FUNCTIONALLY INTEGRATING NEW PRODUCT DEVELOPMENT

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Abstract

This thesis investigates the process of integrating new product development across all contributing functional areas: marketing, planning, engineering/design, and manufacturing. The hypothesis is that integrating new product development across functions will decrease new product time and cost to commercialization, while also developing better products, compared to more sequential processes. This study of managing new product development processes has used Quality Function Deployment, QFD, as an example of a formal, integrating new product development process.

I addressed this topic through three related research efforts.

One major scientific goal of this thesis is to synthesize marketing, engineering, and management of technology new product development research. The field research techniques of retrospective interviewing and participant observation have been used to synthesize these three diverse approaches to the subject in a qualitative and exploratory study of new product development projects. Through these qualitative techniques, I constructed an in-depth understanding about the functioning, implementation, and success drivers for an integrated new product development process. A framework was developed for comparing outcomes across projects, companies, and industries. Data from 35 projects in 9 companies were gathered and analyzed for success and failure.

Previous research has shown that increased new product success correlates with higher levels of cross-functional communication. A pilot study of how different new product development processes alter communication between the functions involved in new product development obtained results for a paired comparison test of QFD versus non-QFD new product projects of comparable technical complexity.

A marketing methods study investigated an interesting issue identified from early findings in the field research. QFD new product development projects often generate many more customer attributes - frequently on the order of 150 - than the 20-30 that traditional marketing research techniques are called upon to analyze. Methods for generating large numbers of detailed attributes and structuring them into hierarchies were refined and tested in field experiments on a low cost durable product. Several means for assigning importances to customer requirements were also tested to determine whether one is most appropriate for assigning importance values for the general marketing situation when large numbers of customer attributes are used.

IN MEMORY

Vera Pearce

and

Susan Pearce Griffin

To two women who gave their daughters the independence needed to make their own lives, and supported their choices.

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FUNCTIONALLY INTEGRATING NEW PRODUCT DEVELOPMENT

TABLE OF CONTENTS

FUNCTIONALLY INTEGRATING NEW PRODUCT DEVELOPMENT

CHAPTER 1. INTRODUCTION AND BACKGROUND

A. The Problem - Improving US New Product Development

The major research question this thesis addresses is:

> How can management consistently and repeatedly develop profitable, easily manufactured, high quality products that effectively meet customer needs and move those products to market quickly, efficiently, and without complications?

In his study of US competitiveness, Scott (1985) concluded that the US has a serious competitiveness problem which is manifested in part by declining market shares, profitability, and manufacturing incomes for most major industrial sectors. Competitiveness consists of the ability to convert new technology into the products desired by the market-place and manufacture those products less expensively and more reliably. Pessemier (1986) estimates that between 10% and 20% of all current corporate revenue is derived from relatively recent (less than four years old) market entries. In industries that depend on new products for significant amounts (50% or more) of their total sales, like aerospace products, semiconductors, and microelectronics, the ability to develop new products which meld leading-edge technology to market needs in a timely and efficient manner is crucial to the long-term success of a company.

A 1987 Department of Defense Task Force on the Industrial Base Initiative concluded that foreign firms take products and processes from R&D into production more effectively than many US firms. These firms are more effective, according to the Task Force, because they

use multidisciplinary (R&D, design, manufacturing, sales, etc.)

> teams to ensure that producibility, quality and serviceability considerations dominate the design process, so that designs are tailored to fit processes and there are few surprises when product designs go to manufacturing engineers or when products are offered to the market. (Kimzey, 1987)

In contrast, US firms

> do 'over-the-wall' design (ie design engineers rarely if ever, communicate with manufacturing engineers, marketing personnel, etc.), with expectable results in terms of producibility and market appeal. (Kimzey, 1987)

The Task Force also concluded that foreign firms (particularly the Japanese) understand better than US firms "that the new global market is one of short product life cycles and short concept-to-delivery times" (Kimzey, 1987).

This thesis investigates the process of new product development in US companies. In the simplest sense, successful new product development requires a firm to successfully complete three tasks: identify the needs of a target customer group, develop a competitively advantaged product to meet those needs, and bring that product to market in a timely and efficient fashion. In order to stay in business in the long term, that product must also provide a profit to the company. Many companies have successfully commercialized products providing enormous economic returns.

However, just because a company has profitably commercialized one successful product does not mean they will be able to repeat the feat at a later date. All three tasks must be completed for a successful new product. If a firm fails to do any one of them well, the new product will likely fail in the marketplace.

In many companies, the responsibilities for these different tasks are partitioned across the functional disciplines (Hayes, et al., 1988). Marketing personnel concentrate on the customer needs portion of new product development and engineering and design personnel concentrate on developing competitively advantaged products. Responsibility for shepherding the project to commercial success falls to a project or brand manager who may not belong to either the marketing or engineering groups. Product development tasks are performed in the functional group best trained to do them, then the project is passed on to the next group of functional specialists.

The study of new product development has also been partitioned across disciplines. Marketing academics have researched the aspects of new product development associated with the customer. Engineering design has investigated better ways to design and produce products. Management of technology has correlated product success with various project factors.

The goal of this thesis is to gain an in-depth understanding of the complete process of new product development across companies and product development project types. This thesis builds on previous research by taking a cross-functional approach to new product development. It looks beyond the functional aspects of new product development to the whole process. Some authors (Takeuchi and Nonake, 1986, and Hayes, et al., 1988) have offered evidence that treating new product development as a holistic process, instead of in a somewhat disjointed functionally oriented series of steps, produces products successful in the marketplace. This thesis investigates that suggestion, trying to identify whether a particular process which is purported to integrate across functions does improve new product development performances, and if so, what it is about that process that seems to be leading to success. From the understanding developed through this thesis work, I hope in the future to be able to suggest process charatceristics, and guidelines for implementing and managing them, that improve the success rate and efficiency of new product development.

B. Current Functional Approaches to New Product Development

Extensive research on product development has been done in marketing and engineering as well as in the management of technology, although no one seems to have integrated across the findings of the three fields. Marketing research has focused on the customer; determining how he thinks about the product space, what he wants in a product, testing whether the current design and marketing platform match his expectations, and forecasting sales of the new product. Engineering research has focused on delivering "the best design," and more recently, delivering the best compromise between design and manufacturability. The next two sections review some of this research, followed by a section covering the management of technology project success findings.

B.1. Marketing Approaches to New Product Development

From marketing's perspective, customers buy products and services that satisfy their perceived needs. As discussed in Urban and Hauser (1980), customers form perceptions, and therefrom preferences, about products based on the product's features and the marketing and communications strategy a company adopts. Marketing researchers have developed a family of progressively more sophisticated techniques which provide increasingly detailed levels of information about customers and their reactions as development proceeds and product concepts solidify. Specific research has been done to:

- Ascertain what relevant attributes drive product perceptions and preferences through focus groups (Calder, 1977), the Echo Method (Barthol and Bridge; 1968), Repertory Grid (Frost and Braine, 1967), and in-depth interviews covering potential use situations (Hustad et al., 1975).

- Model the perceptual product space using direct measurements of attribute levels (Rao and Soutar, 1975), multiple discriminant analysis (Hustad, et al., 1975; Pessemier, 1975), similarity scaling (Green and Rao, 1972) or factor analysis (Urban, 1975; Hauser and Urban, 1977).

- Link perceptions to product preferences using expectancy value models (Wilkie and Pessemier, 1973) or preference regression (Green, 1975).

• Link features to perceptions and/or preferences (Green and Srinivasan, 1978; Lynch, 1985).

• Model individual or segment decision-making. Green and Srinivasan (1978) review the main methods developed.

• Search for new product concepts (Shocker and Srinivasan, 1974) using heuristics (Pessemier, 1975; Johnson, 1971), or subjective methods (Urban, 1975).

• Optimize various product attributes using complex cptimization programs such as POSSE (Green et al., 1981; Gavish et al., 1983).

• Test customer reactions to the product and construct volume forecasts in test markets (Narasimhan and Sen, 1981; Dodson, 1981) or through pre-test market models (Robinson, 1981; Silk and Urban, 1978).

The relationships between these aspects of marketing research and the

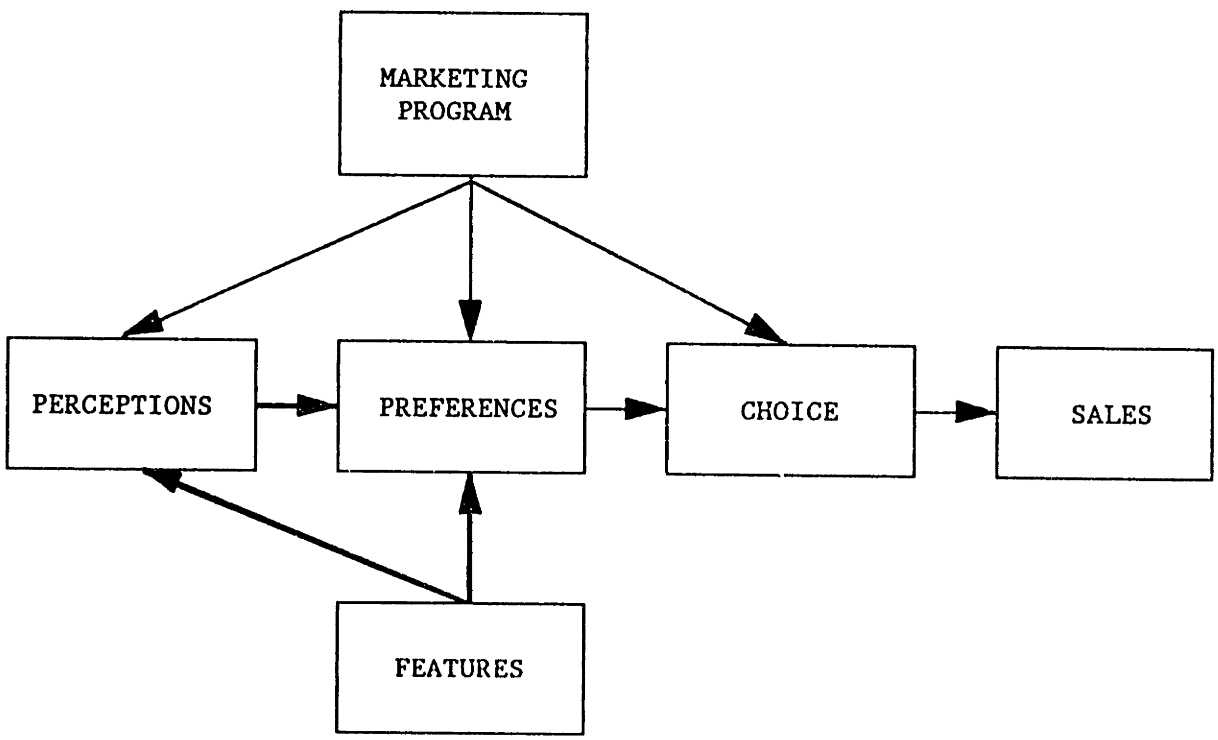


Figure 1.1 The Relationships Between Marketing Research and Sales

objective of new product development, increased sales, is illustrated in Figure 1.1, a modified version of the LENS model from Tybout and Hauser (1981) and Karash (1983).

Emphasis on the technological aspects of new product development varies by new product development text author, but in all, very little information is presented about how to meld technical development with the marketing aspects. Urban and Hauser (1980) deal with new product development primarily from a tactical level, covering the analytical marketing techniques for successful new product development. They indicate what tasks are engineering's responsibility, what outputs are required from engineering during each aspect of new product development, and where marketing and technical personnel should work together closely in the new product development process. They do not offer any tools to aid the engineers in their task or help the two groups work together, but do indicate that getting engineering and marketing to work together may be difficult to manage.

Pessemier (1986) treats new product development more strategically. He presents a much richer flavor of the interdependence between marketing and technology development in achieving new product success and gives a stronger indication of the importance of melding technology capabilities with market needs. However, he too does not fully address the day-to-day managerial aspects of trying to get engineering to actually put together the product that the customer wants.

Both authors acknowledge the importance of engineering inputs in generating new revenue opportunities, designing and testing the physical product, and manufacturing the product. Neither author explicitly deals with the difficulties encountered in obtaining those needed inputs from engineering in a timely, efficient, and understandable manner.

B.2. Engineering Approaches to New Product Development

Engineers design products, and the processes to produce them, to meet specifications or deliver features requested by marketing or management, or to match their own knowledge of customer needs. Engineering product development research has emphasized improving the product design process, designing for increased quality, and integrating across product design and manufacturing design.

Several formal methods for improving product designs have been developed. In Pugh Concept Selection teams generate a large number of concepts for consideration, then systematically identify the best concept from a group meeting a particular set of design criteria (Pugh, 1978; Clausing, 1986). Several different methods for optimizing engineering product performance also have been developed (Phadke, 1987; Clausing, 1987). Value trees and value engineering are being used to arrive at the lowest cost design to deliver a particular functionality (Clausing, 1986).

Quality improvements are being sought structurally through two techniques. FMEA (Failure Mode, Effect and Criticality Analysis), sometimes called Fault Tree Analysis, is used to forecast and eliminate potential product failure areas (Hammer, 1972). Engineers are also using Taguchi Methods to stabilize product and process performance to environmental and processing changes (Taguchi, 1986; Barker, 1986; Sullivan, 1987; Box, et al., 1988).

Several protocols are currently being developed and used to try to improve the integration between design and manufacturing. Simultaneous engineering proponents argue that by engineering the design and manufacturing process at the same time using one team, the total time to commercialization can be collapsed because iterations through some steps are eliminated (Vasilash, 1987). Hayes, et al., (1988) provide some arguments that suggest that moving from a phased to an overlapping approach to engineering problem-solving between the design functions with early and continuous release of preliminary information will also decrease commercialization time by eliminating iterations in the process. Boothroyd and Dewhurst (1988) and Stoll (1988) see Design for Manufacture (DFM) and Design for Assembly (DFA) as means for achieving lowest-cost and easiest to manufacture designs. They use computer tools and simulations extensively for improving quality and capturing previous learning.

Each of the new engineering techniques assumes that "someone else" is responsible for determining what the customer wants and translating those wants into product features, functions, or specifications. Because mechanisms for direct input of the relative importance of customer "wants" seem to be missing, the techniques described above may actually encourage engineering groups to subordinate customer desires to rational-logical "scientific" product-manufacturing optimization. This may allow tradeoffs between customer desires and engineering and manufacturing needs to be made from an engineering or tactical point of view, not a strategic one.

B.3. Management of Technology Product Development Research

Management of technology researchers have correlated better relationships between and balanced inputs across marketing and technology with higher new product development success rates. Cooper (1983) studied 58 industrial new product development case histories. Market-oriented activities dominated 49% of the projects in his sample and technology activities dominated 39%, while he classified only 12% as balanced, complete processes. However, these seven balanced projects had the highest rate of commercial successes. While the sample size is small, this research suggests that a mechanism which integrates and balances marketing and technology inputs into the product development process might help improve firm performance.

