use.

2. ORGANIZATIONAL BUYING: BACKGROUND

As Webster (1978) points out, the amount of rigorous analysis given to industrial marketing problems is quite small relative to that given consumer marketing problems. There are several reasons for this: industrial products, from sulfuric acid to computer software and nuclear power plants, are more diverse than consumer products. Industrial companies tend to be production-oriented, and direct a smaller portion of their financial resources to marketing research activities than do consumer goods manufacturers. Most importantly, organizational buying behavior is far more complex and requires new and different modeling solutions.

For many industrial products—especially for capital equipment—a multi-person decision process is the normal mode of behavior. This decision process is characterized by the involvement of several individuals, with different organizational responsibilities, who interact with one another in a decision-making structure specific to each organization, and whose choice alternatives are limited by environmental constraints and organizational requirements.

Previous work on industrial buying behavior has been essentially concerned with (1) the development of integrated conceptual models and (2) the empirical verification of hypotheses pertaining to specific aspects of this behavior.

Robinson and Faris (1967) develop a descriptive model of industrial buying behavior that categorizes this process according to purchase situations. Webster and Wind (1972) propose a descriptive model of organizational buying. They introduce the concept of a "buying center" which includes those individuals involved in a purchase decision. Response of the buying center is analyzed as a function of four classes of variables: individual, interpersonal, organizational, and environmental. Sheth (1973) develops a model that tries to encompass all industrial buying decisions. The model distinguishes three main elements of industrial buying: (1) the psychological characteristics of the individual involved, (2) the conditions which precipitate joint decision-making, and (3) the conflict resolution procedures affecting joint decision-making.

In addition, a number of empirical studies have dealt with certain aspects of industrial buying behavior. These studies are mainly (1) observations of actual purchase decisions (Cyert et al., 1956; Brand, 1972), (2) analyses of the involvement of various organizational functions in industrial purchasing (Harding, 1966; Scientific American, 1969; Buckner, 1967), and (3) studies of the behavior and decision styles of individual decision participants (Lehman and O'Shaughnessy, 1974; Cardozo and Cagley, 1971; Hakanssan and Wootz, 1975; Wilson, 1971; Sweeney et al., 1973; Scott and Bennett, 1971; Wildt and Bruno, 1974; Scott and Wright, 1976).

A limitation of current models of organizational buying behavior is their lack of parsimony. Typically, available models provide a detailed conceptual structure for the study of industrial buying that is too complex to be operationalized. Moreover, from a managerial standpoint, the influence of many of the intervening variables singled out in these models have only been empirically validated in a limited way.

Recognizing these limitations, we develop an operational model of organizational buying that is more concise than currently available models. It focuses on the links between the characteristics of an organization's buying center and three major stages in the industrial purchasing decision process: (1) the elimination of alternatives that do not meet organizational requirements, (2) the formation of decision participants' preferences, and (3) the formation of organizational preferences.

Although simple, this model is consistent with the current state of knowledge in the field. It operationalizes the concept of the buying center and deals with issues of product feasibility, individual preferences, and organizational choice. And it specifically addresses the sequential process involved in considering purchase of a new industrial product. The next section develops that model in detail.

3. A MODEL OF ORGANIZATIONAL RESPONSE

A complete, operational model of industrial response to a new product requires that organizational heterogeneity be explicitly handled. The model proposed here considers the following sources of heterogeneity:

1. Potential customer organizations differ in their "need specification dimensions," that is, in the dimensions they use to define their requirements. They also differ in their requirements along these dimensions.
2. Potential customer organizations differ in the composition of their buying centers: in the number of individuals involved, in their responsibilities, and in the way they interact.
3. Decision participants, or individual members of the buying center, differ in their sources of information as well as in the number and nature of the evaluation criteria they use to assess product alternatives.

The consideration of these sources of organizational heterogeneity in an aggregate model of industrial response requires that members of the buying center be grouped into "meaningful" populations. Here, we use "decision participant category" to refer to a group of individuals whose responsibilities in their respective organization are essentially similar. Examples of such participant categories are "production and maintenance engineers," "purchasing officers," "plant managers," etc.

Our objective is to gain leverage by focusing on areas where individual or organizational homogeneity allows meaningful aggregation. To this end, we assume:

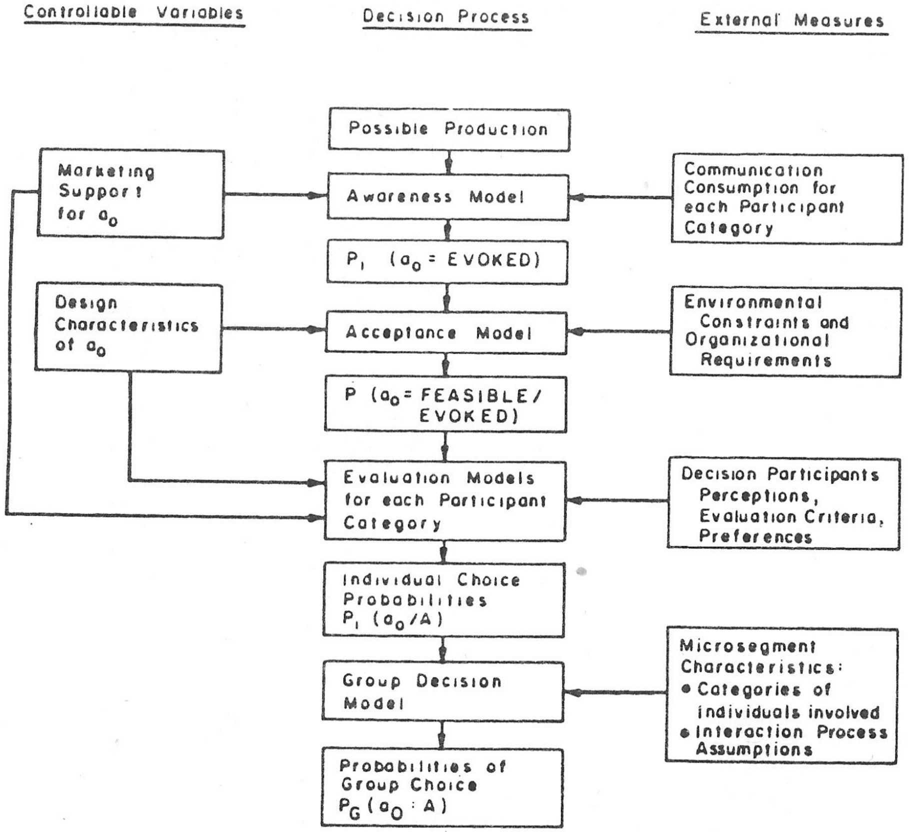
A1. Within potential customer organizations, the composition of the buying center can be characterized by the categories of participants involved in the purchasing process.

A2. Decision participants who belong to the same category share the same set of product evaluation criteria as well as information sources.

Assumption 1 is operationalized in Section 4.2; Assumption 2 is consistent with current knowledge. Sheth (1973) contends that individuals whose task orientation and educational backgrounds are similar tend to have common expectations about industrial products and suppliers. Recent work (Choffray and Lilien, 1976) indicates that meaningful differences exist in both the number and nature of the evaluation criteria used by various decision participant categories.

Figure 1 presents the general structure of our industrial market response model. The structure of this response model states that for an organization to select product a_0 for purchase, at least one decision participant in that organization must be aware of a_0 as an alternative; product a_0 must meet the organization's technical and financial requirements as well as the constraints imposed on that organization by its environment; and product a_0 must be the choice of the buying center in that organization (resulting from the interaction among its various members).

Figure 1. General Structure of an Industrial Market Response Model



Our model and associated measurement methodology focuses on the following issues: (1) identification of "microsegments" or organization, homogeneous in the structure of their buying centers or decision-making units (DMU's); (2) within each microsegment, determination of the fraction of customers who are aware of the product; (3) within that microsegment, and assuming awareness, determination of the fraction of organization for whom the product is feasible, and (4) determination of the fraction of customer-organizations in the microsegment that prefer the product to other alternatives.

Multiplication of the fractions in (2), (3), and (4) gives an estimate of segment market share. The next step is (5) determination of product sales, predicted as the product of segment market share times total segment forecast sales (market potential). Summing this quantity over segments gives the product-sales estimate.

This modeling and measurement sequence makes certain key assumptions. The process of choice—essentially one of sequential screening—is consistent with current choice theory (Tversky, 1972). It will assume that organizations in a "microsegment" (having similar DMU's), use the same dimensions for screening product alternatives. Similarly, as noted above, the methodology assumes that individuals with similar backgrounds and job responsibilities structure preferences similarly. Both these assumptions can be challenged, but both are reasonable a priori and make the procedure operational.

Stated analytically, then, the probability that product a_0 in evoked set A is the organization's choice (given that the organization is in the market to purchase a product in the class) can be written as:

Pr(a_0 = ORGANIZATIONAL CHOICE) =
Pr (a_0 = GROUP CHOICE/INTERACTION, FEASIBLE, EVOKED)
× Pr (a_0 = FEASIBLE/EVOKED)
× Pr (a_0 = EVOKED)

Each element of this structure is reviewed next.

3.1. The Awareness Model

3.1.1. Purpose. The awareness model links the level of marketing support for product a_0—measured in terms of spending rates for such activities as *P*ersonal *S*elling (PS), *T*echnical *S*ervice (TS), and *AD*vertising (AD)—to the probability that a decision participant belonging to category i (say production and maintenance engineers), will evoke a_0 as a potential solution to the organizational purchasing problem. Let

$$P_i (a_0 = \text{EVOKED})$$

denote this probability. Hence, we postulate that

$$P_i (a_0 = \text{EVOKED}) = f_i(\text{PS, TS, AD})$$

The evoking function will be calibrated separately within each microsegment, leading (perhaps) to different structures. Only controllable variables have been included here in line with our objective of making the structure operational.

This formulation also assumes that individuals who belong to the same participant category share essentially the same sources of information. It is reasonable to expect, however, that the awareness functions $f_i(\cdot)$'s will exhibit substantial differences across categories of decision participants as a result of their different levels and sources of information.