Some of Souder's early research (1978) indicated that strong and positive relationships between R&D and marketing organizations significantly improve a company's track record on new product introductions. In a long term research program refining his earlier findings, Souder (1988) demonstrated that product success and failure strongly correlate with the level of harmony (disharmony) between the R&D and marketing groups. While 68% of the 112 projects exhibiting severe disharmony between R&D and marketing were failures, only 13% of the 118 projects exhibiting harmonious relationships between the two groups were failures. The project success rate went from 11% for projects with severe disharmony to 52% for projects with harmony between the two groups. These relationships are significant at greater than a 99.9% confidence level.

A missing link in the literature seems to be trying to construct techniques to improve the relationships and demonstrating that using these techniques 1) improves the relationships and/or balance and therefore 2) improves new product success.

C. The Need for Integration in New Product Development

Clearly, extensive research on improving various aspects of new product development has been done in both marketing and engineering. However, the sophisticated new product development tools at each group's disposal are almost unknown to the other functional group. Engineering may have no idea, nor may it trust, how marketing arrived at a design concept or how much customer research went into developing that concept. Engineering may also not understand why functions, features, or specifications should not change if manufacturing needs dictate. And marketing may not perceive that engineering's design and manufacturing expertise may in fact help improve the product offering.

One can extend the LENS model to illustrate the affects engineering and manufacturing have on new product development in performance-intensive in-

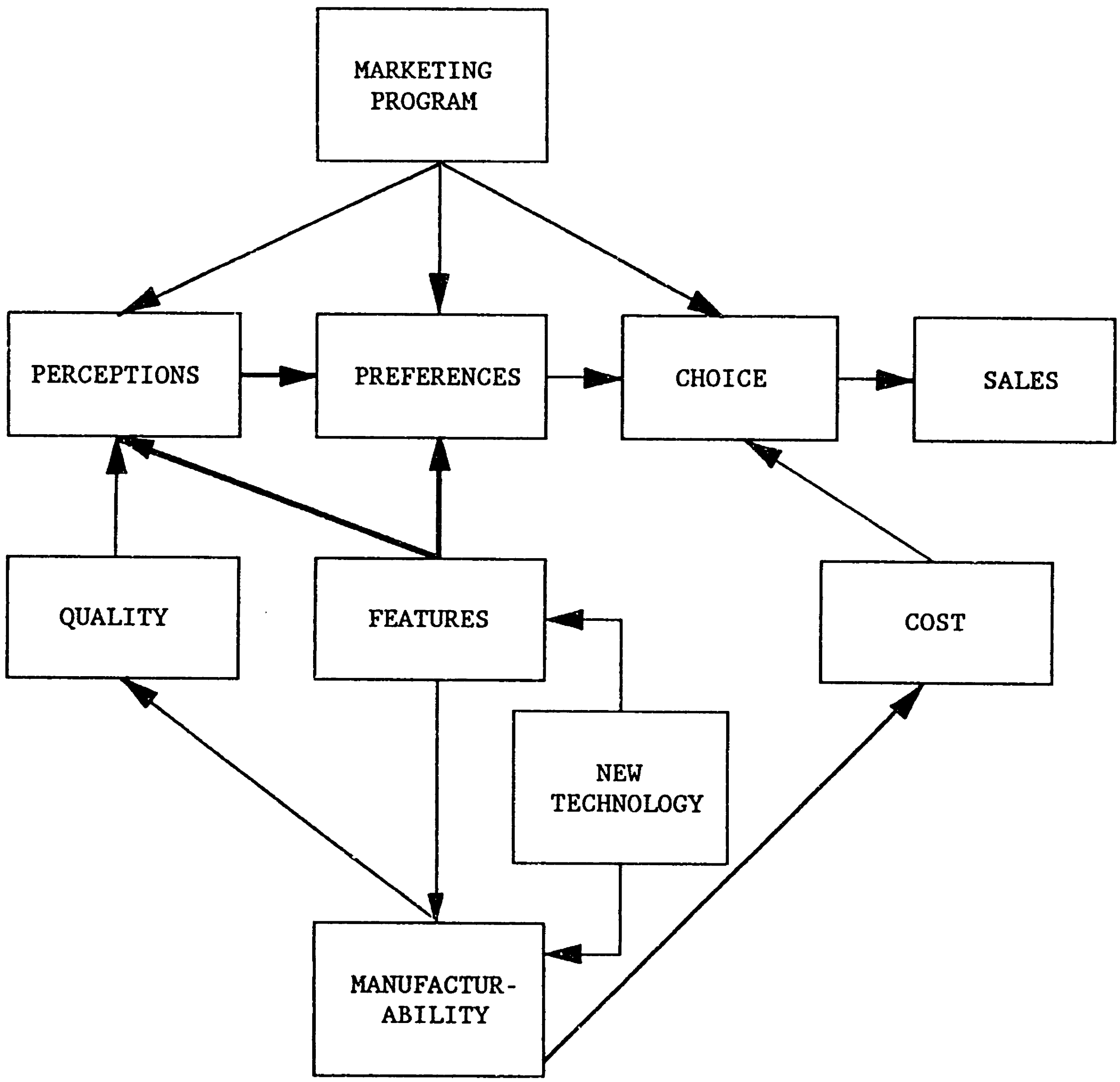


Figure 1.2 The Impacts Engineering and Manufacturing on Products

dustries (Figure 1.2). Technology impacts customers by enhancing product features and affecting manufacturability. Features affect perceptions and preferences both directly and also indirectly through manufacturability via product quality[1] and cost. The engineering and manufacturing aspects of new product development do impact perceptions, preferences, and ultimately, sales and profits generated by the new products developed. To leave their effects out of an investigation of new product development ignores a major part of the complexity of the process, especially for performance-intensive products.

In product lines where relatively more money is spent on advertising and marketing a product than on developing it, focusing on and concentrating resources on understanding customers and developing the product marketing platform may make economic sense. However, advertising and R&D spending varies as a percentage of sales by industry, as shown in Table 1-1. In industries like computers and chemicals, product development requires as much, or more, investment than advertising and marketing.

Table 1-1. R&D and Advertising Investments in Some Industries

INDUSTRY	R&D INVESTMENT % of Sales	ADVERTISING INVESTMENT % of Sales
Personal Care	1-3 %	15-20 %
Food and Beverage	<1 %	5-10 %
Drugs	7-9 %	10-15 %
Autos	3-4 %	<2 %
Computers	9-13 %	<2 %
Chemicals	3-5 %	<1 %
Telecommunications	4-6 %	<1 %

Sources: Siwolop (1987), Ray (1982), annual reports

Understanding the customer and developing the marketing platform is key to new product success in perception-intensive industries like food and beverage and personal care. In more performance-intensive industries like automobiles and computers, where R&D spending is actually higher than advertising spending, understanding the customer is still critical to success.

[1] At this point, we still need to understand "quality" and much of the role it plays in impacting customer preference as well as how designing "quality" into new products up front affects the new product development process.

However, in these industries it is also important to understand how technology affects customers, how customer needs translate into (manufacturable) features, and how to get the right features into the product at the right point in time. These industries may require a much more integrated approach to new product development to ensure more routine success for the new products developed. The work of Hayes, et al., (1988) identifies a "conventional paradigm" for new product development that is sequential and disjoint in nature. The results of the conventional paradigm, according to them, are products with long development cycles and many iterations through various process phases. They propose an "overlapping," more integrated process as the solution.

Another aspect of new product development which suggests integration may be beneficial is the need to resolve engineering and customer tradeoffs. There seem to be few, if any, mechanisms presented in the literature for resolving tradeoffs between meeting customer desires and the needs of manufacturing in specifying final product features for those industries with a heavy investment in the development aspects of new product development. This can frequently result in misunderstandings between the two departments, which, according to Souder (1988), ultimately can lead to disharmony and/or dominance of the product development process by one or the other of the groups. In turn, disharmony and process dominance can in turn lead to poorer new product performance.

The work of Gupta, et al. (1985a) identified a total of 19 task areas that industry managers feel need to be integrated across R&D and marketing for successful new product development. R&D and marketing managers in technology-based companies believe that the five most important areas for integration are (1) providing marketing information to R&D on customer requirements, (2) customer feedback on product performance, (3) customer feedback on competitors' strategies, (4) involving marketing in setting new product goals and priorities in R&D, and (5) getting R&D to develop products according to market needs.

Gupta, et al. (1985a) also found that both R&D and marketing managers are dissatisfied with the current level of integration between the two groups. Marketing managers actively want to be more involved in the up-front activities of new product development - establishing new product goals and priorities and development schedules. They also want to have more input into how current products should be modified to better meet the markets' needs. R&D is most dissatisfied with the level of information sharing with marketing on such things as customer requirements for new products, test market results, and competitors' moves and product strategies - the very areas considered most important for integrating across.

The findings of Cooper (1983), Souder (1978, 1988), Dougherty (1987), and Gupta, et al. (1985a) suggest that corporations might want to try to balance market and technology inputs to new product development, integrate across functions involved in new product development, and provide a means for improving the communication and harmony between the groups doing new product development. The research of Gupta, et al., (1985a) also suggests that both groups might be receptive to approaches which improve the integration across the boundaries.

D. Potential Effects of Integrating New Product Development

The most desired effect of integrating new product development across thefunctions is an improved new product development process which decreases time and cost to development and improves product quality and customer satisfaction. From the literature, improvements in two specific aspect of the process may be used as indicators that the overall process is going to be better, before the cycle is completed.

One of the aspects contributing to harmony (and therefore product success) in Souder's work was communication. Dougherty (1987) also observed that cross-functional communication (getting marketing, engineering, manufacturing and planning to talk to each other) may correlate with product success in new product development. In products classified as unsuccessful in her study, one or more development functions lacked information of one or more major types: user, product design and technology, market, or strategy and planning. All functional areas of the teams producing successful products consistently held high levels of all types of information.

Producing better communication therefore becomes a major potential opportunity for improvement by integrating new product development across marketing and engineering. Marketing data on customer needs are most frequently generated by marketing, sales, and market research staffs. However, the data are needed by engineers. Without customer need information, engineers may develop a product that is mismatched to the needs of the market.

A second possible improvement in new product development performance results by integrating across the technology and marketing groups arises because they operate most naturally at different levels of detail. Integration can help balance the level of detail communicated across the boundary.

Hauser and Koppelman (1979) suggest that nearly as much marketing information is contained in the perceptual dimensions of factor-analyzed product space as it is in the actual attributes used to determine the dimensions. It is easier to visualize a product's position or analyze market data using only two or three dimensions than using larger numbers of attributes. Marketing thus tends to work with as few attributes as possible (Wilkie and Pessemier, 1973). Reduced attribute sets can be achieved by working at the somewhat abstract level of product dimensions obtained from factor analysis; frequently "ease of use" and "works well." Other researchers such as Hansen (1969) and Wilkie and Weinreich (1972) reduce the attribute set to only those that are "salient" or most important.

Engineers, on the other hand, operate at the detail level of specifications and features. They usually have several technical options for delivering an easier to use or better performing product. However, each technical choice involves making tradeoffs between the levels of other benefits delivered. If they are to use marketing information to drive directly a new product design, engineers require marketing information that is very detailed in its content. To be most useful to engineers, marketing information should be directly "actionable" into unambiguous product features or specifications.

Dougherty's (1987) research indicated that 77% of the people from successful new product development teams thought that the marketing research inputs to their project were not adequate. Trying to provide engineers with this detailed marketing information presents a challenge for marketing personnel more used to working at the aggregate level. Explicitly integrating across the marketing and R&D interface is likely to improve new product success rates when the integrating mechanisms provide the right kind of information to each group at the right level of detail.

E. Judging the Outcomes of Integrating New Product Development

Before looking at how integration can be improved, the measurements against which improvements will be judged must be defined. In their research studying the organizational fit of firms to their environments and the association of fit with overall firm performance, Lawrence and Lorsch (1967) developed a definition of integration that fits the needs of this investigation and conveys an appropriate flavor of the concept. They define integration as

> ... the quality of the state of collaboration that exists among departments that are required to achieve a unity of effort by the demands of the environment. (Lawrence and Lorsch, 1967, p. 11)

To use this definition "quality of collaboration" must be operationalized to one or more measurable variables. Lawrence and Lorsch operationalized this construct using a single perceptual question in their survey that asked respondents to provide judgments "about relationships between different parts of the organization." Respondents indicated how good relationships were using a 7-point scale ranging from "sound - full unity of effort is achieved" to "couldn't be worse - bad relations - serious problems exist which are not being solved." Souder (1978, 1988) also used self-explicated judgments by members on the "harmony" between groups.

Cooper (1983), on the other hand, operationalized integration as the "balance" between the involved functions. Gupta, et al., (1985a) and Dougherty (1987) related communication amount and type variables to new product success, looking at aspects more behavioral than attitudinal.

Measurements of attitudes or perceptions about relationships ("quality" or "harmony"), particularly self-stated ones, have two associated problems. First, attitudinal evaluation is subject to individual interpretation. What is "awful" to one person may be only "average" to another. Second, even though two groups get along famously, if there is no interaction between them, there is no "collaboration" in the "quality of the state of collaboration" construct. Two groups can't be integrated if they do not interact.

On the other hand, personnel from two groups may interact frequently and still not work as an integrated team. This can occur if the relationship between them is destructive, not constructive, in nature.

Therefore, a good operationalization of the construct "integration" should include both attitudinal and behavioral aspects of the relationships and the amount of interaction between groups that are to work as an integrated team. To provide convergent validity for the attitudinal measures it would be best to try to develop a more non-subjective measure to be used in conjunction with the easily-measured self-perceptions.

Any investigation of a process to improve the integration between two groups should therefore use at least three criteria against which to judge the success of the integrating mechanisms. The first criterion is whether or not (or how much) the quality of the relationships between the groups is improved <u>and</u> the quantity of interaction is maintained or increased by the integrating mechanism. These variables are direct measures of improvement in integration, but only indirect measures of improvement of new product development. A number of researchers have previously correlated these measures to higher levels of new product development, but causality has not been shown. Nor is it known how large the changes in the integration variables must be to produce visible effects in improving new product development. However, to meet the first criteria, integrating mechanisms should be sought which balance marketing and R&D inputs, or improve the communication, harmony, or the quality of relationships between marketing and R&D.

A second criterion to judge integrating mechanisms by is their potential ability to improve directly either the new product development process or the success of the product outputs from the process. Improvements in the product development process could be operationalized as shortening time to market, decreasing cost of commercialization and number of engineering change orders, increased initial levels of quality, and faster ramp-up to full production. Improved products could be operationalized as more successful in terms of higher sales, profits, or market shares, or higher levels of preference or perceived performance.

The problem with these direct variables is determining with what to compare this product's measures. Is it more appropriate to compare them to the same measures for your company's last generation of this product? To "industry averages" in the product area? To the averages of the last 15, 25 or 50 new products your company produced? While this group of variables directly reflects the changes we want to see occur from an integrating mechanism, there are enormous problems in obtaining believable data that has not been contaminated by other factors.

Even though improvements in products and process characteristics may be hard to measure, integrating mechanisms should be sought which, on the surface at least, have the potential to decrease time to market, engineering change orders, cost to commercialization, etc. They should explicitly address some or all of these goals.

A third way to judge the potential value of integrating mechanisms could be by how well they might work to decrease some of the most important barriers to integration. The research of Gupta, et al. (1985b) indicates that four problems comprise about three-quarters of the stated barriers to integration between R&D and marketing. The largest barrier to achieving integration between R&D and marketing is lack of communication between the two groups. This is followed by an insensitivity to each other's capabilities and perspective, lack of senior management support for integrating across the two functions, and personality and cultural differences between the two groups. Integrating approaches specifically designed to overcome these barriers should therefore be sought.

The qualitative or field research portion of this thesis (explained in section 1.H) looks primarily for measurable improvements in the outputs of new product development: decreased time, cost, increased sales, and products that better satisfy customers. The communication study judges process performance based on differences in interaction levels.

F. Integrating Approaches to New Product Development

While the above research indicates that improved cross-functional relationships are important and that there is a positive relationship between probability of project success and improved relationships, only recent research documents how to make those improvements - how to integrate better across functions. According to Roberts (1987), the best way to achieve the needed positive relationships between R&D and marketing is to "weld partnerships among equals." Naturally, this suggests that one should investigate how a corporation could accomplish Roberts' goals.

Shapiro (1987) posits that corporations can develop internal functional coordination through four general means:

- changing organizational structure
- implementing formal management processes such as reward systems and planning processes
- encouraging informal social systems between the functions
- hiring and cross-functionally training very competent people.

One set of authors has investigated organizational means to improving integration using two case studies. Two other groups of researchers have recommended new management processes for new product development.

As far back as 1965, Lorsch and Lawrence advocated the need for collaborative mechanisms between marketing (called "sales" in those days), research, and production in new product development, while still providing the organizational structures which are conducive to specialist task performance. The authors advocated two organizational fixes to the problem; coordinating committees whose members have a balanced point of view which enables them to work effectively across several specialist groups and cross-functional coordinating committees, where problems are resolved across all the functional groups simultaneously. One might expect that implementing these organizational fixes could signal management's support for increased integration across R&D and marketing. The cross-functional coordinating committee might also inherently increase communication, input balance, and sensitivity to capabilities. In the two case studies reported the results were mixed. The integrating mechanisms had more success in one company than it did in the other company, suggesting that there are aspects about the corporation or its operating environment that might impact the success of one particular integrating mechanism across corporations with different characteristics, or operating in different environments.

Based on years of research in several different industries, Hayes et al., (1988) advocate substituting a new product development paradigm for the sequential and disjoint conventional new product development paradigm they have found in many of the firms they have worked in. Some characteristics of the new paradigm they advocate are:

- cross-functional team led by an experienced business manager
- extensive overlapping of project phases and problem solving with early release of preliminary information to all functional groups
- stable team throughout the whole project
- progress by task completions, not time progression

- cross-functional relationships based on trust and mutual respect, with conflicts addressed early and at low levels.

The first two characteristics are aimed at improving the communication and reducing several barriers to integration. The stable team should capture some of the learning during the project. The last of the characteristics is also aimed at reducing some of the major barriers to integration. If ways can be found to implement this "new paradigm" in firms, some of its characteristics do look as if they should be able to improve integration. Unfortunately, if I had to try to install these characteristics in my firm, I am not sure how I would go about it.

A third set of authors, Takeuchi and Nonake (1986), recommend what they refer to as a "holistic" process for improving new product development, based on the market success of products in six Japanese product case studies. Much like Hayes, et al., the approach they recommend is essentially an integrated approach which operates simultaneously across development phases instead of sequentially. Six commercially successful new products were identified and the processes by which they were developed were documented and analyzed after the fact. Although the authors list six characteristics which indicate that the process used is a holistic process, they don't describe how one might achieve a holistic process. Furthermore, all six projects are case studies from Japanese firms. It is not clear whether a successful process for Japanese-style firms will be equally as successful for American-based firms, which have very different operating styles (Abegglan and Stalk, 1985).

There are many possible ways to try to achieve integrations. Researchers can also identify specific characteristics that suggest that a process has indeed integrated across functions. What they do not seem to know is which of a myriad of potential solutions best fits into a particular new product development situation. This research will look at one new product development process applied across a number of different project situations and try to infer what kinds of process characteristics work in different situations.

G. Quality Function Deployment as an Integrating Approach

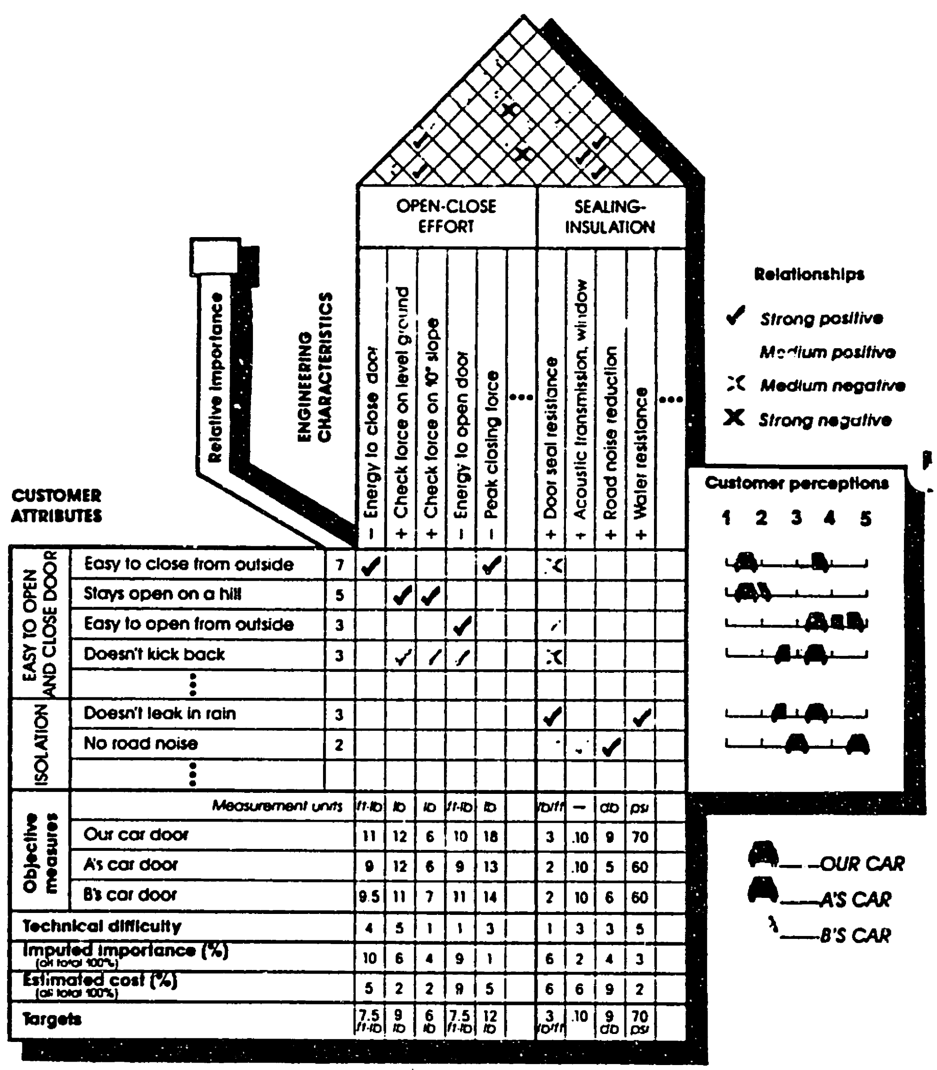
Academics are beginning to advocate integrating new product development across functional areas, approaching the process quite differently than it has been done traditionally. Some firms also understand that integrating new product development across one or more functions is one way to improve the process and its outputs. Some are trying one or more new approaches to try and improve new product development integration. One of the new approaches being implemented at a number of US companies is a new product development process called Quality Function Deployment, or QFD for short.

Quality Function Deployment is a clearly described, formal new product development process which purports to integrate new product development across all the involved functional areas (Sullivan, 1986). Pioneered by the Japanese and now implemented by more than 25 U.S. firms, users claim it can be used either to improve already-existing products or develop entirely new products (Kogure and Akao, 1983). Japanese users claim that it improves product development performance, reducing costs and time to market by as much as 40% (Eureka, 1987; Sullivan, 1986 and 1987).

According to Eureka (1987), QFD teams iteratively and simultaneously translate from customer desires through product attributes, part specifications, process requirements, and into process step specifications. The team consists of personnel from all functions involved in new product commercialization. Process development and manufacturing people are involved from project initiation, and marketing is involved through production aspects.

QFD, developed primarily by engineers, starts by constructing a "House of Quality," which deploys the "Voice of the Customer" into product attributes. The attributes in this "Voice," the qualitatively expressed customer desires, are judgmentally grouped into related hierarchies, then translated by the team into measurable (quantifiable) engineering attributes, or substitute quality characteristics. The degree to which each engineering at-

House of quality



HARVARD BUSINESS REVIEW May-June 1988

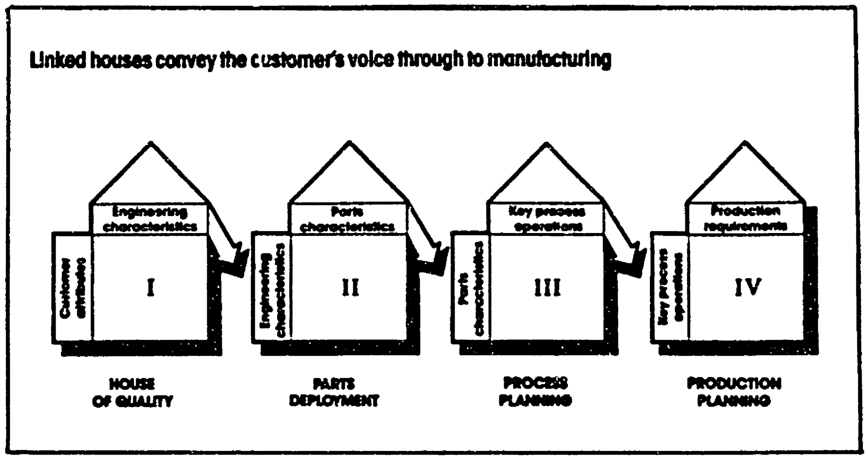
Figure 1.3 House of Quality Example for a Car Door tribute affects each customer desire is qualitatively recorded in the body, or "Relationship Matrix" of the House, while interactions between engineering attributes are qualitatively recorded in the roof section, the "Correlation Matrix." Also recorded are the competitive product relative positions for each customer and engineering attribute, as well as the strategic new product targets. Figure 1.3 is a House of Quality example for car doors.

In constructing the House of Quality engineers are asking marketing to help them develop three-tiered (or higher) hierarchical structures of customer requirements for proposed new products. The integrated new product development teams in this study are generally working with many detailed customer requirements, frequently over 150, organized into three to seven primary and 15 to 20 secondary groups within the primary groupings. They also need to know the relative importances of the most detailed level (the tertiary level) of requirements. Since the team will use these detailed requirements to directly drive the new product design, it is crucial that the values of importance assigned accurately reflect customers' feelings.

A second QFD document deploys engineering attributes into parts requirements. Cost, quality, and function are optimized at this level, under-standing that these functions all translate directly back to customer desires.

A third document deploys part characteristics into key process operations, while the final document translates these key process operations into production requirements. Figure 1.4 schematically presents the deployment process. Figure 1.5 provides a deployment example for closing a car door.

In 1978 Toyota adopted QFD. Much of QFD's US acclaim comes from write-ups of Toyota's success (Eureka, 1987). Toyota claims that QFD virtually eliminated all warrantee problems associated with rust. It also allowed them to substantially decrease start-up costs, engineering change orders



Source: Adapted from a figure supplied by the American Supplier Institute Inc. Dearborn Michigan

Figure 1.4 Schematic Representation of the QFD Deployment Process

processed and the number of product complaints.

QFD moved into the US in 1983, into both Ford and Fuji-Xerox. Since

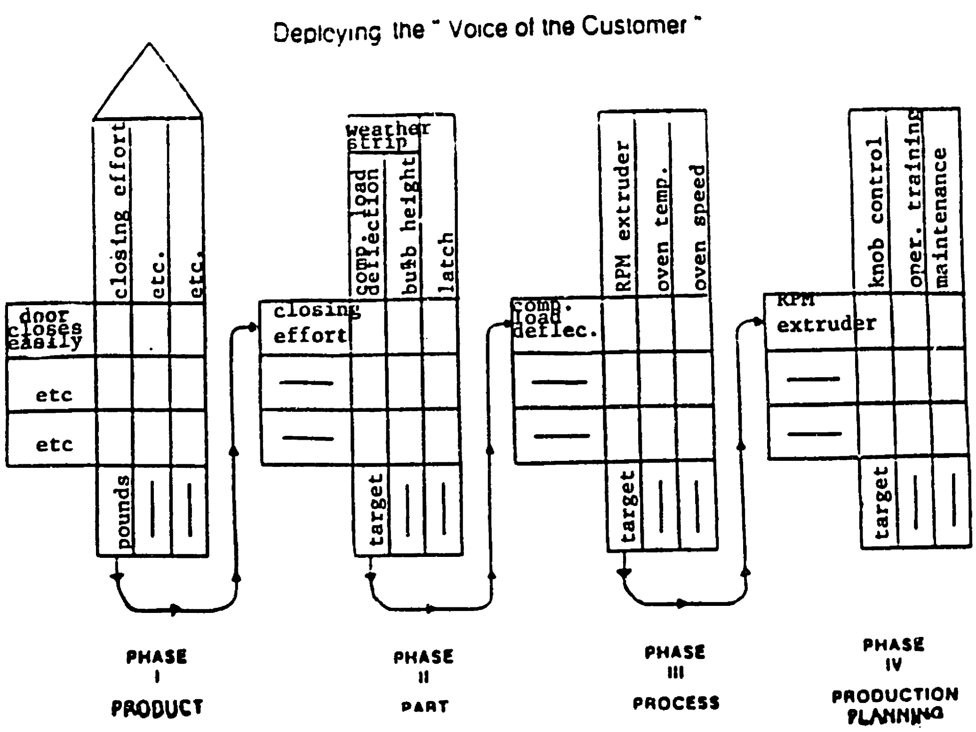


Figure 1.5 QFD Deployment Example for Closing a Car Door

then some two dozen other firms including Cummins Engine, Digital Equipment Corporation, General Motors, Hewlett-Packard, Procter & Gamble, and Polaroid, have moved to adopt QFD.