When several decision participant categories are involved in the purchasing process, the probability that product a_0 will be evoked as an alternative is the probability that at least one member of the buying center will evoke it. Thus:

$$P_G(a_0 = \text{EVOKED}) = 1 - \Pi_i (1 - P_i(a_0 = \text{EVOKED}))$$

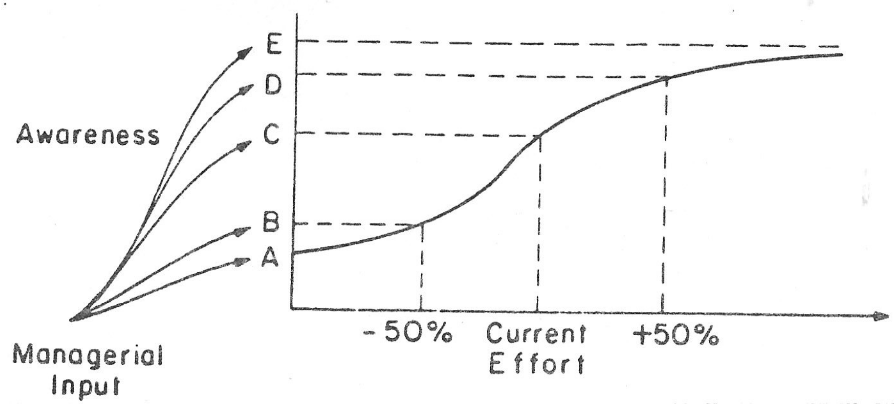
where index i covers all decision participant categories characterizing the purchasing process of the particular microsegment to which the organization belongs. This assumes that these probabilities are independent. Our experience with organizational communication between job functions leads us to believe this assumption is not unrealistic.

3.1.2. Analytical Structure. The functional form of each of the awareness functions $f_i(\cdot)$'s can either be derived empirically through a field study or can be provided by the product manager judgmentally. In the first case, a survey is performed for a sample of individuals from each participant category, exposed to various levels of the control variables PS, TS, and AD. Individuals are asked what brand(s) of product in the class they are aware of, their media consumption patterns, the last time they saw a salesman, etc. (See Morrill, 1970, for a description of a large-scale study of this nature.) These measurements can then be used as input to a set of multiple discriminant analyses or probit analyses which allow the development and calibration of analytical forms for each of the $f_i(\cdot)$'s. In some recent work by Lilien and Rao (1979), a generalized logistic function has been used to calibrate an awareness model. In that study, advertising weight was found to affect the level of product awareness.

In many cases, however, the second approach will be used due to time and cost constraints. It is based on a "decision calculus" approach (see Little, 1970), that relies on the manager's experience with the product and its market to infer what the $f_i(\cdot)$'s are for each decision participant category.

In this case, a base point (c) is provided by current marketing effort level and current awareness. Allowing for forgetting, a manager might be asked what would happen to awareness

Figure 2. Decision Calculus Calibration



- with a 50 percent increase in marketing effort (D)
- with a 50 percent decrease in effort (B)
- with a level of marketing effort which is essentially unlimited (E)
- with marketing effort set to zero (A)

Figure 2 displays the results of a decision calculus-type calibration.

3.2. The Acceptance Model

3.2.1. Purpose. The second element of the market response model is the acceptance model which accounts for the process by which organizations screen out infeasible products. Typically, the methodology assumes that potential customer organizations specify their purchasing needs along a set of "need specification dimensions." Examples of such dimensions are: initial product cost; operating cost; technical features, etc. Companies have specific requirements along these dimensions which limit the range of products that they can consider for final purchase.

Alternatively, need specification dimensions can be viewed as product design dimensions along which the new product characteristics can be defined. Let the new product a_0 be characterized by a vector of features $x_0 = \{x_{01} .. x_{0l}\}$ defined along organizational need specification dimensions $\{X_i\}$, $i = 1 \ldots l$.

The acceptance model relates the design characteristics X_0 of product a_0 to the probability that it will fall in a potential customer's feasible set of alternatives. Let this probability be denoted by

$$P_G\,(a_0 = \text{FEASIBLE/EVOKED}) = g(X_0)$$

Although organizations in the potential market may differ in their need specification dimensions, as well as in their requirements along these dimensions, the acceptance model $g(\cdot)$ assumes that the process by which organizations eliminate infeasible alternatives is essentially similar across potential customer organizations.

3.2.2. Analytical Structure. The notions of feasible sets of alternatives and of organizational need specification dimensions suggest that the models most suitable at this level are of the conjunctive type. Conjunctive models are multiple cutting-point models in which a set of acceptable levels is defined by each potential customer organization along its relevant set of need specification dimensions. To be feasible to a given organization, a product alternative has to fall in the acceptance region along each of these dimensions.

Several models can be used to approximate the process of organizational elimination of unfeasible alternatives. We propose two convergent approaches to specify $g(\cdot)$. Both approaches require information about the maximum (or minimum) requirement along each relevant need specification dimension from a sample of organizations in the potential market for the new product.

The first approach is probabilistic and requires fitting individual Beta probability density functions to the empirical distribution of normalized company requirements along each specification dimensions. The joint probability that X_u falls in the feasible region for a given organization chosen at random in the potential market for the new product is then assessed as:

$$p(a_u = \text{FEASIBLE/EVOKED})$$

$$= \prod_{i=1}^{I} p(X_{ui} = \text{FEASIBLE/EVOKED})$$

assuming that company requirements along the I specification dimensions are mutually independent. If such is not the case, principal component analysis can be used to identify a smaller set of independent composite specification dimensions.

The specification of each function $p(X_{ui} = \text{FEASIBLE})$ from the empirical distribution of company requirements can be made using a Beta density function of the form

$$f(x) = \begin{cases} \dfrac{1}{B(\alpha,\beta)} x^{\alpha-1}(1-x)^{\beta-1}; & 0 < x < 1 \\ 0 & \text{otherwise} \end{cases}$$

$$\text{where} \quad B(\alpha,\beta) = \int_0^1 x^{\alpha-1}(1-x)^{\beta-1}dx \qquad \alpha, \beta > 0$$

The Beta distribution is very inflexible and can approximate a variety of empirical shapes. Its two parameters (α,β) can be estimated by the method of moments.

In order to use the Beta function, company requirements along each specification dimension must first be normalized to lie within the range [0,1]). A simple transformation used to accomplish this is

$$y_{iJ} = \frac{Y_{iJ} - \min(Y_J)}{\max(Y_J) - \min(Y_J)}$$

where y_{iJ} stands for the normalized requirement of company i on specification dimension J; Y_{iJ} stands for the observed requirement of company i on specification dimension J (say Y_{iJ} = $900 per ton of cooling, for company i, where J = maximum acceptable cost per ton of cooling; max (Y_J), min (Y_J) stand for the maximum and minimum values observed for specification dimension J.

Once the parameters of the Beta function have been estimated for each specification dimension, the integral form:

$$\frac{1}{B(\alpha_j,\beta_j)} \int_0^{y_{ij}} x^{\alpha j-1}(1-x)^{\beta j-1}\,dx$$

can be used to estimate the probability that a system with characteristic Y_u (normalized value y_{ij}) is feasible for a randomly selected organization.

As a simplified example, (with a normal rather than a beta density) suppose there are only two need-specification dimensions, cost/unit and annual maintenance cost, and suppose, for simplicity, we calculated the marginal distributions across organizations, as follows:

Cost/Unit:	Normal~mean = $1,000, sd = $100
Annual maintenance cost:	Normal~mean = $ 100, sd = $10

If these distributions are independent, then we would find the fraction of organization who find a product with cost = $1100 *and* maintenance cost = $100 *feasible* as

$$(1 - \Phi\left(\frac{(1100-1000)}{100}\right)) \times (1 - \Phi\left(\frac{(100-100)}{10}\right)) =$$

$$(1 - \Phi(-1)) \times (1 - \Phi(0)) = (.159)(.5) = .079.$$

(where Φ is the cumulative standard normal distribution function). Thus, we would estimate that 7.9 percent of the organizations in that sector would find that "design" (i.e., cost = $1100, maintenance = $100) feasible.

The second approach uses regression on a logit-transferred dependent variable to relate the fraction of organizations in the potential market that would find product design X_u feasible to the individual characteristics $[x_{u1}, \ldots x_{uI}]$ of this product. The logit approach therefore assesses the relative importance of the various features of the new product in the determination of its market acceptance rate.

Calibration of the logit model first requires that a sample of "artificial" designs for the new product be randomly generated through simulation. Let this set of designs be denoted $[X_i, i=1 \ldots I]$. For each such design, the fraction of organizations in the sample that would find it feasible is computed. Let P_j, $j=1 \ldots M$ denote these numbers. The model

$$l_n \frac{\hat{p}_j}{1-\hat{p}_j} = \beta_0 + \sum_{i=1}^{I} \beta_i x_{ji} + \epsilon_j$$

is then assessed by weighted least squares.

Both approaches have their respective advantages. The logit approach gives a confidence interval around the estimate of the market acceptance rate corresponding to the specific features of a new product. It also provides an estimate of the relative importance of organizational requirements in the determination of the rate of market acceptance within a small region around the likely value. The probabilistic approach, on the other hand, explicitly models interaction between organizational requirements. As a result, it is particularly suitable to investigate new product design trade-offs, and is accurate at extremes of the feasibility requirements (when initial cost is very large, say).

Independent of the approach followed, the feasibility model $g(\cdot)$, once specified, can be input to a simulation that (1) quantifies product design trade-offs, and (2) allows accurate prediction of the rate of market acceptance corresponding to specific designs of the new product.

3.3. The Organizational Decision Models

Feasibility of a product for a given organization is only one step toward adoption. Usually, several alternatives are feasible in any purchase situation. The one that is retained for final adoption is related to the individual preferences of decision participants and of their mode of interaction.

The methodology proposed here explicitly addresses these two issues. First, it investigates the formation of individual preferences for feasible product alternatives for each category of decision participants. Second, it proposes ways to formalize the interaction process among decision participant categories within each microsegment.