Most interesting about QFD is that it is an industry-initiated movement, without much academic research to either 1) define what it is and how it works, or 2) work to improve either parts of all of it. Although Toyota's results are widely publicized, they seem to be the only published outcomes.

H. The Proposed Research

The major hypothesis of this thesis is that achieving the goal of improved new product development performance can be accomplished through implementing a new kind of new product development process - one that integrates new product development across all the contributing functions. The proposed research will study QFD as an example of an integrated new product development process that might achieve management's goal.

The research has both scientific and managerial goals. The ultimate managerial goal is to move toward enabling management to successfully implement a new product development process that might repeatedly and consistently improve product development performance at US firms. By product development performance, I mean melding customer needs with technical capabilities to improve customer preference and satisfaction for the developed products, decrease speed and cost of commercialization, and give the firm a defensible, competitively advantaged product.

An interim managerial goal is to synthesize our understanding of the marketing, engineering, and management of technology research approaches to new product development. Whereas the engineering community might focus on research which streamlines how products are designed or improves product manufacturability, the marketing community might be most interested in results pertaining to producing "better" products from the customer's point of view. Management of technology researchers might be most interested in improving the success rate, from management's point of view, of a stream of new products. This research bridges the disciplines by investigating the goals of the three areas simultaneously.

Scientifically, I want to determine the following about QFD:

- whether it improves new product development
- how it works to improve new product development
- how effective it is across different product situations
- whether it can be improved.

The resulting research is a scientific study, primarily field-based, of QFD, the representative integrating process, and the results it achieves in US firms The overall flow of the work has been to understand the QFD process as it is used and implemented, quantify new product development improvements in US companies which have implemented the process, identify aspects of the process and its implementation that might improve new product development, and begin developing and testing potential improvements to the current process.

No one research approach could address all the issues under investigation. Each aspect is being investigated using the methodology most appropriate for the desired research outputs. I have used three approaches:

1. Participant observation and retrospective interviewing to gain insight and evidence over whether QFD works, and if so, how

2. Comparative quantification of communication patterns to measure differences in interaction, and

3. Development of an improved measurement methodology for the marketing inputs to QFD.

Presented in Chapter 2, the field research portion of this research (participant observation and retrospective interviewing) is vital in gaining understanding about integrated new product development processes and their success. By watching how multiple teams go through the QFD process and interviewing team leaders and members about various aspects of integrating new product development, I hope to define how QFD (as a representative integrating process) produces better products, faster and less expensively than more traditional processes, if in fact it does. I also hope to identify key success factors in implementing an integrated process.

The literature and field research identified a need to quantify interaction levels by new product development process type. The communication study, Chapter 3, investigates how different processes impact communication between contributing functional groups involved in product development. This question uses a quantitative research technique developed by Allen (1970). This methodology quantifies how much communication occurs between and within the different functions of new product development projects using different development processes, in this case QFD and the "traditional" process used in that company.

One process change deemed important from the field results is an improved method for providing market inputs to technical development staffs. Technical staffs require information about a large number of very detailed attributes so that they can make rational tradeoffs among design alternatives. Chapter 4 outlines the product investigated and the overall findings. The methods studies of Chapters 5 and 6 present processes for generating large numbers of product attributes and structuring them into hierarchies. Chapter 7 investigates different ways of measuring importances for customer requirements. For the same set of customer requirements, different direct and revealed methods for measuring importances will be compared on internal validity, external validity, and predictive ability.

Conclusions from each research piece are presented at the beginnings of Chapters 2, 3, and 4. Overall conclusions and implications from the research are presented in Chapter 8, along with some areas I'd like to investigate further in post-graduate research.

CHAPTER 2. THE FIELD RESEARCH

A. Background and Impetus for the Research

From strategy delineation to commercial success, new product development is a complex process (Cooper, 1983) involving multiple functional groups, each with a different orientation (Dougherty, 1987; Lorsch and Lawrence, 1965), which melds customer needs to technical and manufacturing capabilities. Companies do this successfully at times. At others, they fail to successfully bring new technologies or products to commercial profitability, or even to commercial sale.

The research of Cooper (1983), Souder (1978, 1988), Dougherty (1987), and Gupta, et al. (1985a) suggests that corporations might improve new product development performance by integrating across the functions involved. Some researchers have begun to define "integration" and the mechanisms by which it can be achieved. By analyzing six Japanese product successes, Tak-[illegible]i and Nonake (1986) identified six characteristics of integrated processes (termed "holistic" by the authors). They claim holistic processes exhibit built-in instability[1], self-organizing project teams, overlapping development phases, "multilearning,"[2] subtle control, and organizational transfer of learning. Shapiro (1987) suggests that any of four general means (formal management processes, organizational structures, personnel, informal mechanisms) can be used for developing cross-functional cooperation.

However, Lorsch and Lawrence (1965) demonstrated that two companies im-

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[1] The authors define built-in instability as the tension produced in a development team by providing them with great design freedom and setting very challenging strategic goals for the product.

[2] According to the authors, "multilearning" is achieved when team members acquire broad knowledge and diverse skills from multiple levels within the corporation (individual, group, and corporate) and across multiple functions.

plementing the same organizational approaches for cross-functionally integrating new product development may differ in the degree of improvement in process outcomes. Their research suggests that environmental or contextual factors may affect product development success in addition to the specific process used for new product development. No one appears to have turned the research question around and rigorously investigated the factors affecting one product development process as it is implemented across a number of projects, looking for factors which may differentiate between project success and failure within one new product development process type.

One objective of this thesis is to investigate one new product development process as applied across a number of contexts and environments to try to identify generic and context specific keys to success in implementing it. The nine companies of Table 2-1. agreed to act as research sites. As the major business groupings in the table indicate, they represent a wide array of contexts for the research.

Table 2-1. Major Businesses and Codenames for Research Sites

Business Category of Firm	Number of Firms	Firm Codenames
Consumer Package Goods	2	Goods A, B
Complex Durable Products		
- Consumer Durables	2	Durables A, B
- High Tech Durables	2	HiTech A, B
Components for Complex Durables	3	Parts A, B, C

The product development process investigated across projects in these nine companies is Quality Function Deployment (QFD). In Shapiro's framework of types of integrating mechanisms, we can classify QFD as a formal management process for new product development. QFD was chosen for investigation because industry users claim that QFD integrates new product development across contributing functions, Japanese users claim great success with QFD in terms of speeding time to market and decreasing cost to commercialize, a number of large, influential American firms have adopted QFD, providing a sample base for study, and relatively little is understood in the academic community about how or why QFD works.

Another reason QFD is a good process to investigate is because a literature exists that provides specific instructions on QFD process steps; what the matrices consist of, how to calculate the numbers (King, 1987; Clausing, 1986). Other literature poses potential benefits for implementing QFD (Sullivan, 1986a), documents Japanese success with QFD (Eureka, 1987), and provides some information on U.S. case studies (McElroy, 1987). However, several issues pertinent to managing the process are not addressed in the QFD literature, including:

- Does QFD really work in US companies?
- How might QFD best be brought into a corporation?
- How is QFD successfully managed as a process in corporations?
- How is QFD used in conjunction with other new product development processes already in use?
- What are the key success factors in using QFD? Are there pitfalls?
- Why/how does QFD improve new product performance?
- What factors affect QFD's utility?
- Does utility or effectiveness change with product type or context?

Answering the above questions requires comparing the outcomes of different ways of implementing and managing the new product development process across contexts (project, corporate, and environmental characteristics).

The next section of this chapter presents an overview of the field research findings. Section C details the methods used in the research.

A major objective is to try to apply the findings from firms using this specific process (QFD) to improve other new product development processes and their implementation in corporations. Therefore, I wanted a set of independent variables which might be used to analyze data not only from this set of projects using this process, but also for comparing results from future research on different projects with different development processes.

Section D outlines a framework and the independent variables used as measures of aspects of the framework developed to analyze the contextual situations surrounding new product projects. One hypothesis held prior to starting the field analysis was that contex variations would produce significant differences in the outcomes (the dependent variables) from using QFD for developing new products.

Section E discusses a set of variables characterizing the implementation and management of QFD as a new product development process. These variables, and their importance, arose out of the data analysis.

The sample of companies and projects is described in Section F. The full details of the analysis and conclusions are presented in Section G. Some additional implications of this research are presented in Chapter 8.

B. Key Findings from the Field Research

- Across 35 projects, QFD provides some successes, some failures, and fails to impact some projects. Variables associated with process implementation seem to differentiate better between success and failure than most context variables.

- Two aspects of implementation seem most important in affecting success and failure.

  - Successful QFD implementation requires the full backing of project managers and members. Lack of commitment for the process in development from either group can lead to abandonment of the process or rejection of the results (failures).

  - To produce project-related improvements, QFD must be undertaken with specific goals that the team expects the process to achieve. Goals can take multiple forms, including "faster to market," "best product," cheaper to produce." QFD does not improve development outcomes when undertaken as a "demonstration" project to gain expertise with the method, a "generic" project for an entire product category, or when implementing the process is the goal instead of the means to a goal.

• Several contextual variables do seem to differentiate somewhat between successful and unsuccessful project implementations.

-QFD is more likely to be abandoned as a process or the results rejected when it is used on large and complex projects and where the team is starting development with a clean sheet.

- QFD may take longer to develop products than the normal process when done in firms with low levels of integration and a tradition of moving and promoting personnel only within their own functional area.

• QFD is a cross-functional investment in people and information. As with other corporate fixed costs, expecting to recoup the outlays over just one project may misjudge QFD's ability to affect new product development. While quantitative evidence that QFD delivers on the project-specific development process claims cited by Japanese users is scarce, members of over 82% (29 out of 35) of the projects believe that using QFD provided definite strategic (not easily quantified) benefits to the company in the long term, themselves, or to the process of developing new products.

C. Methods Used in the Research

Some contextual factors affecting successful new product development have been identified by Souder (1978, 1988), Dougherty (1987), and Gupta, et al. (1985a). Lawrence and Lorsch (1967) also identified some factors associated with successfully implementing integrated management processes in corporations. While these studies suggest some directions to look in, it was not clear *a priori* what all the factors are which might affect the implementation and management of an integrated new product development process across contexts. This piece of research was thus an exploratory study using research methodologies which cast the broadest information gathering net. Two qualitative methods, participant observation and in-depth retrospective interviewing, were combined to identify multiple factors affecting, and generate hypotheses about, implementing and the utility of QFD as an integrating new product development process.

Participant observation has been used to investigate how groups form and function (Kidder, 1981). Participant observation of teams using QFD to develop new products was used to develop a dynamic view of how the QFD process works, and how QFD teams function. Using an inductive process, the participant observer researcher starts with data, generating hypotheses and a theory from the ground up (Glaser and Strauss, 1967). Participant observation allows a researcher to mold his own frameworks and hypotheses about the operation of a process without respondent bias.

In-depth retrospective interviewing (described by Merton, Fiske, and Kendall [1956] as focused interviewing) allows a researcher to inquire into what other people think about a situation; why things did or did not happen, what was and was not successful, how the person felt (and why) during the process. It provides access to frameworks, conceptual structures, and hypotheses developed by others with experiences not had by the researcher (Kidder, 1981). It also allows a researcher to acquire information about aspects of the investigation he has not been able to observe, either because they went on before the researcher arrived, or because they were judgments, thoughts, or other invisible actions. Focused interviewing also allows a researcher to test his interpretations of previously observed situations.

This research combined participant observation with retrospective interviewing in hopes of maximizing the data obtained from each corporate approach to QFD and each new product development team's experience with the process. Data on how the QFD process proceeds was gathered by attending, as a participant observer, team meetings of ongoing QFD groups. I acted as a participant observer in 9 projects.

Through structured interviews with members of 26 QFD teams, I inquired why QFD was used for their product development project, how the team was chosen, how the team worked together to resolve technology/marketing trade-offs and what the results of the project were in terms of project time, cost engineering changes, product success, and organizational improvements, what they liked and didn't like about the process and why, what they thought the benefits and drawbacks of the process were. The interviews were structured to cover specific points of interest as well as gather a history of the interviewee's project(s). Over time the structure of the interviews changed as pieces of an analytical framework coalesced.

Senior managers at companies were interviewed about the differences between QFD and the previous process for developing new products, general corporate characteristics, and why and how QFD was initiated at their company.

The data from the fieldwork is captured in (extensive) write-ups of each interview and team meeting observed. Notes were taken during interviews and meetings and formally typed up as soon after the contact as possible. The analysis consisted of trying to fit all the richness learned about QFD, integrated new product development, and implementing cross-functional management processes into a coherent framework that 1) says something important and/or interesting, 2) makes sense, and 3) could be used in the future for more quantitative testing. The framework for analysis is thus a major output of this portion of the research.

D. A Framework for Analyzing New Product Development

Researchers have generally analyzed the success and failure of new product development in terms of average proportions of projects falling into outcome categories (Cooper, 1983; Souder,1978). In the research on new product success, projects have been treated as if there were no project-to-project differences. Differences between the specific characteristics of projects and the possible effects these differences may have on success rate have not been investigated. I consider this an assumption about the workings of new product development.

In the early stages of the field research I found QFD was being used on a wide range of projects with very different characteristics. While the same formal development process was being used across the projects in the research set, the process was being implemented and managed differently across the set of projects. Therefore, in addition to testing for overall success and failure across QFD projects I decided to try to test the assumption that project characteristic differences will not measurably change the overall results. To do this, I needed to develop a framework of characteristics that described project and implementation differences.

The objective of developing a framework for investigating new product development is to determine which, if any, variables or groups of variables differentiate between the success and failure of projects using a particular product development process, while also describing substantive differences between characteristics of the systems studied. By substantive characteristics, I mean ones that can be positively linked to projects and used to affect product development decisions.

Before looking at specific process and implementation findings of the field research, I present the analysis framework and the variable operationalizations used to categorize projects in the framework. Two dimensions of independent variables were developed and investigated for correlating characteristics to outcomes (the dependent variables). One dimension describes the context within which new product development takes place. The framework for describing project contexts was developed before analyzing the data, from prior judgments as to the kinds of variables that might dictate what tasks needed to be accomplished during product development. The second dimension of independent variables grew out of the analysis. These variables describe aspects of the way QFD was implemented and managed across projects.

E. Contextual Independent Variables for Analyzing New Product Development

New product development projects vary along a number of dimensions which might affect the utility of a product development process. When one of the car companies creates a new car, they use hundreds of engineers (chemical, mechanical, electrical, and aerodynamic) and designers over a five year period. On the other hand, a "new and improved" consumer product may be brought about using a relatively small staff of specialists from one technology area. The large car team will have personnel and subsystem coordination and integration problems that must be solved that the small staff will not have. The staff, however, may benefit by having available the history of changes already made on their product (and the associated performance results) and a documentation of the interactions between materials in the product. It is not clear that all the same tasks must be done for each of these projects in the same way to generate a "successful" outcome.

The framework for describing the context in which product development takes place consists of three sets of variables corresponding to three dimensions affecting product development.

- Project-specific characteristics which relate to aspects inherent to the new product project undertaken

- Corporate characteristics which relate to the nature of the firm developing the new product

- Environmental characteristics which relate to the state of the industry or environment the company operates in.

Each dimension can be changéd or affected independently. Together, these three sets of variables allow one to independently look at variations in new product development across products, companies, and industries to infer situationally-based key success factors. The next three sections (E.1, E.2, and E.3) describe each dimension and identify specific variables associated with them.

E.1. Environmental Characteristics

Although firms cannot change characteristics of the environment in which they operate, those environmental characteristics may affect a company's willingness to change their current new product development process or try a new one. Environmental conditions may also affect the firm's new product strategy. For instance, highly competitive environments may move a firm to continually seek radical product changes instead of incremental product improvement. Specific variables in the analysis include the:

- level of competition in the industry
- rate of technological change
- rate of market change
- stage in the product life cycle
- nature of competition: local, US, or global.

I would expect higher levels of competition and change should correlate with more willing experimentation with new product development processes and their implementation.

By keeping the analysis within one industry, one can hold environmental conditions constant. This allows one to analyze differences in process or implementation success given one set of environmental variables, or independent of environmental changes.

Team perceptions of these variables are used to code the projects into low, moderate, or high rates of change and levels of competition. Four stages of product life cycle were used: introduction, growth, mature, and decline, although none of the products in this investigation were in decline. (This makes sense. Why would a company pour development money into a declining product area?) The nature of competition was categorized as local, US, or global.

Leaders and members of most teams had a good feel for the environment in which their product competed. They were easily able to provide their perceptions of the levels of the environmental variables. That one person's "moderate" rate of change may be another person's "high" is a limitation of the soft data gathered in this study.

In a more quantitative study of product development, or one which studied fewer numbers of products in fewer environmental situations in more depth, it would be useful to associate numbers with the rates of change. For instance, rates of changes in the market can be quantified as the percent of total sales going to products commercialized in the last two years, or the percent of firms selling these products which have entered the market in the last two years. Levels of competition might be inferred from average profitability, or the concentration ratio for the top four firms in the market. Gathering these more quantitative measures for the environmental variables of the 35 projects (in nearly 35 different environments) is left for future analysis.

E.2. Corporate Characteristics

Corporate characteristics will affect the way and the ease with which specific new product development process mechanisms are implemented in and across the corporation. While it may not be simple to do, firms can change aspects of their corporate characteristics to promote the implementation of efficient or "successful" new product development processes. Four corporate factors were used in the new product development framework: management style, degree of cross-functional integration, assignment and movement of personnel, and corporate size and diversity.

Management Style

The firm's overall management style affects how a new product development process needs to be "sold" to the firm. There are many classifications of style, but the three general types found in the sample in this study are autocratic, bureaucratic, and entrepreneurial. While an autocrat might be able to force-feed a new process into his organization, the process will have to prove its worth to each potential user in an entrepreneurial organization. Adoption in a bureaucratic organization may have to proceed through very formal channels, for instance through absorption into the formal planning process.

In many companies there is an acknowledged generally-accepted management "style." Not only can persons working for that firm articulate what the accepted style is, other persons at competing and even other non-competing firms concur about the general style. The US government, for instance, has a bureaucratic management style. The companies in this research were categorized primarily on how members of the firm talked about the management style and "the way things are done." Concurrence on perceptions of a firm's style was also sought from other research sites.

Cross-Functional Integration

The current degree of cross-functional integration affects both how the new product development process should be brought into an organization as well as the ease of implementing. To implement a cross-functional new product development process in an organization with no cross-functional ties, one must build cross-functional ties as well as install the process. Getting functionally different groups to work together might be a tough barrier to overcome in companies where significant amounts of animosity have built up over time between groups. In companies with significant animosity between some of the functional groups, a "neutral" group may have to be the one to introduce the process. In organizations which have already worked to build cross-functional bridges, implementing one more cross-functional management process will not be as difficult as it is in an organization which must first build those bridges.

In this study comments from team members that indicated their attitudes toward and degree of interaction with other functional groups were used to categorize the companies into low, moderate and high degrees of cross-functional integration. At most of the companies, assignment was easy. One example comes from a company I label HiTech A. An engineer on one team said:

> marketing here is probably different from marketing like you're used to. Engineers at [HiTech A] develop the products. Marketing guys are just supposed to put together the promotional material that sells the product. But <u>we</u> give them the product they have to sell.

Statements like this were taken as indicators of low integration across functional areas. Other indicators of low levels of integration included not knowing any of the people associated with manufacturing or marketing the products previously worked on and derisive remarks concerning the capabilities of other functional groups. Interestingly enough, even consumer products companies have trouble integrating their product teams across functions. Two functional managers at "Goods A" had a difficult time identifying people in their organizations who could even be asked to try to work together constructively on a QFD effort.

In my judgment, none of the companies was highly integrated across functions. Three of the firms were functionally integrated to a moderate degree. These firms had been working toward increased integration as a specific corporate goal. Personnel in these three companies knew people in other functions and had previously worked with them. They had more positive attitudes about the roles other functions played in their division.

In future studies it would be useful to try to quantify the level of integration between functional areas. This will allow more precise research into the interaction between integration and new product development than is possible in this study. A self-stated evaluation of the state of interdepartmental relations across functions, similar to the one used by Lawrence and Lorsch (1967) is one way I would to try to quantify integration. A second is to use the level of communication (see Chapter 3 for one possible measure) to quantify the amount of interaction. A self-stated judgmental scale of frequency of interactions, while subject to personal biases, is another possible measure.

Assignment and Movement of Personnel

The assignment and movement of personnel within the firm affects new product development in two ways. Personnel movement is one way to transmit knowledge of a process rapidly from group to group (Allen, 1980). At the same time, however, personnel movement can also eliminate the accumulated learning about a particular product area within a company. When a stable group of people stays with a product from inception to death, that group embodies a great deal of the knowledge associated with developing all the iterations of the product. However, if a new team is formed each time a product goes through a new generational cycle, then unless the product development knowledge generated by the previous team has been captured in some form and transmitted to the new team, the next generation team must start from scratch. For incremental changes between product generations, having to start from scratch each time is an inefficient use of development staff time and effort.

Companies were categorized as moving people predominantly within function, both within and across function, or predominantly across function. Only one of the nine firms moves people across functions to any degree.

Even though personnel rarely move across the functions, they also do not tend to stay with a product for long periods of time. The personnel of some companies in the research tend to move people after very short periods of time (less than 2 years), but the majority move people after moderate periods of time (2 to 5 years). In some companies with long development cycles, the average job assignment is shorter than the development cycle.

Corporate Size and Diversity

The final corporate factor affecting the ease with which a new product development process is implemented is firm diversity. A firm that produces only electrical components for the automotive market may be able to routinely use the same new product development process over and over. On the other hand, a firm that produces a large number of different kinds of products may require a range of new product development processes that can deal with all the different levels of complexity for their products. In the more diverse organization, then, implementation may be more difficult because the processes must deal with more variation in product development tasks.

The companies in the research set were divided into three groups: "highly" diversified companies whose set of products require multiple technology and manufacturing skills; "focused" companies using a range of closely related skills in the development and production of their products, even though the whole line of products produced might be quite extensive; and "narrow" companies producing a single line of products using one set of skills. Corporate size has also been divided into three segments: "small" (less than $50 million in sales); "medium" (less than $250 million); and

"Fortune 500," or very large firms.

One can mitigate the cross-corporate differences by analyzing new product development processes within one firm, or within two firms with similar characteristics on these four dimensions. One can also look across firms with specific differences in one or more of these variables to analyze those impacts on new product development processes.

E.3. Project-Specific Characteristics

While environmental and corporate characteristics primarily affect the implementation and management of new product development processes, it is characteristics inherent to specific products or projects that determine the full nature of the tasks that the new product development process must accomplish. The product development process must successfully perform these tasks regardless of the nature of the corporation or operating environment.

The product (project) classification scheme used in this thesis differs from typologies frequently found in the marketing literature. Traditional marketing typologies have not been used because new product development focuses on a part of the marketing process that other typologies do not. One of the typologies frequently used in marketing arises from differences in the buying process. Marketers divide products into consumer and industrial goods, depending on whether the potential market is a set of individuals or a group of firms. This categorization has arisen from the need to cope with demand side variations that affect the marketing management task.

An alternative categorization useful for new product development arises from the supply side variables that affect marketing management tasks. As illustrated in Figure 2.1, these supply side issues fall along three axes: inherent product complexity, dispersion of market data, and amount of previously developed information available. These three axes roughly correspond

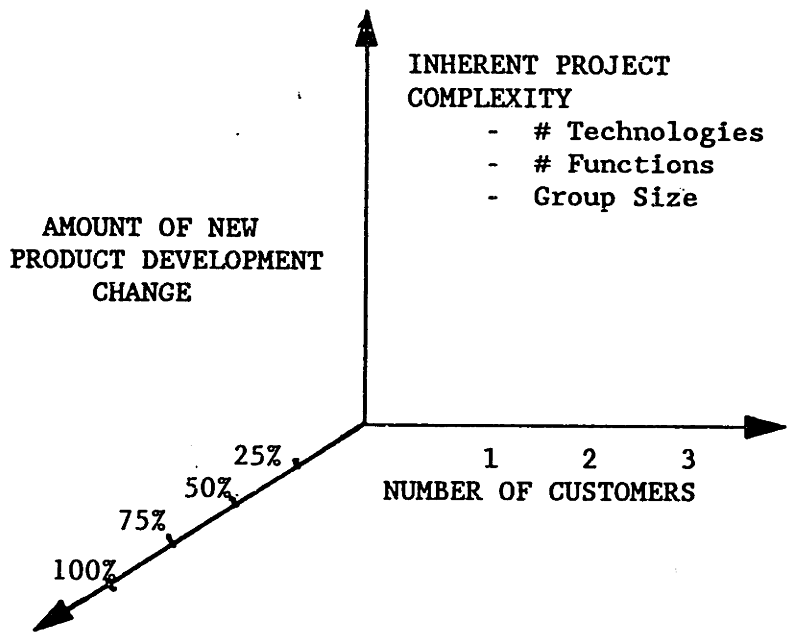

Figure 2.1. Framework for New Product Development Project Analysis

to the development questions:

- How large and complex is the product development effort going to be?

- Where (and from how many places) do I have to go to gather the marketing data?

- What are my developmental start and end points, or is this a clean sheet effort?

Dispersion of Market Data

The dispersion of market data for the project affects both the kind and amount of marketing research that must be done. If a product is a stand-alone product, that is, it is to be used independently as it is manufactured (it is not, or does not become, part of another product) then marketing data is obtained directly from product end users. Shampoo, a car, and a computer system are all examples of stand-alone products.

A product is not a stand-alone product, but is a "dependent" product, if it is an input to another product, or if it depends on aspects of another product for its performance. Examples of dependent products include car engines, computer memory chips, and the measuring cap for a bottle of detergent. Gathering market data for a dependent product requires input from both the end user and the producer of the complete unit.

Even though a product is an independent product, marketing data may still be located in multiple places. For instance, producers of medical devices must consider the needs of health care workers and hospitals in addition to the needs of the patient in developing new or improving old devices.

The more disperse the marketing data, the more effort must go into obtaining data that represents the needs of all the customer sets for a product. The functions and manufacturing impacts of dependent products will have to be coordinated with whatever division or outside company makes the end product.

Product Complexity

Product complexity refers to how inherently complicated the product is. One aspect of complexity is the number of technology disciplines embodied in the product (technological complexity). The second is the number of functions performed by the product (functional complexity). Adding the number of functions to the number of technologies produces an indicator of overall product complexity. The resulting framework for delineating overall product

Table 2-2. Framework for Determining Product Complexity

Product Classification	Technological Complexity	Functional Complexity	Team Size
Complex Product Systems	Multiple Technologies	Multi-functional	> 100 Personnel
Subsystem Level Products	One or More Technologies	Single Function	10<Team<100
Component Level Products	One Technology	Single Function	< 20 Personnel
Materials	Single Moiety	Single Function	< 10 Personnel

complexity is shown in Table 2-2. The size of the development team needed for designing this product from scratch also generally correlates with overall complexity.

Product complexity is thus a continuum ranging from materials consisting of single moieties on the least complex end of the spectrum, through multiple technology and functionality products like cars and computers on the more complex end of the scale. Component level products may be either stand-alone or dependent products.

Developing complex products requires managing inputs across multiple technical disciplines and coordinating large numbers of people contributing to a project. More complex products will probably also have more complex and difficult engineering tradeoffs. Less complex products, like components, are more likely to be developed by fewer people within one functional group, with fewer engineering tradeoffs which are easier to track.

The marketing research process may also differ across product functional complexity. Gathering marketing data should be more complex for multifunctional products than for single function products because the firm must understand the functional tradeoffs that customers make. Single function, independent products should be the easiest types of products for which to gather marketing research; there are only one set of customers and one function to understand. Market data for dependent products will have to reflect both what the end customers want from the end product (and from your dependent product's input to the end product), as well as what your customer (the manufacturing firm or division for the end product) wants from your input in terms of performance and compatibility. Thus, even a dependent component has two sets of "customer needs" to understand.

Level of Product Change

The third aspect of the project framework has to do with the starting and end points for a new product development project. What is the project's starting point and how much total effort will go into the project. The data is categorized into four levels of product change. Assignment of projects to specific categories was based on the team's perception of how much effort they were to put into the project, per management's instruction.

On one end of the spectrum a number of groups were making a clean sheet efforts, starting from scratch. Clean sheet projects have very little or no data or experience available from previous new product development efforts (the developers start with a "clean sheet of paper" and proceed from there). Clean sheet efforts may arise when a company enters a new market or product area. They also may occur if a company routinely assigns a next generation product development to a team unfamiliar with the product; one that has not worked on the previous generation. Projects categorized as clean sheet efforts were ones in which members talk about "starting from scratch," or where the team had not previously worked in the product area before.