3.3.1. Models of Individual Preference Formation

3.3.1.1. Purpose. Individual evaluation models relate evaluations of product characteristics to preferences for each category of decision participant. The models permit the analysis of preference response to changes in product positioning. They therefore feed back important information for the development of industrial communication programs that address the issues most relevant to each category of participant. Let

$$P_i(a_u;A/\text{FEASIBLE, EVOKED})$$

denote the probability that an individual belonging to category i will choose a_u from the set of feasible alternatives A. It is developed as:

$$P_i(a_u;A/\text{FEASIBLE, EVOKED}) = h_i(E_{uj})$$

where E_{uj} refers to individual j's evaluation of alternative a_u along those performance evaluation criteria $C_i = [c_1, \ldots, c_{in}]$ common to all individuals belonging to category i. These criteria will typically be calculated by factor-analyzing product attribute perceptions data.

3.3.1.2. Analytical structure. Most empirical studies of how individuals perceive and evaluate product alternatives have been done in the consumer goods area (see Allaire, 1973; Hauser and Urban, 1977; and Urban, 1975, for example). These methodologies share the same theoretical foundations. They all assume the existence of an n-dimensional perceptual space common to all consumers. An individual's perception of a product may then be thought of in terms of the coordinates of this product on the set of relevant perceptual dimensions. Operationally, an individual's perception of a product is provided by his ratings of the product on a set of perceptual items representing the salient attributes in the product class.

In order to relate individual preferences to product perceptions, the methodologies developed in the consumer area suggest the reduction of the perceptual space to a subspace of lower dimensionality whose coordinate axes express how these individuals structure basic product attributes into higher-order performance evaluation dimensions (Hauser and Urban, 1977) or choice criteria (Howard and Sheth, 1969). An individual's evaluation of a product may then be viewed as the projection of this product on his relevant evaluation criteria.

Straightforward application of these methodologies in the case of industrial adoption decisions raises substantial problems due to the multi-person nature of these decisions. The methodology proposed here therefore attempts to answer the following questions:

1. How do different categories of decision participants differ in the way they *perceive* available alternatives, including the new product?
2. How do these groups of decision participants differ in the way they *structure* basic product attributes into higher-order evaluation criteria?
3. How do these evaluation criteria affect product *preferences* for each of these different groups of individuals?

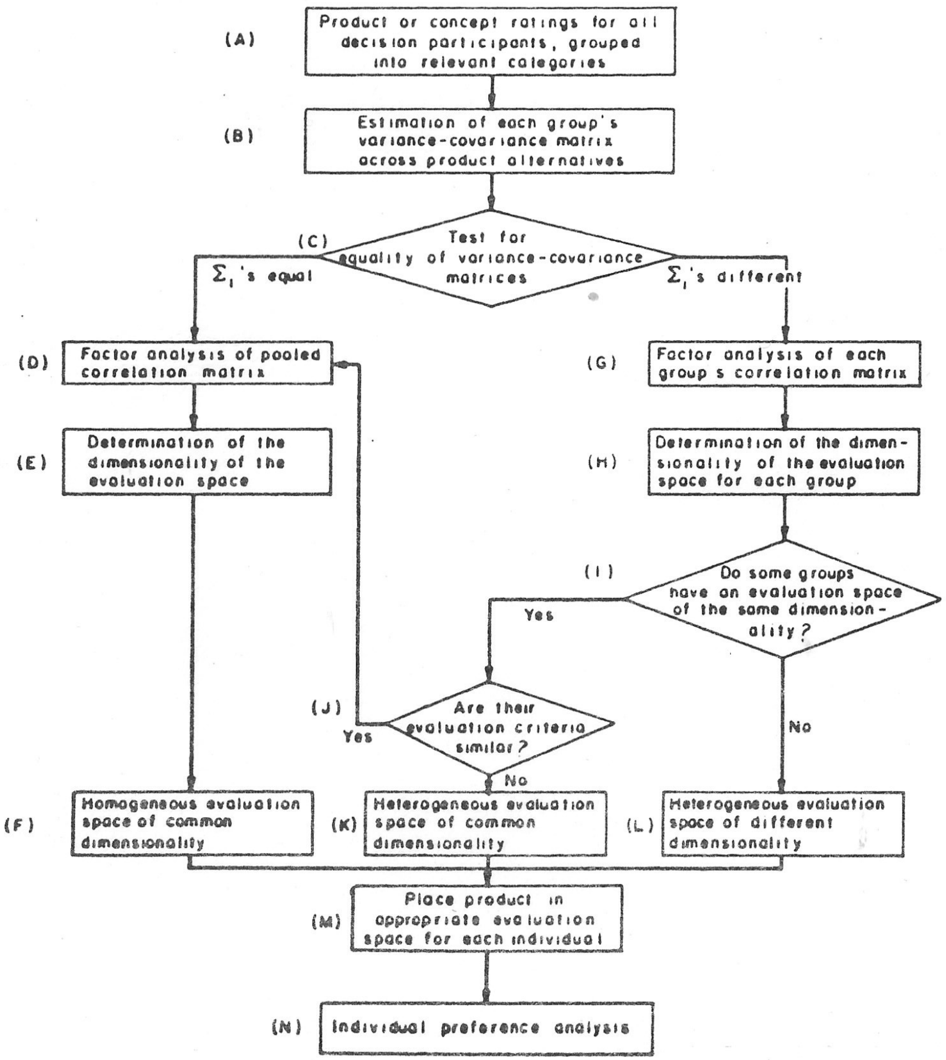
An answer to the first question is essential for developing sensible communication programs aimed at reducing resistance to the new product within specific participant categories. In the same way, answers to the other two questions aid in the study of positioning trade-offs for the new product.

Perceptual Analysis. As stated earlier, implementation of our methodology requires that decision participants be grouped into homogeneous categories with respect to their task orientation or job responsibility. The perceptual analysis part of the methodology aims at answering the two following questions: For each category of decision participant, are feasible products perceived differently? This step of the analysis is called product discrimination analysis. Alternately, for each feasible product, do the categories of decision participants exhibit substantial perceptual differences? This step of the analysis is called differential perception analysis.

The formal analysis of product discrimination is tested via one-way multivariate analysis of variance. Then, for each feasible product alternative, differential perceptions across participant categories are tested via multivariate profile analysis. If the groups differ in their perception of an alternative, univariate analyses of variance are performed to isolate those items that are the major sources of these differences.

Product Evaluation Analysis. Figure 3 outlines the steps that are used to assess differences in the evaluation criteria used by each category of decision participants. First, variance-covariance matrices between all perceptual items are

Figure 3. Outline of Evaluation Space Methodology



computed using the ratings obtained for all feasible product alternatives from each individual in every participant category (B). Then, a test for equality of all participant categories' covariance matrices is performed and allows for an early detection of possible differences in the way individuals in each of these groups structure the relevant product attributes into higher-order evaluation criteria (C). The Box test is used for this purpose.

If the hypothesis of equal covariance matrices is accepted, the correlation matrix between perceptual ratings is computed across all individuals and factor analyzed (D). The dimensionality of the common evaluation space is determined (E) by the parallel analysis method (Humphreys and Ilgen, 1969). The exact composition of the evaluation criteria common to all categories of decision participants is then appraised (F).

Rejection of the hypothesis of equal covariance matrices across decision categories requires separate factor analysis for each group (G). The dimensionality of the evaluation space is then determined for each group (H). If the number of evaluation criteria is different for each participant category, the analysis concludes at the existence of differences in the evaluation space harbored by different categories of participants. On the other hand, when some groups have an evaluation space of the same dimensionality, additional tests (J) for the equality of evaluation criteria are necessary (Choffray and Lilien, 1976). These tests investigate all subsets of participant groups with the same dimensionality for equality of evaluation criteria. If all evaluation criteria are found to be identical, these participant categories have a common evaluation space, so that a factor analysis of their pooled correlation matrix is not required (D). If at least one of their evaluation criteria is different, the analysis concludes at the existence of heterogeneous evaluation spaces across those decision groups with the given dimensionality.

The final step of the analysis is concerned with the behavioral relevance of the differences in the evaluation criteria used by the different categories of participants. This step is called preference estimation (N) and is concerned with linking individual preferences to product coordinates in the appropriate evaluation space.

Following Allaire (1973), for each participant category, several functional forms are tested by regression analysis and the best one retained. Here the dependent variable is stated product preference (rank-ordered or ratio-scaled from paired-comparison data), while the independent variables are the evaluation criteria. These models of individual preference formation may lead to the identification of decision style differences among participant categories. Once calibrated, these models are used to predict preference for feasible product alternatives. They can also be used in a "sensitivity-analysis" mode to assess likely changes in individual preferences caused by a change in the positioning of the new product on the respective evaluation criteria of each participant category.

Once calibrated, individual preferences can be transformed into probability of choice in one of several ways. First, we can assume that an individual will choose his first preference product. Secondly, a transformation, relating ratio-scaled preference to probability of purchase such as

$$\text{Prob (purchase of } a_0) = \frac{(\text{Pref } (a_0))^\beta}{\sum_j (\text{Pref } (a_j \epsilon A))^\beta}$$

can be used. (See Silk and Urban, 1977 for the use of a model of this type in predicting purchase from preference data.)

3.3.2. *Models of Group Interaction*

3.3.2.1. *Purpose.* Prior to calibrating group interaction models, our methodology calls for identification of those participant categories involved in the new product adoption process within potential customer organizations. Part of our methodology, called microsegmentation analysis, is concerned with measuring the composition of the buying center within potential customer organization and with identifying groups of firms which exhibit similar patterns of adoption process involvement. This part of our methodology is described later.

Models of group interaction map individual probabilities of choice for feasible alternatives into group probabilities of choice. In our methodology, this aggregation is made for each microsegment of organization identified in the potential market for the new product.

3.3.2.2. *Analytical structure.* We propose four models of group choice. Each one corresponds to different assumptions about the nature of the interaction process. We distinguish a Weighted Probability Model, a Voting Model, a Unanimity Model, and an Acceptability Model. All of them are proposed for a typical organization of an unspecified microsegment of the potential market.

Weighted Probability Model. The Weighted Probability model assumes that the group, as a whole, is likely to adopt a given alternative, say a_0 ϵA, proportionally to the relative importance of those members who choose it.

Let

$P_G(a_j;A)$ = probability that the group chooses a_j

w_i = relative importance, on the average, of decision participant d_i, $i=1, \ldots r$ in the choice process. So,

$$\sum_{i=1}^{r} w_i = 1$$

Then the weighted probability model postulates that

$$P_G(a_0;A) = \sum_{i=1}^{r} w_i P_i(a_0;A)$$

We can interpret this as a two-step sampling process where in step one, the organization samples a decision-maker from the set of decision participants proportionally to each participant's relative importance in the choice process. In step two, the sampled decision-maker selects an alternative according to his own choice probabilities.