On the other end of the spectrum are small, incremental changes where only a very small amount of development effort is expended compared to the total effort the original team invested in the first generation product. Typical of these changes are the ongoing day-to-day product "improvements" made in reaction to customer complaints or suggestions. The teams of projects in this category talked in terms of making "incremental" or "minor" changes in products that were already well-established in the market.

The other two levels of product change are products with "major changes" and "next generation" products. Products with major changes have a stable base product that will have one or a few very different components or subsystems. Less of the base product of a next generation project will remain stable through the changes, although next generation projects have some set of aspects that are the same as the previous generation.

Differences between these four categories are perhaps best explained through an example. A car company designs a new car, taking perhaps 5 years and several hundred people. This car has been a "clean sheet" design. Even though some of the parts may be taken from other development efforts (engines, for example, are not designed for a specific car), the way all the pieces are put together has proceeded independently from other development efforts. Ford's Taurus and GM's K-car programs are good examples of clean sheet new car developments. After commercialization the development staff becomes aware of small problems in the car that could easily be fixed. These problems involve changing very little of the car - less than 25% of the car (usually far less than 25%) will be affected by the change.

In year four of the life cycle the development generally goes through a "refresher," with some styling changes and a few more major changes to some of the subsystems. In all, somewhere around 50% of the car will be affected by these changes, but they certainly affect much more of the total product than the incremental changes made yearly or even quarterly.

About year seven of a car's life cycle, a major generation change program is initiated. In this program the development staff will look at the majority of the systems of the old car. The structural platform may stay the same, but changes that have been incorporated into most of the subsystems over the last seven years will be absorbed into this "next generation" model. In all, somewhere around 75% of the car will be affected by the program changes. And somewhere along the line this whole car concept will be scrapped and a new car program will start again from a clean sheet.

The 35 projects in the field research have been categorized based on the team member's description of the amount of change expected in the product. Some teams articulated the amount of change directly in terms of how much of the product was going to be different ("oh, most of it - well over half the product is different from when we started). Others described how much knowledge about the product they had at project inception and what they did to the product over the course of development, from which I inferred the most appropriate category.

F. Independent Variables Associated with Implementing and Managing New Product Development Processes

The way QFD has been implemented and the teams managed differs by company and even by project within company. I have used six variables representing the two basic categories of implementation and project management to describe these differences. Many more variables that describe actual differences could be used. These six rose out of the analysis. They seemed to affect success and failure and they varied across the project set.

F.1. QFD Implementation Differences

In the interviews team members were asked how they became aware of QFD, how it was introduced to the team, who introduced it, and why it was used in the project. The answers to these interview questions provided several variables which describe whether the team was using QFD because they wanted to and thought it would provide them with some real benefit, or because they felt they had to at least try using it because it was "someone's" latest buzzword. Three variables concerning the way QFD was implemented for a project seemed to correlate with differences in project outcomes.

One variable indicates who was responsible for introducing QFD into the project. Is using QFD being pushed from the top (management), the bottom (grass roots movement from a functional individual contributor) or by a neutral third party (such as quality).

The second implementation variable is a measure of how well accepted QFD is by the functions involved with new product development. If the whole team has decided by consensus that QFD is the "right" process to use, I would expect virtually everyone involved with the project to have a positive attitude about its potential to improve the outcome of the project. If only one part of the team is enthusiastic about QFD, then I would not always expect everyone involved with the project to be committed to QFD's ongoing use. I would expect teams with only partial commitment to be readier to dropQFD at the first sign of process tedium or difficulty.

The data has been coded as high, moderate, and low commitment to the process. High commitment means all functions on the team and management are fully committed to using QFD. In interviews or in the QFD sessions in which I participated all the personnel exhibited enthusiasm for the process. None of the team members withdrew from participating in the process and when questioned, no one interviewed could pinpoint any member of the team who declined to participate or was not enthusiastic about using the process.

One or more persons on moderately committed teams are not convinced that QFD is worth the effort. This situation was identified by participants in the process leaving scheduled QFD sessions "to do their own work," or by team members who could point to persons who did not participate during the process.

On teams categorized as having low commitment, only one person or functional group is spearheading the effort to use QFD. They have introduced the effort and tried to drive its use, but just have not been able to sell QFD's utility. The end result is a team that goes through the motions.

The last variable associated with implementation concerns the goals for using QFD. The goal with which QFD is undertaken may effect project outcomes. Some projects undertook QFD with a specific affective goal like "decrease time to market" and "improve performance x% at no incremental cost." For these teams, QFD was a means to a specific end. Other teams undertook QFD as a process trial, or because "other people have had 'success' with it." These teams seem more concerned with the process than with the outcome. One indication that a team was process-oriented was if they treated the matrices of QFD as inflexible diagrams to be filled out. The data has been classified into "affective" and "process-oriented" categories.

F.2. QFD Project Management Differences

Three variables associated with the way QFD projects were managed were investigated for correlation with project outcomes.

The first variable quantifies the breadth of functional membership on the team. According to the literature (Sullivan, 1986b; 1987) QFD teams should consist of members from planning (management and the staff functions), the field (marketing, sales, and field service), engineering, and manufacturing. Team membership by function was obtained for each of the projects. A function representation variable was created which is the percent of the four functional areas who should be included on the team who actually are involved with the team. I would expect teams with more functional areas participating to have a larger potential to affect a project's outcomes. These teams also might require longer times to go through QFD if the groups previously had not worked together or were familiar with each other.

The second management variable is an indication of how familiar the functions of the teams were. This variable is a measure of how much team building would be required to make the team function as a team. The data is categorized into weak, moderate, and strong teams (or can be thought of as low, moderate, and high familiarity). Most of the members of weak teams had not worked together previously, either because the functions in this company work in isolation or because the team consists of a number of members new to the company or division. The majority of the members of the strong teams had worked together previously, for example, on the previous generation of this project's product. Moderate teams fall in the middle; some members in some functions had worked together, some had not.

The last project management variable delineates whether management views QFD as a long-term investment in people and information or as a method to improve this project's results. A descriptive analogy is whether management treats doing QFD as a fixed cost of product development or an expense. I would expect managements which treat QFD as an expense to be far readier to drop the process if it only produced long term benefits, not benefits which look like they will accrue on this project.

G. The Sample

G.1. Description of the Companies

Companies implementing QFD have been this research's target sites. Of some two dozen US companies using QFD in 1987, 9 have been research sites where interviewing and/or observation has taken place. Due to continuing publicity about QFD, many additional firms have begun using QFD since this research was initiated.[3] Many more research sites could have been included in the sample, but were not pursued for 2 reasons. The first reason for limiting the sample was simply a lack of funds for travel to research sites scattered across the US.

The second limit on the number of sites came from focusing the research on sites with significant experience in implementing QFD; those which had been through the process more than once. From them I hoped to find out what they had done wrong as well as right, how they had adapted the process and its implementation to fit the corporation's needs, and how the payoffs of QFD change over repeat use. Only a very few US organizations had implemented QFD prior to 1987; perhaps 15, all told. Over half of those organizations are in the research sample.

Access to companies and projects was obtained primarily through cold calling prospects. Names of those associated with or leading QFD projects at prospective firms were obtained from published reports of QFD use, speaker listings at QFD conferences, or as referrals from other contacts. Seven research sites evolved from cold calls, although some sites took a significant amount of time to approve cooperation (up to six months). Only one contacted firm declined to participate (citing confidentiality problems). One site in the final group contacted Professor Hauser after reading his article on QFD (Hauser and Clausing, 1988). One research site resulted from a consulting contact.

Cooperation was elicited from the firms by promising no disclosure of proprietary information. Most firms requested anonymity. Therefore,

[3] The number of companies implementing QFD in 1989 is now much larger than 24. Thanks to good publicity for the process (Holusha, 1989), by the middle of 1989 well over 50 companies had formally announced they were using QFD in new product development.

throughout this thesis, the firms in the study shall be referred to by the codenames presented in Table 2-1, which also identifies the major business category of each firm. Information from two marketing research firms about how they generate, organize, and quantify marketing data for QFD projects also was obtained.

Table 2-3 summarizes the corporate characteristics (Section C.2. of this chapter) of the nine firms in this research. Most of the firms are large, diversified Fortune 500 companies with many divisions and products. Only one firm moves personnel cross-functionally with any regularity, and most firms do not integrate well across functions. The three companies producing components (Parts A, B, and C) are all much smaller than the other six, with less diversified product lines and presumably therefore, simpler new product development processes which can be more consistently implemented across all parts of the company.

G.2. Description of the Projects

The sites offer opportunities to study QFD's relative impact and utility across product type, one of the factors specifically varied in the study. Information was gathered from team leaders and members of 35 QFD projects representing many of the different project types in section C.3. The projects are listed by (disguised) company and project characteristic in Appendix 2.1. Tables 2-4 and 2-5 summarize the project and implementation characteristics of the sample.

The sample does not include any materials projects. I have never heard of QFD being used to develop a new material or chemical. QFD is used to direct the development of multiple material or input goods and services. It may be that materials producers require a process aiding different tasks than those improved by QFD.

Table 2-3. Corporate Characteristics of the Research Sites

CORPORATE SIZE	Small (<$50 M)	Medium ($50-250M)	Fortune 500
	Parts C	Parts A,B	Durables A,B Goods A,B HiTech A,B
Total	1	2	6
CORPORATE DIVERSITY	Low - 1 Product Line	Moderate - Many Products, 1 Business Line	High - Many Business Lines
	Parts A,B,C	Goods A,B	Durables A,B HiTech A,B
Total	3	2	4
MANAGEMENT* STYLE	Bureaucratic	Autocratic	Entrepreneurial
	Durables A Goods b	Durables B Parts C HiTech B	Goods B HiTech A
Total	2	3	2
MOVEMENT OF* PERSONNEL	Within Function	Within & Across	Across Functions
	Durables A,B Goods A,B HiTech A,B	Parts C	
Total	6	1	0
DEGREE OF CROSS-FUNCTIONAL INTEGRATION*	Low	Moderate	High
	Durables A Goods A HiTech A,B	Durables B Goods B Parts C	
Total	4	3	0
LENGTH OF PERSONNEL ASSIGNMENTS*	Short: <2 yrs	Moderate: 2-5 yrs	Long: > 5 yrs
	Goods A Parts C HiTech A	Durables A,B Goods B HiTech B	
Total	3	4	0

* No Information available for Parts A and B

In the project analysis, I have included one more categorization of the projects in addition to those presented in section C3. I have classified

Table 2-4. Summary of Project Characteristics

	Total #	% of 35	# Successful	# Failed	# Mixed	# No Bens.
INHERENT PROJECT COMPLEXITY						
Complex System	7	20.0%	1	2	3	1
Subsystem	14	40.0%	3	2	4	3
Component	14	40.0%	3	0	3	2
PROJECT TYPE (Inherent Project Complexity)						
Product	20	57.1%	2	2	5	4
Service	7	20.0%	5	1	0	1
Software	8	22.9%	0	1	5	1
PROJECT DEPENDENCE STATUS (Complexity of Market Research)						
Independent	13	37.1%	2	3	2	4
Dependent	22	62.9%	5	1	8	2
NUMBER OF CUSTOMERS (Complexity of Market Research)						
1 Customer Set	8	22.9%	0	0	1	2
2 Customer Sets	20	57.1%	5	3	5	3
More Than 2	7	20.0%	2	1	4	1
HOW MUCH CHANGE IN THIS DEVELOPMENT PROJECT						
Incremental	3	8.6%	0	0	2	0
Major Change	6	17.1%	1	0	0	3
Next Generation	8	22.9%	6	1	0	2
Clean Sheet	18	51.4%	0	3	8	1

projects as to whether they produce products, services, or computer software. This categorization differentiates between inherent aspects of the manufacturing process. Products can generally be produced at a set of central locations where the production process is usually invisible to the consumer. A consumer can frequently hold products in inventory, at least for a short period of time. (Some products are subject to spoilage and must be produced within a short time of consumption.) Services, however, are produced as the consumer needs them. Services cannot be inventoried. The place of production is sometimes dictated by the consumer and usually very visible to them. Over half the QFD projects investigated were products, and one-fifth were services.

Table 2.5 Summary of Implementation Characteristics(22.9% of the total)

	Total #	% of 35	# Successful	# Failed	# Mixed	# No Bens.
WHO PUSHES QFD						
Top-Down	8	22.9%	0	1	2	3
Bottom-Up	10	28.6%	4	1	1	0
Neutral Other	17	48.6%	3	2	5	3
LEVEL OF TEAM BUY-IN OR COMMITMENT						
High	10	28.6%	7	0	0	0
Moderate	12	34.3%	0	0	5	2
Low	13	37.1%	0	4	3	4
GOALS FOR USING QFD						
Process-Oriented	20	57.1%	1	2	5	4
Affective	14	42.9%	6	2	3	2
CORPORATE ATTITUDE TO QFD						
Investment	21	60.0%	7	0	7	3
Expense	14	40.0%	0	4	1	3
NUMBER OF FUNCTIONS INVOLVED						
1 out of 4	2	5.7%	1	0	1	0
2 out of 4	8	22.9%	3	2	1	2
3 out of 4	15	42.9%	1	2	5	3
4 out of 4	10	28.6%	2	0	1	1
TEAM FAMILIARITY						
High	3	8.6%	0	0	0	0
Moderate	14	40.0%	5	2	4	1
Low	18	51.4%	2	2	4	5

from other products because software production processes seem very different. While the software design process and set of benefits delivered may be very complex, the production of a piece of software (replication of floppy disks) is trivially easy. Some companies, especially the Japanese, believe that software design houses should be run like factories where the production process is the process used by the programmers to design and write the software, not copy the floppies containing the code. Because of the question of what the production process for software is, I have split it from the general category of products.

The data suggest that obtaining marketing inputs for products may be a much more complex task than one would think. Three-quarters of the projects have multiple customers. Over two-thirds of the projects in the sample set are "dependent" products. They become part of or work only in concert with another product or service. The multiple customers for those projects include the needs of the end product of which the dependent product is a piece as well as the needs of the users of the end product. However, five of the 13 independent projects (38.5%) still have multiple customers from whom information must be obtained. In this sample, the number of projects requiring market inputs from multiple customer sets is three times the number of projects for which marketing data is available from just one customer set.

Over half the projects in this data set are clean sheet development projects. Of the 18 clean sheet projects, only eight (44.4%) are products or services "new to the world" or "new to the company." The other 10 are major change or next generation products for products the company already makes. Thus, over a quarter of the projects in this sample set are being treated as clean sheet developments even though significant amounts of product and development data from previous product generations should be available and could potentially be used to speed the development process.

The sample of QFD projects investigated in this research is fairly broad. It includes products and services with different levels of inherent complexity, inherently different manufacturing processes, single and multiple customer sets, different amounts of effort to be put into the development and products and services that are used independently of other products as well as those that can only function in concert with another product. The next section tries to link these various project characterizations, along with the corporate and environmental aspects of the projects' companies and industries, with successful and unsuccessful implementations of QFD.