There are two interesting special cases of the weighted probability model: (1) *Autocracy:* If $w_e = 1$, then all other $w_{i \neq e} = 0$; then a single decision participant, d_e is responsible for the group choice. (2) *Equiprobability:* If $w_i = 1/r$, for all i, then every decision participant has equal weight in the process. This is an appealing model, as it is a sort of zero-information or naive model. The industrial marketing manager need only identify the decision participants and does not have to measure or provide subjective estimates of the importance coefficients.

The equiprobability form of the weighted probability model has received some empirical support, both in dyadic decision making (Davis et al., 1973) and in group decisions involving more than two participants (Davis, 1973). Moreover, the model was found to accurately describe group risk shifts (Davis, 1973).

One must be careful, however, in interpreting these results. Indeed, although the cumulative frequencies of actual group decisions were reproduced accurately by the equiprobability model, these experiments mainly involved ad hoc groups whose members had little experience in working together. The equiprobability model might then be a reasonable approximation to organizational choice behavior in situations that involve decision participants from different departments who are not accustomed to working together.

As an example, consider an organization with three decision participants d_1, d_2, d_3 and three alternatives $A = [a_0, a_1, a_2]$.

Individual Choice Probabilities $P_i(a_j;A)$

a_j	$P_1(a_j;A)$	$P_2(a_j;A)$	$P_3(a_j;A)$
a_0	.2	.3	.7
a_1	.5	.2	.2
a_2	.3	.5	.1

Then $P_G(a_0;A) = .2w_1 + .3w_2 + .7w_3$. An equiprobability model with w_i = 1/3, i=1,2,3 will yield $P_G(a_0;A) = .4$. An autocratic model with $w_1 = 1$ will yield $P_G(a_0;A) = .2$; with $w_3 = 1$ will yield $P_G(a_0;A) = 7$. These are upper and lower bounds on $P_G(a_0;A)$ for the weighted probability model. In terms of our example: $.7 \geq P_G(a_0;A) \geq 2$.

The Voting Model. The voting model attributes the same weight to all individuals involved in the decision process. It states that the probability that the group will choose alternative a_o is equal to the probability that a_o is selected by the *largest number* of decision participants. Let

$$X_{ij} = \begin{cases} 1 & \text{if } d_i \text{ chooses } a_j \\ 0 & \text{otherwise} \end{cases}$$

Then

$$\Pr(X_{ij} = 1) = P_i(a_j; A)$$

Let

$$Z_j = \sum_{i=1}^{r} X_{ij} \quad \text{then}$$

$$P_G(a_0;A) = \text{Prob}\,[Z_0 = \max_j (Z_j)]$$

In terms of the previous example, we get $P_G(a_o; A) = .417$. This compares with .4 for the equiprobability model.

The Unanimity Model. This model assumes that, in order to be accepted by the group, an alternative, say a_0, has to be the actual choice of all decision participants involved in the choice process. Thus a group might, in theory, "vote" over and over again until unanimity is reached. Empirical studies of the industrial adoption process indicate that this model does capture some of the essence of the multi-person choice involved in this process (Buckner, 1967). This model reflects the so-called management by consensus, reportedly practiced by Japanese businessmen.

Formally, the unanimity model implies that

$$P_G(a_0;A) = \frac{\prod_{i=1}^{r} P_i(a_0;A)}{\sum_{j=0}^{n} \prod_{i=1}^{r} P_i(a_j;A)}$$

assuming that individual preference distributions are mutually independent. This is the conditional probability that the product a_o is selected, given that the group reaches unanimity.

Acceptability Model. This model assumes that if a group does not reach unanimous agreement, it is most likely to choose the alternative that "perturbs" individual preference structures least. This may be referred to as "management by exception." Suppose the following pattern of individual preferences holds in a group of two.

Decision Participant	Preference Pattern	Probability of Getting Pattern θ_k
d_1	$\theta_{1e}: a_0 \geq a_1 \geq a_2$	$P_1(\theta_{1e}/A)$
d_2	$\theta_{2h}: a_2 \geq a_0 \geq a_1$	$P_2(\theta_{2h}/A)$

where θ_{ik} means that individual i exhibits a preference structure θ_k. Given the pattern of preference structures $\gamma_{eh} = [\theta_{ie}, \theta_{2h}]$, we define the perturbation $Q(A_j \mid \gamma_{eh})$ associated with the choice of alternative a_j as the total number of preference shifts necessary for a_j to be everyone's first choice. In the above example, we get:

$$Q(a_0 \mid \gamma_{eh}) = 1$$

$$Q(a_1 \mid \gamma_{eh}) = 3$$

$$Q(a_2 \mid \gamma_{eh}) = 2$$

Assuming that all preference shifts are strictly comparable, we have:

$$P_G(a_0 \mid \gamma_{eh}) = 3\, P_G(a_1 \mid \gamma_{eh})$$

$$P_G(a_0 \mid \gamma_{eh}) = 2\, P_G(a_2 \mid \gamma_{eh})$$

As $\sum_{j=0}^{n} P_G(a_j|\gamma_{eh}) = 1$, we get

$$P_G(a_0 \mid \gamma_{eh}) = 6/11$$

$$P_G(a_1 \mid \gamma_{eh}) = 2/11$$

$$P_G(a_2 \mid \gamma_{eh}) = 3/11$$

Formally, given the distribution of preferences $P_i(\theta|A)$ for each decision participant, we can compute the probability that a specific pattern of preference structures γ_w will occur across individuals.

Thus, we get

$$\Pr[\gamma_w] = \Pr\,[\theta_{1k}, \theta_{2k}, \ldots \theta_{rk}]$$

$$= \prod_{i=1}^{r} P_i(\theta_{ik}|A) \qquad \text{where } w = 1, \ldots k^r \text{ and } k = 1, \ldots (n+1)!$$

assuming that individual preference distributions are mutually independent.

Letting $Q(a_j \mid \gamma_w)$ be the perturbation assocated with alternative a_j in the pattern γ_w, we postulate that the ratio of probability of group choice equals the ratio of needed preference perturbation to achieve first preference within the group:

$$\frac{P_G(a_j|\gamma_w)}{P_G(a_e|\gamma_w)} = \frac{Q(a_e|\gamma_w)}{Q(a_j|\gamma_w)}$$

Moreover, if $Q(a_e|\gamma_w) = 0$, then

$P_G(a_e|\gamma_w) = 1$ and

$P_G(a_j|\gamma_w) = 0$ for $j \neq e$ (This is a case of unanimous first preference.)

As the total number of possible preference shifts is fixed, these conditional probabilities are uniquely determined. Hence, the unconditional probabilities of group choice are given by:

$$P_G(a_j;A) = \sum_w P_G(a_j|\gamma_w) \cdot Pr[\gamma_w]$$

Although conceptually simple, the acceptability model entails combinatorial difficulties. Its justification follows from the observation that many groups seem to choose "everybody's second choice," or more precisely, the alternative that perturbs individual preferences least.

The models above are intuitively appealing but by no means exhaustive. An alternative to explicit modeling is to simulate the impact of different interaction assumptions on the estimate of group response. This approach is particularly suitable when neither the manager in charge of the new product nor sales people have an accurate understanding of the interaction process that characterizes decision-making within each microsegment. This approach allows them to consider various types of assumptions and assess the sensitivity of group response to these assumptions.

4. IMPLEMENTATION OF THE INDUSTRIAL MARKET RESPONSE METHODOLOGY

Implementation of the structure described above requires a set of measurements that provides input to the various submodels. This section reviews the measurement steps involved in a typical implementation of the response model. These measurements are summarized in Figure 4.

4.1. Measurements at the Market Level

The first measurement step, called macrosegmentation following Wind and Cardozo (1974), specifies the target market for the new product. The purpose of macrosegmentation is to narrow the scope of the analyses to those organizations most likely to purchase the product. Bases for macrosegmentation might be as

Figure 4. Major Measurements Needed for Calibrating the Industrial Market Response Model

Data Type	Source	Target
1. Hard	1.1. Market	1.1.1 Macrosegmentation: Target Market Definition
	1.2. Organizations	1.2.1 Identification of Need Specification Dimensions; Measurement of Organizational Requirements.
		1.2.2 Microsegmentation: Grouping of Organizations on the Basis of Buying Center Composition
	1.3. Decision Participants	1.3.1 Production Awareness and Communication Consumption Patterns
		1.3.2 Production Evaluations and Preferences
2. Soft	2.1. Industrial Marketing Manager	2.1.1 Judgmental Estimates of Interaction Process

general as S.I.C. code classification, geographic location, etc. The output of this measurement step is an estimate of the maximum potential market for the product. Let Q denote that maximum potential.

4.2. Measurements at the Customer-Organization Level

Two major types of measurements have to be obtained at this level. If the potential market for the product contains a large number of customers, a representative sample can be drawn. In other cases, gathering data from all potential customers might be considered.

Organizations' need specification dimensions have to be identified first, and then the requirements of each firm in the sample along these dimensions must be assessed. Identification of these dimensions follows discussions with potential decision participants. Group interview methods (see Wells, 1974) are particularly suitable for this purpose. It is the authors' experience that such interviews with members of the buying center of a few (3-5) potential customers are generally sufficient to identify the set of relevant specification dimensions.

Survey questions are developed next. These questions request the maximum (or minimum) value along each specification dimension beyond which the organization would reject a product out of hand. In order to reduce individual response bias, respondents are allowed to use any information sources in their organization (including colleagues) to provide their answers. These answers are the main input to the acceptance model. Figure 5 gives an example of these questions for an industrial air conditioning system.

Next, information is collected on the composition of the buying center and the respective organizational responsibilities of its members. This information allows the development of a decision matrix (see Figure 6 for an example) that requests the percentage of the task responsibilities for each stage in the purchasing process associated with each category of decision participants. This instru-

Figure 5. Sample Question for Evaluation of Need Specification Dimension

2.1 Suppose your company had decided to install an a/c system in a *new* plant and has identified several different systems for consideration. In screening these alternatives, your company *will eliminate* any system,

a. If its expected life is *less than* ________ years.
b. If its initial investment cost is *more than* ________ \$/ton of cooling.
c. If it is covered by a complete warranty of *less than* ________ months.
d. If it is successfully operating in *less than* ________ other industrial installations.
e. If its annual operating cost (maintenance included) is *more than* ________% of its initial investment cost.

ment has been shown to give consistent estimates of involvement in the decision process when completed by different members of the same organization (Choffray, 1977). This corroborates earlier observations by Wind and Kelly (1974).

We next develop a microsegmentation scheme that uses cluster analytic procedures to identify microsegments of potential customers that are homogeneous in the composition of their buying centers. Figure 7 outlines the main steps in this analysis.

First, the decision matrix is used to measure involvement in the adoption process for a sample of organizations in the potential market. Let x_{ijh} denote the entry in row j and column h of the decision matrix for company i. This value represents the "percentage" of the task responsibilities associated with decision phase h that are part of the role of participant category j in the adoption process for company i. We then have

$$x_{ijh} \geq 0 \qquad \text{for all i, j, h}$$

$$\sum_j x_{ijh} = 1.0 \qquad \text{for all i and h}$$

Second, an index of inter-organizational similarity or dissimilarity must be selected. One measure of the degree of dissimilarity between two organizations (r,s) in the structure of their adoption process is the distance function

$$D^2_{rs} = \sum_{j,h} (\sigma_{rjh} - \sigma_{sjh})^2$$

where

$$\sigma^{ijh} \begin{cases} = 1 \text{ if } x_{ijh} > 0 \\ = 0 \text{ if } x_{ijh} = 0 \end{cases}$$

Third, cluster analytic procedures are used to identify groups of organizations which exhibit similar patterns of involvement in their adoption process. Choffray (1977) presents criteria to determine the number of such microsegments which should be retained for final analysis.

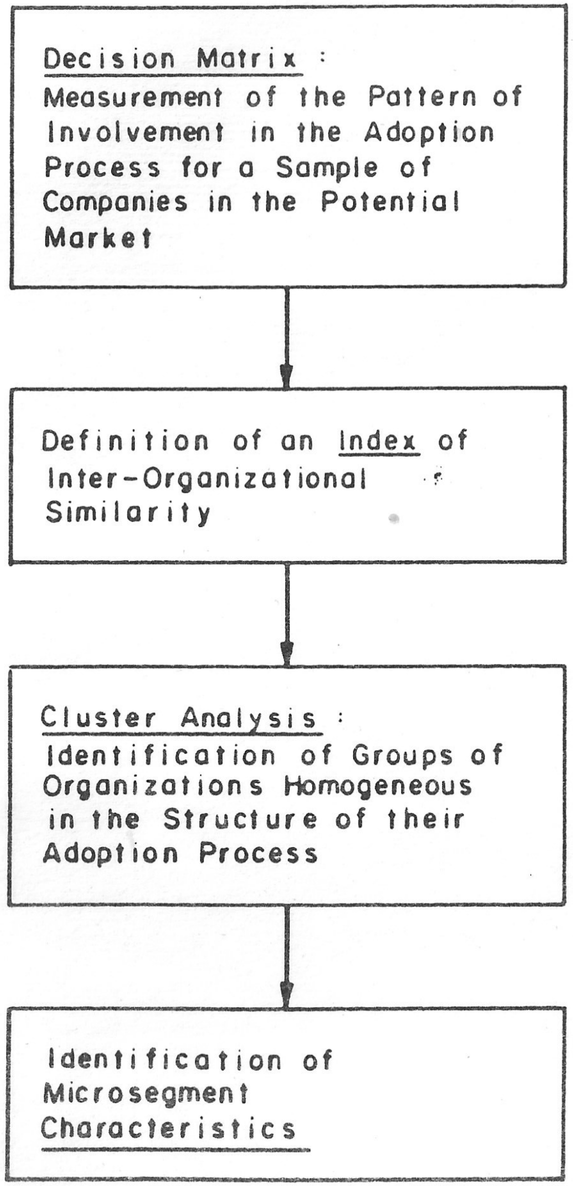
The final step of the microsegmentation analysis concerns the identification of

Figure 6. Sample Decision Matrix: Industrial Air Conditioning Study

	Decision phases / Decision Participants	1 Evaluation of a/c needs, specification of system requirements	2 Preliminary a/c budget approval	3 Search for alternatives, preparation of a bid list	4 Equipment and manufacturer evaluation*	5 Equipment and manufacturer selection
COMPANY PERSONNEL	Production and Maintenance Engineer	%	%	%	%	%
	Plant or Factory Manager	%	%	%	%	%
	Financial controller or accountant	%	%	%	%	%
	Procurement or purchasing department	%	%	%	%	%
	Top Management	%	%	%	%	%
EXTERNAL PERSONNEL	HVAC/Engineering firm	%	%	%	%	%
	Architects and Building Contractor	%	%	%	%	%
	a/c equipment manufacturers	%	%	%	%	%
	COLUMN TOTAL	100 %	100 %	100 %	100 %	100 %

* *Decision phase 4 generally involves evaluation of all alternative a/c systems that meet company needs while Decision phase 5 involves only the alternatives (generally 2-3) retained for final selection.*

Figure 7. Outline of the Microsegmentation Methodology



microsegment characteristics in terms of: general pattern of decision process involvement; and external company measures such as size, growth rate, etc. Analysis of variance or other statistical methods can be used for this purpose.

Let $S_1 \ldots S_n$ denote the microsegments identified in the potential market for the new product and $V_1, \ldots V_n$ their relative size in terms of market potential. Each microsegment S_u is further characterized by a set of participant categories DEC_u that are usually involved in the adoption process for the companies it comprises. For instance, in segment S_1, corporate managers along with design engineers might be the major categories of participants involved. In S_2, production engineers are involved, too, etc.

4.3. Measurements at the Decision Participant Level

For each decision participant category, product awareness, perceptions, and preferences are measured at the individual level.

Product awareness can be obtained through survey questions asking each potential decision participant what product(s) or brand(s) of product they think of in a specified product class. Several other methods commonly used in consumer goods marketing to measure brand awareness (see Johnson, 1974) can also be used. Both measurements are used to calibrate the awareness submodel.

The measurement of individual perceptions, evaluations, and preferences for product alternatives requires more complex methods. In industrial markets it is often difficult to expose potential buyers to a physical product due to transportation and time constraints. For this reason, the use of concept statements, accurately describing each product in the class considered, is a reasonable alternative. Due to the technical orientation of potential buyers, the use of concept statements to measure individual perceptions and preferences seems as suitable for industrial markets as in consumer markets, where the method has been used with considerable success (Hauser and Urban, 1977). Figure 8 gives a sample concept statement for solar-powered air conditioning.

Individual product perceptions can then be recorded along each of a set of perceptual scales that include the relevant attributes used by individuals to assess products in this class. Figure 9 develops the measurement procedure used for solar air conditioning.

Preference data can be collected in several ways. Two convergent methods, rank-ordered preferences and constant sum-paired comparisons, were used in the solar cooling study (see Figure 10). The latter method allows the evaluation of a ratio-scaled preference score via Torgerson's least squares procedure (1958). Preference rankings obtained by the two methods can then be used to assess respondents' inconsistency in preference judgment.

An important assumption inherent in the measurements of individual percep-

Figure 8. Sample Concept Statement: Solar Air Conditioning Study

Solar Absorption a/c System: SOLABS

SOLABS consists of a standard absorption chiller as used in ABSAIR and a hot water solar collector which replaces the boiler in a standard absorption a/c system. As it uses solar energy as a power source, SOLABS is less sensitive to fuel shortages and power fluctuations than other industrial a/c systems.

The solar collector used by SOLABS is a flat type that is located on the roof of the building. In some cases, collectors can even replace the roof. Collectors come in panels of various standard sizes that are attached to one another by normal plumbing connections. Two water storage tanks are also part of SOLABS and are generally buried in the ground. One of these tanks is for chilled water, to meet the immediate demands of the absorption system. The other one is for hot water, to meet a/c needs during periods of little sunshine or alternatively to provide heating during these same periods. When the system is used exclusively for a/c, water storage capacity need not be large as more solar energy is available when cooling is most needed. A small backup heating and cooling system can be used to make up for prolonged periods of low sunshine.

Solar energy alone can provide 40%–60% of all building a/c requirements, significantly reducing energy costs. In addition, warm water produced by the solar collector can be used for manufacturing or domestic water needs. In colder climates, this system can provide 30%–40% of heating requirements.

The initial cost of SOLABS is at least 50% higher than for non-solar systems, depending on the size of the installation. The operating cost of SOLABS, however, is considerably lower than for other systems due to a reduction of at least 40% in a/c energy consumption (depending on the geographical location). Maintenance costs for SOLABS are similar to those for ABSAIR.

SOLABS produces no pollution. As it requires a minimum of moving parts, SOLABS is very quiet and vibration free.

The solar a/c concept is not new. Several well-known manufacturers produce components and one such system was in operation at the University of Florida as early as 1960. Currently, there is a new school in Atlanta, Georgia that is air-conditioned by SOLABS and there are several projects to install similar a/c systems in different parts of the U.S.

tions and preferences is that these measurements are obtained from actual decision participants. To minimize this potentially important source of bias, the authors suggest a two-stage sampling procedure. First, a member of top management in each company in the sample is identified, using published sources of information. He is asked to specify those members of his organization that, in his judgment, would be most likely to participate in the purchase of a product in the class. Only individuals identified at this second stage are interviewed or mailed a copy of the survey instrument.