H. Results from the Field Research

This thesis presents findings concerning success and failure of the various projects. Using a new process for developing products can be overwhelmingly successful, a disastrous failure, or introduce both positive and negative changes at the same time. Even though a new product development process has worsened development performance across one or more measures, it may have improved (even enormously improved) performance across one or more other dimensions. In the judgment of management (upper, project, or functional) the overall corporate or project benefits obtained from the improved dimensions of product development may outweigh the penalties associated with the worsened qualities. Therefore, even the analysis of partial failures must include a look at the positive aspects that may have accrued with the "failure."

Because a new product development project may take up to five or six years to complete, some of the projects can not yet be categorized as either successful or unsuccessful. Even though incomplete, some projects may already display indications that implementing QFD on that project was successful or failed. Each piece of analysis in this chapter is therefore based on the results from the subset of projects for which data are available.

H.1. Indications of QFD's Success

Tactical Indications of Improvements from QFD

Industry practitioners claim that QFD decreases the cost and time required to develop new products. Many of the companies experimenting with QFD have done so specifically because they would like to realize these claims in their new product development process. These effects, if realized, are quantifiable and visible. They are the "tactical" benefits made possible by implementing QFD because the results show up "in this project." While they may have improved this project's performance, the change is not necessarily instilled into the system for cross-project benefits.

Tactical indicators of QFD's success are measures that demonstrate improvements in the commercialization process or product performance which the team thinks are attributable to using QFD. Tactical success can be indicated by a number of measures. A project using QFD has been defined as successful if it demonstrates improvements in any of the possible indicators of tactical success, without worsening any other aspect of product development.

Process improvements are measured through decreases in time or cost to commercialization. No measures of cost were available for the projects. Changes in time to commercialization were measured as differences from the planned or expected schedule. These schedules are generally derived from previous product development project experiences.

Measures of time and cost differences of the process are not applicable for 11 of the projects in the sample. These projects modified services that are not "sold" in the marketplace,[4] or were "generic" QFD projects that were done at a product category level and were not specific to any particular product or brand. Neither of these types of projects has any actual "development schedule" associated with it. In these instances QFD was used as a problem-solving technique, not a new product development technique.

[4] For instance, a service not sold in the market place may be a management process, like order entry, which is used internally at a corporation. One form of the management process may already be in place and working. The company is using QFD to improve the delivery of the service.

If a project using QFD improved the product under development, then the project has been successful. Products can be improved by increasing product performance, quality, or resulting customer satisfaction. These improvements may or may not directly affect overall corporate results. However, QFD may also directly affect corporate results through changing the product (not necessarily improving it) in ways which increase sales volume or decrease product cost.[5]

Improvements in product (service) quality and performance were compared with standard values for performance and quality measures. Customer satisfaction was measured only for the customers of several staff groups who used QFD to decide which services to offer their organization. Satisfaction was measured as perceived changes in morale and job enjoyment for the deliverers of the services and changes in upper management's assessment of the group's performance. Almost half (17 out of 35) of the projects were not far enough through development to provide indications that these measures of product performance would be impacted.

Increased sales were measured against "expected" project sales. Since only eight projects were for products or services "new to the company," trends or expected sales were available for almost all the products. For several of the "new" products, this measure could still be derived because the development had been undertaken as a contract for a particular manufacturer. Generating sales to manufacturers beyond the original contractor was taken as an indication that sales had been increased. The "increased sales" measure did not apply to six of the 35 projects (17.1%) which did not produce salable products or services. Data were not available for 18 (51.4%).

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[5] The real measure of interest is increased profits, but so many other variables intervene between process change and profit, that decreased cost is the measure used to infer profit increase.

Product cost is the final indicator used to infer success for implementing QFD as a product development process. The measure was taken as cost change from expected, projected, or previous generation, with no indications that performance, quality, or customer satisfaction had deteriorated. The measure did not apply to four projects (11.4%). Another 13 (37.1%) were not far enough through development to provide any indications of success. Information was not available for one project, leaving 17 for analysis.

Strategic Indications of Improvements from QFD

Companies implementing QFD also have discovered that using QFD as a new product development process provides them with other effects and benefits, many of which are "soft" or less tangible than the tactical benefits described above. These benefits are certainly not quantifiable in terms of improving specific project results. These effects, while not easily quantified, in the long run may be more instrumental in advantageously changing the culture and environment for developing new products than the tactical benefits explained above.

Even if there is no evidence that QFD produced any tactical benefits for a project, it may have provided some intangible benefits. The soft benefits that accrue very slightly in the first project may increase in magnitude in following projects, until they have instituted a cultural change across the organization. They are thus the "strategic" benefits of implementing QFD because they may be more instrumental in changing the organization's overall operations than in producing changes in this project.

Indications that implementing QFD on a project produced strategic benefits were drawn from responses to two open-ended interview questions: "What did QFD do for this project? What benefits did using QFD produce?" These questions were posed to each project member and leader interviewed. Respondents were not prompted with strategic benefits that had been received from other projects. Thus, the indications of strategic benefits gathered and reported for these projects should be only the largest of the strategic effects felt for each project.

The strategic benefits cited by teams were coded into 17 items which improve the process of new product development (through improving information flow, forcing rational decision making, solidifying the design early, or strengthening the team), benefit the company over the long term, or merely indicate the team felt value from going through the process in some non-specific way. Table 2-6 presents the specific items coded out of the data.

Table 2-6. Categories of Strategic Benefits

LONG TERM CORPORATE	NON-SPECIFIC INDICATIONS OF VALUE
• Forge Better Cross-Functional Relationships	• "Liked it;" Considered QFD Valuable
• Captures Knowledge	• Would/Did Use QFD Again
	• Produced a Product or Process Change
PRODUCT DEVELOPMENT PROCESS BENEFITS	
• Improve Information Flow	**• Make Decisions Rationally**
- Improve Market Input	- Structures Thinking
- Customer Information	- Meld Design to Needs
- Competitor Information	- Shows Inter-relationships
- Move Information from Source to User	- More Complete Analyses of Problems
	- Set Project Priorities
• Melds a Better Team	**• Solidify Design Early**
- Builds Morale	- Avoid Project Blindsides
- Creates a Common Vision	

H.2. Indications of QFD's Failure

Failures from implementing QFD can be categorized as complete failures, projects with mixed results and projects for which no strategic benefits were cited by team members. It is important to differentiate between these three types of results in the analysis. Complete failures suggest that a new product development process produces no visible benefit from its use, or that the negative aspects associated with a particular process outweigh any positive aspects when the outcomes of the new process are compared with the outcomes from the previously used process. In the user's eyes, this new process is not preferred over his old new product development process.

Indications of complete failure of QFD as a process are abandonment of the process before project completion or through the next product development cycle, or management rejection of the results suggesting which design direction should be taken. Failure could also be operationalized as a product or service rejected by the marketplace (measured by low sales) or which did not make it to market due to technical difficulties. None of the projects in this data set had failed in the marketplace or due to technical difficulties at the time of analysis.

Mixed results are obtained when one or more aspects of the development indications worsens. Even though one aspect of performance was worse than previously, the team or management acknowledges that other aspects of the process were beneficial. In their minds, the positive results from those beneficial aspects outweighed the aspects where development performance declined. The only perceived performance declines teams indicated were increases in development time.

Another kind of failure is indicated by any lack of strategic benefit for a project. Team members for all but six projects investigated indicated that even though they couldn't produce quantitative evidence of product or process parameters that had been improved, they felt the project had benefited in one or more strategic ways from QFD. Six projects, however, could not articulate any strategic benefits derived from using QFD. While four of these projects are not outright failures (there is no evidence that QFD produced worse results) they are projects for which there are no perceived differences between QFD and the standard development process.

H.3. QFD's Ability to Impact Product Development Results

This section first reviews overall success and failure results. It then looks at the characteristics of projects that are successes, failures, mixed results and projects exhibiting no improvement. It then reviews which variables differentiate between the four outcome types.

Overall Success and Failure

The vast majority of the teams using QFD as a process for developing new products obtained some kind of "success" or improvement from using it.[6] Only seven teams perceive that QFD provided them with tactical improvements for their project (Table 2-7). These projects were completed in less time or using fewer financial resources than the teams expected, or produced products with higher sales, performance, quality, or satisfaction than they expected. Each of these projects also indica-

Table 2-7. Summary of Projects Exhibiting Indicators of Success and Failure

SUCCESS CATEGORY	# PROJECTS	# WITH STRATEGIC BENEFITS	% OF TOTAL
TACTICAL SUCCESS	7	7	100.0%
MIXED RESULTS	8	8	100.0%
NO TACTICAL IMPROVEMENT	7	7	100.0%
NOT APPLICABLE/ NO INFORMATION	9	5	55.6%
FAILURE	4	2	50.0%
TOTAL	35	29	82.9%

[6] Appendix 2.1 provides the project-related context characteristics for each project. Appendix 2.2 lists the Implementation characteristics by project. Appendix 2.3 lists the strategic benefits cited by the members of each project.

ted they thought QFD provided them with less tangible success, in terms of strategic benefits garnered from QFD. In all, 29 of the 35 projects (82.9%) indicated that the project obtained some level of strategic benefit from using QFD.

Even though the majority of the projects indicated that QFD provided some kind of improvement, over 34% of the projects using QFD (mixed results plus failed) also indicated some aspects that were only equal to or worse than (at least in some respect) the current development process. According to eight teams, using QFD slowed their development down (a partial failure). A slower time to commercialization was the only kind of partial failure exhibited by any of the projects in the sample. Each of these teams indicated that using QFD had also resulted in a number of strategic improvements, and that the benefit from those improvements outweighed the negative aspects from slower development times. These eight teams therefore experienced mixed results from using QFD, but where the positive outcomes outweighed the negative ones.

The negative aspects of QFD seldom overrides the positive aspects. Only four (11.4%) projects using QFD for new product development exhibited a complete failure of the process as manifest through abandonment of QFD or rejection of the results. Two of these four projects indicated that part of the problem was that QFD had lengthened the time to development. For these two projects, other benefits, including other strategic benefits, did not outweigh the longer development time.

Six teams could not cite any strategic improvements from using QFD. QFD was rejected in the middle of the project for only two of these projects, however. Three of the remaining four projects with no identifiable strategic benefits are generic projects, for which the measures of tactical improvements are not applicable.

Projects Achieving Tactical Success

In this data, measurable tactical improvements in the development process and the product outputs from QFD have only been demonstrated for component type products and services (of all different levels of complexity) for which the development team and their managers are all committed to using QFD to specifically effect a change in either the product or process.

Of the seven successes in the sample, more of the projects improved characteristics associated with the resultant product or service than with the process used to obtain it. Only two projects claim that they think using QFD was responsible for decreases in the time or cost to commercialization. These two projects (Durables B-1 and HiTech B-6) are both components with multiple customer sets from whom market information must be obtained and where the teams were developing "next generation" products. Using QFD was primarily the idea of the members of the team, who undertook implementing QFD with specific affective goals they wanted it to provide.

Of the 11 component type projects in the sample for which results are available (two projects are not completed or far enough along to determine whether these variables will be affected) only these two measurably improved the commercialization process. They are also the only teams of the 11 which undertook using QFD with specific affective goals in mind, and with high levels of buy-in for using QFD from both the members and their managers. While the results from this sample may not generalize, product development process improvements were achieved only for products of the component type, and only for those component products where QFD was implemented with specific affective goals in mind, and where both the management and the team had committed to using the process.

The two component products listed above claim QFD provided product improvements in addition to the process improvements. However, they are the only products for which QFD provided improvements. The other five teams who indicated that using QFD improved product-related outcomes were all modifying already existing services, not products. These teams used QFD affectively, to either drive service offerings based on customer needs (two projects) or change the operations used to provide the services (three projects). Both the teams using QFD and their managers were highly committed to using QFD as the process for developing the products.

Only two service applications in the sample did not indicate that using QFD provided tactical benefits. The only difference between these two projects and the five successful service projects is in the level of buy-in to using QFD. While the managers of the service projects not attaining tactical success were committed to using QFD, the groups developing the project were not. Everybody was committed to using QFD in the successful projects.

Projects with Mixed Results from Using QFD

Overall, eight projects using QFD resulted in a mixture of change where the improvements outweighed the negative aspects. In each case, the worsened outcome was a slower time (compared to what would have been expected from the "traditional" process) to commercialization. However, the team from each of these eight projects indicated that QFD had provided them with significant strategic benefits. On average, each of the eight teams cited 3.5 different kinds of strategic benefits for using QFD. This is higher (but the difference is not statistically significant) than the average number of strategic benefits cited across all the projects in the sample (2.4).

The eight teams with mixed results had several factors in common. None of the eight were highly committed to using QFD for developing their product. None of the teams were highly familiar or had worked together prior to this project. The level of cross-functional integration is generally low in each of the companies with a mixed-result project and people are promoted predominantly within their own functional area.

That all these "slow" teams had these factors in common leads me to speculate that perhaps part of the reason using QFD was taking longer for these projects than their traditional process was because QFD had to first build the unfamiliar members of the team into an integrated group. Because the functions at the firm were generally not well integrated, forging the cross-functional relationships needed to make QFD work was taking significant amounts of time. Five of the mixed result teams (62%) specifically cited "better, stronger teams" or "improved cross-functional relationships" as a strategic benefit of using QFD, which seems to provide support for the above speculation.

A total of 19 projects in the sample have the characteristics that are common across the eight mixed result projects. Of those 19, over 50% (10) resulted in slower development when QFD is used as the process for product development. Two of those projects were abandoned, eight were continued. While these results may not generalize past the projects in this sample, this research suggests that using QFD in companies where the functions are not well integrated is quite risky and may take longer to complete than the normal process, especially when all the team members and their managers are not highly committed to using the process.

QFD Projects That Show No Indications of Strategic Benefit

Members of four projects (11.4%) which have not been abandoned or the results rejected have not found they could identify any positive aspects from using QFD. While QFD has not been detrimental, it has not helped in any special way. A characteristic common to each of these projects is that they are "generic" projects where QFD was used to specify in great detail all the customer attributes for products in entire product category and understand the links between customer needs and engineering characteristics. There are no specific problems in the category that QFD is solving.

Two Japanese QFD examples that have been cited as "very successful" applications of QFD were for generic charts. However, each of these generic charts was used to solve a specific problem endemic to a whole product line. All of Toyota's car models had horrible rust problems 10 to 15 years ago. This problem was complex; rust occurred in many different parts of the car and its mechanical components. No one car line had the resources to study and solve the entire problem. Toyota's solution was to use QFD to draw together the appropriate people responsible across the car lines to solve the problem simultaneously for all of them. Toyota also used QFD to solve the problems of vibration and driver visibility in all its fork lift trucks. These generic QFD studies led to sets of design principles to eliminate the particular problem investigated that could be applied across all the products in the category.