Figure 9. Sample Evaluation Scheme: Solar Air Conditioning

Ratings for SOLABS	(Circle one number for each item)						
	Strongly Disagree						Strongly Agree
1. The system provides reliable air conditioning.	1	2	3	4	5	6	7
2. Adoption of the system protects against power failures.	1	2	3	4	5	6	7
3. The effective life of the system is sensitive to climate conditions.	1	2	3	4	5	6	7
4. The system is made up of field-proven components.	1	2	3	4	5	6	7
5. The system conveys the image of a modern, innovative company.	1	2	3	4	5	6	7
6. The system cost is acceptably low.	1	2	3	4	5	6	7
7. The system protects against fuel rationing.	1	2	3	4	5	6	7
8. The system allows us to do our part in reducing pollution.	1	2	3	4	5	6	7
9. System components produced by several manufacturers can be substituted for one another.	1	2	3	4	5	6	7
10. The system is vulnerable to weather damage.	1	2	3	4	5	6	7
11. The system uses too many concepts that have not been fully tested.	1	2	3	4	5	6	7
12. The system leads to considerable energy savings.	1	2	3	4	5	6	7
13. The system makes use of currently unproductive areas of industrial buildings.	1	2	3	4	5	6	7
14. The system is too complex.	1	2	3	4	5	6	7
15. The system provides low cost a/c.	1	2	3	4	5	6	7
16. The system offers a state of the art solution to a/c needs.	1	2	3	4	5	6	7
17. The system increases the noise level in the plant.	1	2	3	4	5	6	7

4.4. Measurement at the Managerial Level

The measurements described above are used to calibrate the three first components of the industrial market response model. Development of group choice models, however, requires assumptions about the type of interaction that takes place between decision participant categories.

As suggested earlier, the measurement methodology relies on the marketing manager's experience with the product class. The final input to the industrial

Figure 10. Sample Preference Measurement Scheme: Solar Cooling Study

You have just rated three alternative industrial air conditioning systems. Now we would like to know your overall preferences for these systems, listed below. *Assume that all three systems satisfy the requirements you stated in question 2.1.* Write a "1" next to the one which would be your first choice, a "2" next to your second choice and a "3" next to your third choice.

Conventional Absorption a/c system	ABSAIR	______
Conventional Compression a/c system	COMAIR	______
Solar Absorption a/c system	SOLABS	______

Assume your company has reduced the choice of system alternatives to two, *both meeting the requirements you stated in question 2.1.* For each of the pairs listed below, allocate 11 points between the alternatives in a way which reflects your relative preference for the two systems.

a. COMAIR vs. SOLABS

Conventional Compression a/c system	COMAIR	______
Solar Absorption a/c system	SOLABS	______
Total	=	11

b. ABSAIR vs. COMAIR

Conventional Absorption a/c system	ABSAIR	______
Conventional Compression a/c system	COMAIR	______
Total	=	11

c. SOLABS vs. ABSAIR

Solar Absorption a/c system	SOLABS	______
Conventional Absorption a/c system	ABSAIR	______
Total	=	11

response model consists of the manager's specification of those models of interaction which best reproduce his understanding of the purchasing decision process for the companies which fall in each microsegment.

In terms of the models proposed earlier, the manager's estimates for microsegment S_q might be:

Model	Fraction of Segment S_q Using this Model
Weighted Probability Model	α_{1q}
Voting Model	α_{2q}
Unanimity Model	α_{3q}
Acceptability Model	α_{4q}

with $\sum_e \alpha_{eq} = 1$ for each microsegment q. If the manager considers that the companies within a particular microsegment exhibit homogeneity in the nature of their conflict-resolution process, only one $\alpha_{eq} = 1$, and the others $= 0$.

Note that we segment organizations according to *who* is involved; the group decision models determine *how* they interact. It is usually most convenient, in practice, to assume one interaction model per microsegment, however.

5. ASSESSING RESPONSE TO INDUSTRIAL MARKETING STRATEGY: INTEGRATING MEASUREMENTS AND MODELS

The information provided by the measurement methodology and fed into the various models components leads to an estimate of market response. $M_q(a_0)$ denotes the estimated share of microsegment S_q that finally purchase product a_0. Hence

$$M_q(a_0) = \sum_e \alpha_{eq} P_r[a_0; A/MOD_e, DEC_q]$$

where $P_r[a_0; A/MOD_e, DEC_q]$ denotes the probability that a_0 is the organizational choice, given the involvement of decision categories DEC_q and an interaction model MOD_e.

Given a maximum potential sales of Q for product a_0, we can estimate expected sales of a_0 by computing

$$\text{Sales}(a_0) = Q\left[\sum_{q=1}^{S} V_q M_q(a_0)\right]$$

The model-based methodology presented here provides a sensible framework to assess response to industrial marketing strategy for new industrial products. The model is quite general and its components can easily be adapted to account for the different problems of specific new industrial products. In particular, the model clearly encompasses single-person decision-making as a special case. In fact, any part of the submodel can be deleted if it is irrelevant, resulting in model simplifications as well as in fewer measurements. So, the group decision model would be ignored in case of single-person decision-making, as would the microsegmentation methodology. The acceptance model and associated measurements, on the other hand, become irrelevant for industrial products that lead mainly to straight-rebuy situations, and can therefore be omitted from the model.

6. APPLYING THE METHODOLOGY: SOLAR AIR CONDITIONING CASE STUDY

This section reviews a case example using the methodology developed here. It incorporates the measurement procedures outlined in Section 4 and the analysis presented here parallels the theoretical developments discussed in Section 3.

6.1. Background

Currently, over 25 percent of the energy used in the United States is consumed by heating and cooling of buildings and by providing hot water (Westinghouse

Phase 0 report, 1974). At a conversion efficiency of 10 percent, 11,000 square miles of solar collectors (or 0.3 percent of United States land area) could have satisfied the 1970 water and space heating and cooling needs of the United States (Williams, 1974).

Space cooling is the fastest growing area of United States energy use, projected to account for over 5 percent of United States energy demand by 1980 (Westinghouse Phase 0 report, 1974). A substantial portion of this demand is for use in industrial buildings. Thus, a considerable amount of fossil fuel could be saved by wide-scale adoption of solar-powered cooling systems.

Recognizing the potential for this saving, the United States Energy Research and Development Administration, together with the United States Economic Development Administration, is sponsoring a multi-year study to (1) demonstrate the technical feasibility of solar-powered cooling in a commercial-industrial setting, and (2) to evaluate the potential market for such a system. (Lilien et al., 1977, gives complete details.)

There are two major classes of cooling systems in wide use today—compression systems and absorption systems, comprising about 90-95 percent and 5-10 percent of the market respectively.

Compression cooling, the most familiar system used in cars, room air conditioners, most refrigerators, etc., uses a single refrigerant in conjunction with an evaporator, a compressor, and a condensor. In the evaporator, the refrigerant, under pressure, passes through an expansion valve and vaporizes. As it evaporates, the refrigerant absorbs heat from the vehicle (water or air) that it is cooling. The refrigerant vapor is then compressed and sent to the condensor where it rejects heat to the environment. Finally, the refrigerant returns to the evaporator to start the cycle again. The initial cost of compression cooling systems is the lowest available and it is also the most efficient convertor of thermal or electric energy into cooling.

An absorption chiller uses a refrigerant (e.g., water) and an absorbent (e.g., lithium bromide) in conjunction with an evaporator, absorber, generator, and condenser. In the evaporator, the refrigerant, in a vacuum, is vaporized by a sprayer. As it evaporates, the refrigerant absorbs heat from the water that is used to cool the building. The refrigerant vapor is then absorbed by the solution in the absorber. The resulting solution is heated in the generator to drive off the refrigerant. At the condensor, the refrigerant vapor condenses and rejects heat to the environment. The refrigerant then returns to the evaporator to start the cycle again.

Initial costs for absorption systems tend to be significantly higher than for compression systems. They are particularly inefficient at sizes under 100 tons, making single family residential applications (around 5 tons) inappropriate. These systems are generally used by firms (such as pharmaceutical companies) that use steam for other industrial processes and who wish to make additional use of that steam.

The solar cooling system investigated in this study uses an absorption cycle in which the necessary heat to drive off the refrigerant is captured by solar collectors.

6.2. The Industrial Cooling Adoption Process: Background and Measurement

An objective of the market analysis was to obtain an understanding of the technical, economic, and organizational issues associated with the adoption of industrial cooling systems in general and solar cooling in particular. Specifically, we wish to determine (1) what kinds of decision variables are important in the adoption process for solar cooling, and (2) who takes part in, or influences, that decision process.

To this end, a series of in-depth personal and group interviews were conducted with personnel from industry and heating, ventilating, and air conditioning (HVAC) consulting firms. As these interviews progressed, a questionnaire was gradually developed, refined, and pilot-tested. Two versions of the questionnaire were finally developed—one for internal, company people and a second for outside consultants. Both these questionnaires requested data of the sort indicated in Section 4.

The questionnaire was administered as follows: a sample of firms was selected by size, S.I.C. code, and geographic area, and a senior management member was identified. He was sent a personal letter asking for names of two or three members of his organization most likely to be involved in the adoption decision process for industrial cooling equipment. A detailed questionnaire was then sent to the individuals mentioned. This two-step sampling procedure increased the likelihood of reaching key people in the adoption decision for this class of product. The return rates were 27 percent and 46 percent respectively.

6.3. Feasibility Analysis

Figure 11 gives some descriptive statistics about company requirements for industrial air conditioning systems. Figure 12 gives the regression results using the logit model described in Section 3.2 to assess system feasibility.

These results point to the overall importance of a system's cost in the determination of acceptance, evidenced by the high value of the corresponding standardized regression coefficient.

In order to assess market potential, probability estimates of likely characteristics of the new solar air conditioning system along each specification dimension were obtained from experts. These levels and their associated likelihood of occurrence are shown in Figure 13. Using these values as input, market acceptability was calculated as 2.00 percent, as noted in Figure 14.

By linking system characteristics to market acceptance, the feasibility analysis

Figure 11. Range of Company Requirements

	Minimum	Mean	Median	Maximum
1) Expected life of the system should be greater than:	5 years	11.6 years	10 years	20 years
2) Initial investment cost of the system per ton of air conditioning should be less than:	\$100	\$983	\$1000	\$3000
3) Warranty period should be greater than:	1 month	15.4 months	12 months	60 months
4) The number of successful installations in the field should be at least:	0	17.6	5	100
5) The annual operating cost as a percent of initial cost should be less than:	5%	14.0%	10%	50%

Figure 12. Results of the Logit Regression Analysis: Solar Cooling Study

Variable	Estimated Coefficient	Standardized Coefficient
Expected system's life	.071	.236*
Initial Investment Costs	−.001	−.676*
Warranty Period	.011	.119*
Number of successful Installations	.001	.022
Annual Operating Cost	−.084	−.733*
CONSTANT	−2.857	

$F(5,137) = 58.42$
$R^2 = .69$

*Significant at the level < .01.

Figure 13. Expert Estimates of Solar Absorption System Characteristics

	Low	Most Likely	High
Likelihood	1/6	2/3	1/6
Expected life (years)	10	15	20
Initial Investment (per ton)	1500	2000	2500
Warranty Period (months)	12	24	60
Number of Successes	5	25	100

Figure 14. Simulated Distribution of Market Acceptance for Solar Absorption Air Conditioning

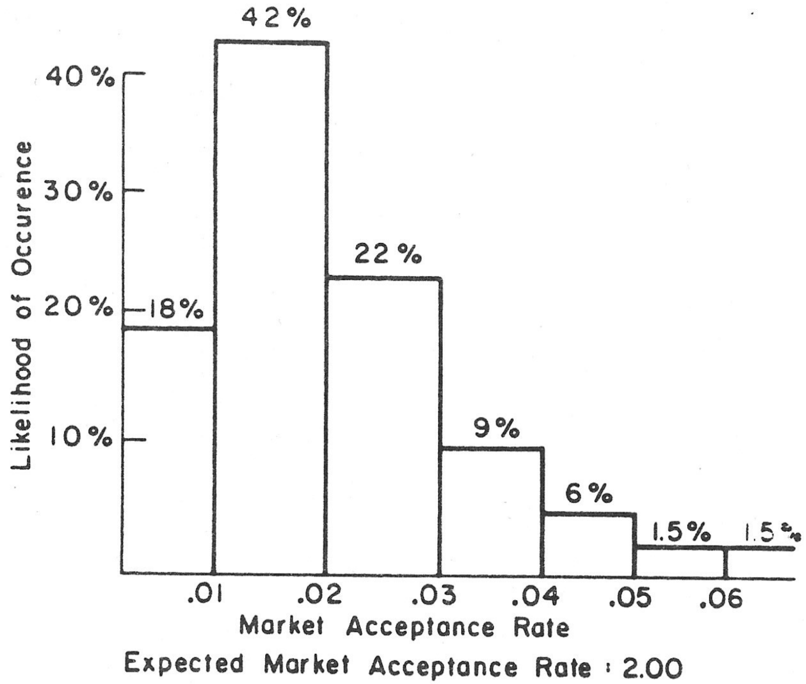
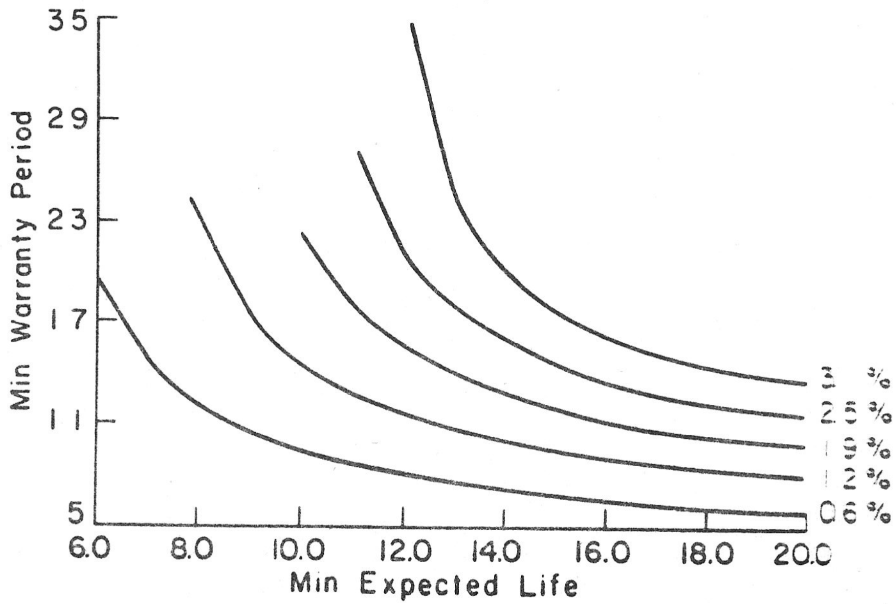


Figure 15. Solar Absorption Iso-Acceptance Trade-off Curves—Expected Life vs. Warranty Period



provides a tool to investigate design trade-offs. As an example, holding all other dimensions at their median value, Figure 15 displays trade-offs between warranty period and expected life. From these curves, we see that potential customers become increasingly concerned about warranty issues the shorter the expected life of the system. Moreover, these curves suggest the existence of a saturation level for the warranty period. After the warranty exceeds 23 months, it becomes hard to further increase system acceptance by increasing the warranty period.

6.4. Perceptual Analysis

Analysis of the responses by the different groups of decision participants to the different concepts, using the methods developed in Section 3.3, indicated that each group of decision participants perceived the three alternatives differently. Perceptual differences for each concept were also found between each group. For example, analysis of the perceptual differences via one-way univariate analysis of variance suggests that plant managers view solar cooling as a more substantial means of protection against power failures than do HVAC consultants. They also consider it more cost effective than HVAC consultants. Finally, plant managers view the solar system as a complex system whose components have not been fully tested, but that provides a state-of-the-art solution to industrial cooling needs. HVAC consultants' perception of the solar systems differ considerably in this last respect.

6.5. Evaluation Space Analysis

Careful analysis of the evaluation spaces of each category of decision participants showed significant structural differences. Corporate Engineers and Plant Managers had 2 dimensional evaluation spaces, interpreted in Figure 16.

The issue of industrial cooling systems' initial costs does not appear as clearly for Plant Managers. Modernness, energy savings, and protection against fuel rationing and power failure, on the other hand, account for a substantial portion of the variance in Plant Managers' perceptions. Corporate Engineers see the system's reliability and first costs as primary issues.

Figure 16. Comparison of Factor Solutions for CE, PM

	Factor A	Factor B
Corporate Engineer (CE)	Field Tested First Cost Reliability Noise Level	Reduced Pollution Energy Savings/Protection Modernness
Plant Manager (PM)	Energy Savings/Protection Low Operation Cost Reduced Pollution Modernness	Reliability/Field Tested Modularity Noise Level

Figure 17. Comparison of Factor Structures for PE, TM, and HC

	Factor A	Factor B	Factor C
Production Engineer (PE)	Energy Savings/Protection Low Operating Cost Modernness Reduced Pollution	Modularity Noise Level	Complexity Field Tested/Reliability
Top Manager (TM)	Energy Savings/Protection Low Operating Cost Modernness Protection against power failure Reduced Pollution	Reliability/Field Tested Initial Cost Complexity	Noise Level
HVAC Consultant (HC)	Modernness Reduced Pollution Energy Savings/Protection	Field Tested/Reliability	Noise Level Initial Cost

Similarly, Figure 17 presents an interpretation of the factor solutions for the other three groups, TM, PE, and HC. The composition of the first factor indicates minor differences between these groups in terms of their first evaluation criteria (TM include protection against power failures, and HC do not place the same emphasis on low operating cost). Major differences, however, arise in the second and third factors. Production Engineers (PE), emphasize system complexity and modularity more than other groups. First cost comes out clearly as an essential element in top managers' (TM) evaluation of industrial cooling equipment.

6.5. Preference Analysis

The relevance of these differences for marketing strategy formulation can be formally assessed by linking individuals' preferences for the three alternative industrial cooling systems to their evaluation of these alternatives. For this purpose, a linear regression model was fitted with rank order preference used as the response variable and individual product evaluations (estimated individual factor scores) used as independent variables. (Hauser and Urban, 1977, suggest that least squares regression closely approximates monotonic regression for integer rank-ordered preference variables.)

The results of this analysis are summarized in Figure 18. Separate evaluation spaces were used for each group of participants. Note the following: first, rank order preference (1st, 2nd, 3rd, etc.) was the dependent variable. Thus, "the lower the better" in terms of product evaluation (i.e., a negative regression coefficient is good.) Second, the factors are *not* named because they mean different things to different groups. See Figures 16 and 17 for interpretation. Finally, since a principle axes solution was used, with a varimax rotation, the factors are orthogonal and, thus, more readily interpretable.

The results suggest important differences in the way product evaluations are related to individual preferences within each group. First, consider Corporate Engineers and Plant Managers. Corporate Engineers find reliability and first cost important, while Plant Managers find modernness, fuel savings, and low operating costs to be most significant.

The comparison of the other three groups is most interesting. Production Engineers find modernness, low operating cost, and protection against fuel rationing most important. But they seem to favor less field proven, less noisy, and less easily substitutable equipment. Production Engineers are perhaps the only individuals in the decision process who will work with this equipment directly, and seem to favor that equipment which makes their job more challenging. Top Managers also find modernness, protection and low operating cost most important, but weight reliability and initial cost heavily as well, in the expected direction. Finally, HVAC consultants do not seem concerned about modern image, low operating cost, and fuel rationing protection. Their concerns are immediate—they weigh initial cost and noise level most heavily and, secondarily, reliability and the presence of field proven components.

Hence, each of these groups not only evaluates the various alternatives differently, but links product evaluations and individual preferences differently as well. It is important to note that preference regressions were also run assuming a common evaluation space and heterogeneous preference parameters, and suggested neither the positive association with less substitutable, less proven equipment noted above for Production Engineers (PE), nor the absence of association with modernness, low operating cost, and fuel rationing protection for

Figure 18. Preference Regression Estimates

Group	Constant	Factor A Regression Coefficients	Factor B Regression Coefficients	Factor C Regression Coefficients	No. of Observations
CE	2.02	−.46	−.10	×	115
PM	2.00	−.25	−.19	×	84
PE	1.99	−.39	.27	(.09)*	66
TM	1.99	−.37	−.18	−.13	123
HC	1.99	(−.02)*	−.31	−.45	273

*not significantly different from 0 at the .10 level

HVAC consultants (HC). The derivation of the evaluation space for each category of decision participant is, then, an important step in the development of accurate and behaviorally relevant models of industrial product evaluation.

6.6. Microsegmentation

Analysis of the decision matrices from the responding companies led to the identification of four microsegments. Figure 19 gives the sizes of these microsegments as well as the key decision participants in the equipment selection phase of the decision process. Figure 20 gives a qualitative interpretation of the results of the analysis of variance run on company characteristic. Companies in Segment 4 are smaller, more satisfied with their current cooling system, and more concerned with the economical aspects of cooling. They are characterized

Figure 19. Major Microsegments of Organizations in Potential Market for Solar A/C

	Segment 1	Segment 2	Segment 3	Segment 4
Microsegment size in Potential Market	12%	31%	32%	25%
Major Decision Participants in A/C Equipment Selection Decision	Plant Managers (1.00)	Production Engineers (.94)	Production Engineers (.97)	Top Management (.85)
(Frequencies of Involvement)	HVAC Consultants (.38)	Plant Managers (.70)	HVAC Consultants (.60)	HVAC Consultants (.67)

Figure 20. Relative Characteristics of Organizations in Each Segment

	Segment 1	Segment 2	Segment 3	Segment 4
Satisfaction with current a/c system	medium high	low	medium low	high
Consequence if new a/c less economical than projected	medium high	low	medium low	high
Consequence if new a/c less reliable than projected	medium high	low	high	medium low
Company size	medium	large	large	small
Percentage of plant area requiring a/c	medium large	small	large	medium
Number of separate plants	medium large	small	large	medium small

by a more frequent involvement of managerial function, and they rely on external sources of expertise (HVAC consultants) to assist them.

Segments 1 and 3 do not differ much by size of firm, but segment 3 companies have more plants, larger cooling needs, and are more concerned with reliability of cooling than segment 1. Thus companies in Segment 3 rely on engineering functions for air conditioning assessment while Segment 1 relies on management functions.

Segment 2 groups large companies with a small number of plants. Such companies tend to have decisions made at the plant level, as indicated by the high frequency of involvement of Plant Managers and Plant Engineers.

6.7. Market Potential Assessment

Discussions with decision-makers in the industry suggested that the use of a weighted probability model to evaluate the interaction process between participant categories would be generally "acceptable." Thus, to get conditional probability of choice given feasibility, we use the equation:

$$P_G(a) = \sum_i w_i P_i(a)$$

where i = decision participant category and $P_i(a)$ = first preference for solar.

Figure 21 gives the conditional probability of group choice for each segment.

Figure 21. Microsegment Response

Segment	Size	Conditional Probability of Group Choice Given Feasibility $(P_1w_1 + P_2w_2)$
1	.12	.44 × .72 + .15 × .28 = .359
2	.31	.50 × .57 + .44 × .43 = .474
3	.32	.50 × .62 + .15 × .38 = .367
4	.25	.45 × .56 + .15 × .44 = .318

Our model suggests putting these pieces together as

Penetration = Choice level, given feasibility
× feasibility, given awareness
× awareness

For awareness, it was found that 15 percent of company people and 41 percent of HVAC consultants were aware of solar a/c.

Thus, the probability that the group will be aware is 1 − probability that no

one is aware or $1 - \Pi(1 - P(\text{aware}))$. Thus we get awareness by segment as

$$\begin{aligned}
\text{Segment 1}: &\ 1 - .85 \times .59 = .50\\
\text{Segment 2}: &\ 1 - (.85)^2 = .28\\
\text{Segment 3}: &\ 1 - .85 \times .59 = .50\\
\text{Segment 4}: &\ 1 - .85 \times .59 = .50
\end{aligned}$$

considering only the major decision-participants from Figure 19.

To develop total market response, we take feasibility = .02 and calculate likely response as .32 percent as in Figure 22. A similar calculation assuming 100 percent awareness (perhaps on the basis of a heavy media campaign) would yield an expected share of 0.77 percent.

Figure 22. Calculation of Expected Response

Segment	Size	×	Awareness	×	Feasibility	×	Group Choice	=	Response
1	.12	×	.50	×	.02	×	.359	=	.00043
2	.31	×	.28	×	.02	×	.474	=	.00082
3	.32	×	.50	×	.02	×	.367	=	.00117
4	.25	×	.50	×	.02	×	.318	=	.00080
							Response	=	.0032

Applying these numbers against projected total a/c sales gave an estimate of total solar a/c potential: $15 million in 1980 and $17.9 million in 1985.

7. USE OF THE METHODOLOGY

The methodology has important implications for the design of industrial products as well as for the development of associated communications programs.

7.1. Improving Product Design

An important problem in the development of a new industrial product is the determination of those specific features that the product should incorporate. The product acceptance portion of the methodology provides actionable information for making such decisions.

First, the analysis forces management to identify and evaluate organizational need specification dimensions. Second, the acceptance model assesses design trade-offs in terms of market potential.

The acceptance model forces industrial marketing managers to explicitly analyze product design and pricing decisions. Moreover, given data about R&D, production and distribution costs, a complementary model can optimize industrial product features within the firm's constraints.

Figure 23. Sensitivity of Market Feasibility to Changes in Design Characteristics

Base Case	Expected Life	Investment	Warranty Period	# Successes	Operating Cost	Expected Feasibility
	15	2000	24	25	7	2.00%
1	20	nc	nc	nc	nc	2.90%
2	10	nc	nc	nc	nc	1.40%
3	15	2500	nc	nc	nc	1.25%
4	15	3000	nc	nc	nc	0.76%
5	15	1500	nc	nc	nc	3.3%
6	15	2000	36	nc	nc	2.3%
7	15	2000	12	nc	nc	1.8%
8	15	2000	24	5	nc	1.9%
9	15	2000	24	100	nc	2.2%
10	15	2000	24	25	10	1.64
11	15	2000	24	25	5	2.4%

nc indicates no changes from the Base Case.

As an example, Figure 23 shows the effect of design changes on market feasibility for solar a/c. It shows the relative sensitivity of market feasibility to design feature changes one at a time. Similar analyses can be run for joint effects.

7.2. Developing and Testing Communication Programs

Industrial communication programs, including advertising and sales presentations, affect response through the awareness model and the individual evaluation models.

The analysis of individual preferences for each category of decision participant allows analysis of product positioning. For example, our analysis showed that Plant Managers were more concerned about low operating cost, additional protection offered by the system, and substitutability of its components than were Corporate Engineers. The latter category of participant on the other hand, placed considerable emphasis on the system's first cost and reliability.

Following identification of the relevant evaluation criteria for each category of participant, average product evaluations can be assessed for each product in the class investigated. Results of this analysis can be used in three different ways: to identify those attributes of the new product that are not perceived by certain categories of decision participants as management wants, so that corrective action can be taken in a product communication strategy; to develop a communication program that addresses the specific needs of each group of decision participant; and to simulate the impact of changes in communication content on the preferences of each category of individuals.

7.3. Targeting Industrial Communication Programs

The microsegmentation methodology tells what categories of decision participants are most likely to become involved in the purchase decision. By isolating microsegments of organizations, the methodology provides an accurate description of the structure of the purchasing decision process. For example, in the industrial cooling study, the four microsegments identified showed substantial differences in terms of the number of decision phases in which each category of participant is involved; the number of participant categories involved in each stage of the process; and the frequency of involvement of each category of participant in each decision phase.

This information allows development of differentiated communication strategies, targeted at those categories of individuals most influential in the various microsegments. Typically, the microsegmentation results can be used to eliminate from a communication program categories of individuals that are involved in the decision process less often than management expected; concentrate communication efforts on those categories of individuals that are involved in the purchasing process in the largest microsegments; and predict the structure of the decision process for a specific firm on the basis of its external characteristics.

In addition, as categories of decision participants differ in their level and sources of information, the microsegmentation analysis provides additional help in the selection of communication vehicles.

For example, suppose we had our choice of improving preference among only one of the four key groups of solar a/c influences. Figure 24 suggests that we get

Figure 24. Preference Sensitivity Analysis

	Change in Share with 10% Preference Improvement in Group
Plant Manager	+4.7%
HVAC Consultant	+8.1%
Production Engineer	+5.3%
Top Manager	+4.0%

the most leverage by addressing HVAC consultants, as a 10 percent preference improvement among that group leads to a relative projected share increase of 8.1 percent vs. 5.3 percent for production engineers, the next highest group.

7.4. Cost/Value of Implementation

By now, the managerial reader (if not thoroughly exhausted) is certainly convinced that the procedure is too complicated and expensive for him. The same argument was made at the introduction of pre-test-market simulators in the packaged goods area a few years ago. Use of these procedures is now a well-established, standard practice.

The procedure is complex. But organizational purchasing is complex—simple procedures bypass the very richness of that process that makes industrial marketing challenging! But the procedure is conceptually simple (see Figure 1). It is based on breaking down the purchasing process into steps that are readily model-able and measurable, constructing the appropriate measurements and consistently and accurately analyzing the results.

The time and cost considerations for implementation vary, depending primarily on the number and distribution of potential customers. Personal administration of the survey instrument will cut down non-response bias and develop data with generally more integrity. However, if a manufacturer has 50 customers, one in each state, travel costs are going to be enormous.

If we assume that customers can be found in two or three relatively concentrated areas, the total cost to perform this analysis (at this writing), would be in the \$30–\$60 K range. It would also take 10 to 15 weeks from conception to reporting (assuming the software was already operational).

A lot of money to study the market potential for a new industrial product? Maybe and maybe not. A company we know had no other way to study the market potential for a new industrial product than to build a prototype. It cost \$800,000. It was a dud. It was also a preventable loss, given prior application of the procedure proposed here.

8. CONCLUSIONS

The methodology described here provides some powerful new procedures to support the marketing of new industrial products. It explicitly addresses issues of product feasibility, individual preference formation, and organizational decision-making. It provides a new framework to operationalize the concept of the buying center.

A set of measurements provide input to each model component. The methodology provides tools to measure involvement in the purchasing decision process and uses this information to abstract microsegments of organizations homogeneous in decision-making structure.

To date, the procedure has been used to: develop a market introduction plan for an industrial air conditioning system powered by solar energy; design an "intelligent" computer terminal and develop a supporting communication program; and evaluate the market for or support the introduction of thermic diode solar panels, photovoltaic systems, and copier systems.

Some of the submodels are still being improved, as are some of the measurement tools. We are currently working on extensions and generalizations of the

feasibility models that will combine the benefits of the probability and logit models. We are also incorporating a time dimension with a manufacturing experience curve component, to allow evaluation of product potential sales over time.

The general structure, however, is currently operational and can produce much-needed information for better industrial marketing decisions for new products. As such, the model and associated measurements should be viewed as a first, but important, step in the development of better tools for industrial marketing.

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