Generic QFD charts in the US are usually the suggestion of upper managements who see doing a generic chart as one of the ways they can "save time" and yet still use the process. The teams saddled with this work are generally doing it in addition to their "real" jobs. The tedium of the tasks, generating huge lists and understanding how the attributes fit together, quickly becomes bothersome to many team members, who can think of many better ways to spend their time.

There seems to be a large difference between the Japanese and US generic QFD charts seems to be in their goal orientation. The Japanese teams start with a problem and drive to solve it using QFD. The charts get large, detailed, and very complex, but they only cover aspects of the product that affect or are affected by the problem under investigation. The US generic charts are also large and complex, but they don't have any purpose in life. While they may structure the team's thinking about some problem areas, they waste a lot of time laying out details for product areas that are not problems. This limited set of US data suggests that the generic use of QFD will not produce product development process or product improvements unless QFD is undertaken with specific affective goals.

QFD Failures

The four QFD projects where using the process was either abandoned or the results rejected by management had a number of similar context and implementation factors including:

- low team or management commitment to using QFD
- attitude that using QFD is an expense, not an investment
- low to moderate team familiarity
- low levels of functional integration in the corporation
- personnel movement primarily within function
- clean sheet efforts (3 out of 4 projects).

Using QFD was a failure in four of the five projects in this sample that met these requirements. The two most important criteria for creating failures are the top two listed: four of the seven projects with low QFD commitment and for which QFD was treated like an expense were implementation failures. While these results may not generalize to other projects or companies, they suggest that obtaining high levels of commitment from the personnel on the team and treating QFD like an investment in people and information are crucially linked to preventing projects and managers reject the process or its results.

H.4. Differentiating Between Success and Failure

Of all the variables investigated, only two implementation and management variables cleanly differentiate between QFD project successes and failures.[7] While QFD has the potential to be successfully applied across many contextual variations of product development projects, success is achieved only if two conditions hold. Firms always treated successful QFD projects like investments in people and information, while failures were always treated them like expenses that must be incurred, but should be minimized (Figure 2.2). All the involved management and team members of the successful projects were highly committed to using QFD as the process for development (Figure 2.3). Only one subset of the group was committed to QFD in the implementation failures.

An additional implementation variable that seems to be necessary but not sufficient for project success is the goal orientation of the project Figure 2.4). Six of the seven successful QFD projects were undertaken to effect a specific change in some aspect of the product or development process. However, an affective goal did not ensure success. Two of the failed QFD projects had affective goals.

One can hypothesize that project goals contribute to the team's commitment to QFD. Perhaps buy-in to using QFD was high in the successful projects because the team was going after a goal that they believed QFD would allow them to reach, but which they could not foresee reaching using any other means. Although the findings of this research may not generalize to other cases, it suggests that to be successful, QFD projects should not only have specific goals which the team wants to achieve, they must also be committed to the idea that QFD is the most appropriate means to achieve them.

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[7] The results for variables differentiating between success and failure are pictured in this chapter. The figures demonstrating the lack of relationship between the remaining variables analyzed and project success or failure can be found in Appendix 2.4.

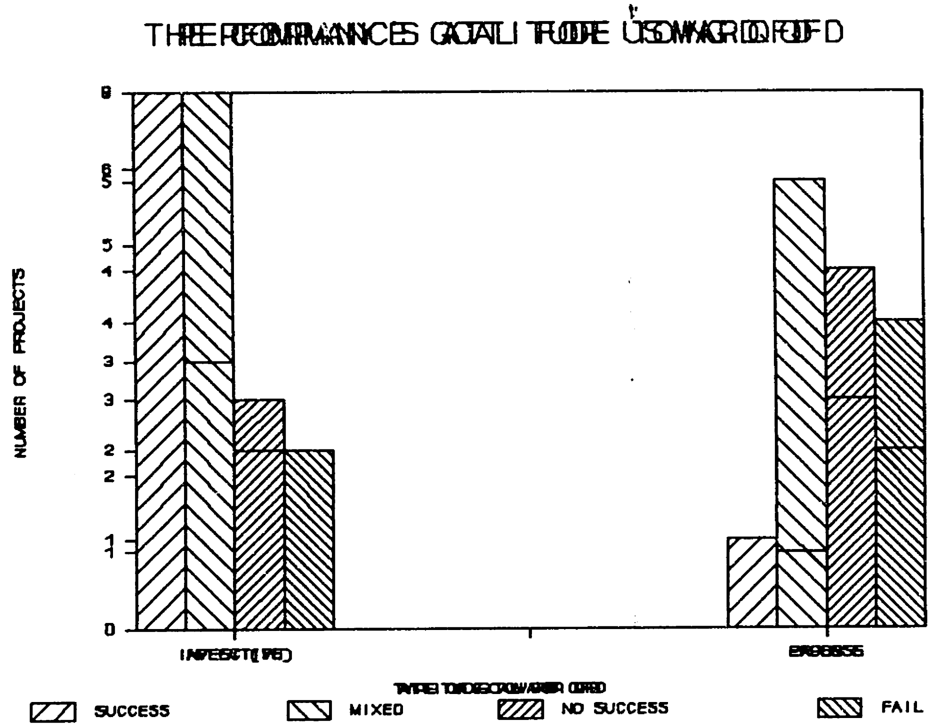

Figure 2.2. Implementation Variables Differentiating Success from Failure

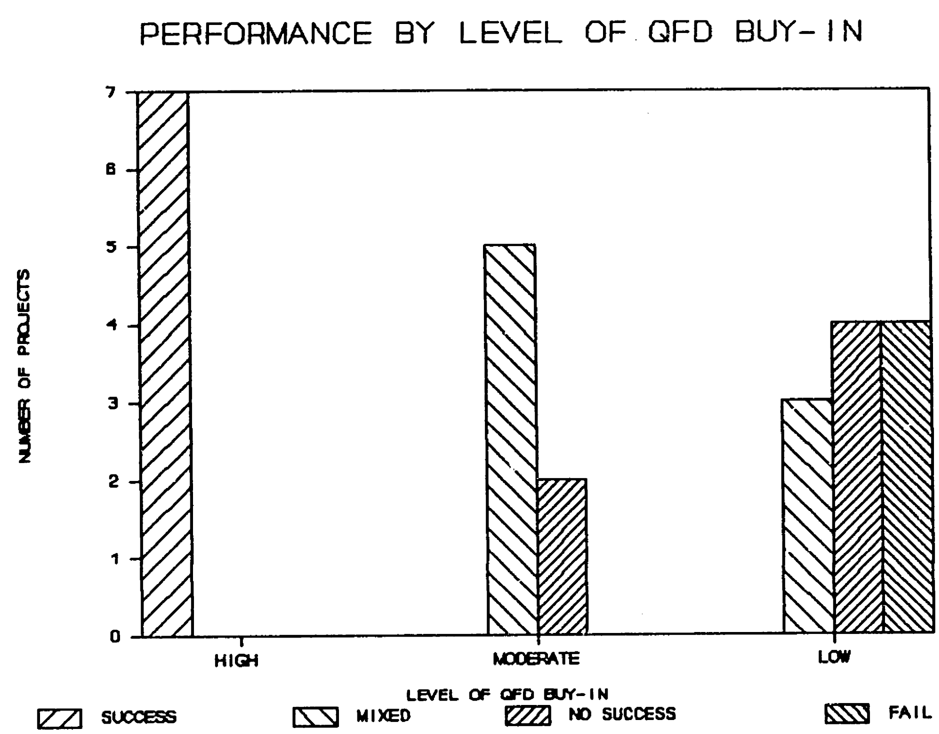

Figure 2.3. Implementation Variables Differentiating Success from Failure

While none of the other implementation or context variables cleanly differentiates between project success and failure, the figures summarizing differences between kinds of success and failure in Appendix 2.4 provide some additional insights toward improving the probability of success in applying QFD.

Some of the context variables seem to be more associated with some kinds of outcomes than others. The dependent projects tended toward successful or mixed results while the independent projects were more likely to produce no strategic benefits or fail (Figure A2.1). Successes only occurred for projects using QFD on services and component level projects (Figure A2.2). Mixed results, failures, and projects lacking strategic success were distributed across the levels of project complexity. Using QFD to determine which services will be offered or to improve the operations delivering those services is more likely to result in some kind of improvement than no improvement or an implementation failure. Out-and-out failures occur when QFD is used on projects seeking higher levels of change, especially those starting with a clean sheet (Figure A2.3). No successes were achieved for clean sheet QFD projects.

One additional implementation variable, who is pushing to implement QFD, seems to be more associated with some kinds of project outcomes than others. Far more successes or partial improvements were achieved with QFD when the proponents of using the process were persons other than upper management (Figure A2.4). Dictating QFD's use from the top of the division or corporation seems to be associated with fewer cases of successful or partially successful implementation. On the other hand, when the project members are the ones pushing for QFD, the implementation almost always produces at least partially successful results.

H.5. Closing Remarks About QFD's Apparent Utility

The results on the success and failure across the 35 new product development projects in this sample suggest that QFD is not a panacea. It may or may not be the solution to cure US product development ills. It produced improved results only when specific changes were being sought. Furthermore, the way QFD is implemented in a project or corporation may have more to do with whether it achieves the hoped-for improvements than the context of the project or some of the specifics of the process itself.

When all the team members in all functional areas and their managers are committed to using QFD as the means to drive toward achieving a specific affective goal, and when they and upper management treat the time, energy, and money spent on implementing the process as an investment in the product and team, QFD may provide at least some of the tactical benefits touted by QFD proponents. However, judging from the number of projects not achieving tactical successes from using QFD, guiding implementation of the process is not easy. It can be hampered by a lack of support from any one of the four functional areas involved in new product development. One key success factor in implementing QFD is having champions for the process among the engineering, manufacturing, planning (management), and field functional staffs on the project.

The implementation effort is also hampered if adequate personnel time is not provided for going through the process, especially early in the development effort. Time is more likely to be available if management sees QFD as an investment in the future of the product. Management patience and support for the time to build a group of individual contributors into a cohesive team and let them work through the details of the House of Quality before pressing them for specific design or specification changes is key to providing an atmosphere conducive to using QFD successfully.

In some companies where the functions are not well integrated, QFD may actually lengthen development time. Indeed, before any tactical benefits from QFD are realized in one of these companies, it may be necessary to increase the company's level of cross-functional integration. For these companies, QFD might be a useful change actor over a period of time in moving the company toward higher levels of cross-functional integration.

In conclusion, if I was a manager in a corporation who wanted to improve the way new product development was done at my company, QFD is one of the techniques I would want to have available for new product development teams. As a manager I have a fine line to walk; I have to make the technique available and support its use with time and money, but I can't push it on teams without their consent and commitment. I also probably need to guide projects with little chance of using QFD successfully (clean sheet, complex, strictly process-oriented groups) away from QFD. In my corporation, QFD needs be one technique in an arsenal of methods for developing new products.

CHAPTER 3. THE COMMUNICATIONS STUDY

A. Background and Impetus for the Research

Research suggests that new product development processes that improve cross-functional communication during new product development improve product development performance. In a study of the relationships between marketing and R&D, Souder (1988) showed that increased communication was a major contributor to increased harmony between the two groups. More harmony in turn contributed to increases in the percentage of commercially successful new products developed by the groups.

Dougherty's (1987) research correlated product success with increased communication between all the functions involved in new product development. Dougherty's findings, however, indicated that content of the information conveyed was also important. Dougherty identified nine subjects, under the general topics of design and technology, market, and planning, that were important to communicate between the functional groups involved in new product development. All team members of more successful projects consistently had higher levels of knowledge across all content areas. Team members of unsuccessful projects had gaps in at least one type of content.

Gupta, et al. (1985a) found that a lack of cross-functional communication can build barriers to integrating across functions. When surveyed, industry marketing and R&D managers identified 19 subjects that industry managers feel need better cross-functional information flow. Both Gupta, et al., and Dougherty indicate that content as well as communication level are important in integrating across functions.

If QFD or any other new product development process is to improve product development performance, the above research suggests the process must improve cross-functional communication. This phase of the thesis set out to investigate what, if any, effects using QFD as the new product development process has on the communication amount and patterns of a new product development team.

B. What are the Research Needs?

Dougherty's (1987) communication data were in the form of individual subjective perceptions of the overall amount of project-related communication for new product development projects. Souder (1988) collected subjective perceptions of communication levels over the life of projects. Gupta, et al., (1985a) surveyed respondents regarding their perceptions of the general relationship between communication and past project success.

While this research consistently supports the general correlation between communication level and project success, it also suggests a number of research opportunities. One research need is to try to implement a less subjective set of communication measures. With individually subjective measures of communications level there is always a possibility of bias in the results, especially for any data gathered retrospectively. Using a measure which quantifies "a lot" and "some" or substitutes actual amounts for current subjective measures would allow finer-grained research questions to be investigated.

Two more specific research questions are of particular interest.

- Do communication levels need to be uniformly high for all participants of all functions involved in the project throughout the entire new product development process?
- What specific sorts of product development process changes positively affect project-related communication?

So far, reported findings only relate overall communications levels across an entire project to success. The research to date also has not attempted to relate which process aspects lead to increased communication.

This thesis is intended as a pilot for additional post-graduate research. The thesis demonstrates that it is possible to implement a more quantitative measure of real-time communication in field research for multi-functional new product development projects. This thesis investigates communication levels and patterns for one matched pair of new product development projects within one firm using different management processes in one firm. Users of QFD claim that QFD increases communication. This claim is investigated by comparing communication for a project using QFD to one that does not.

C. Key Findings: Communication in New Product Development Projects

Communication consists of levels of interaction and degrees of effectiveness the flow of information from one point to another. The findings of this project suggest research should not just look for a process which increases aggregate communication levels. A "better" new product development process should produce increased levels of efficiently-flowing communication. In this research:

- A measure for quantifying communication levels was successfully implemented in field research which minimizes the subjectivity of the participants.[1] The measure is daily conversations per functional communication link.

- The efficiency of information flows is inferred from specific values of the quantitative measure implemented.

In this one case comparison between a team using a QFD process and another using a more traditional process to develop two components of comparable technical complexity at the parts specification stage of development:

- Aggregate levels of organization-wide and cross-functional communication indicate that the non-QFD team interacts more in ways that previous research has related to increased project success. However,

[1] However, this measure does not indicate the "quality" of the communication.

a qualitative analysis of the micro-level information flow processes through which these increased levels are attained suggests that the non-QFD team information flow process may be less efficient than the QFD team process.

• Communication among the members of the team using QFD was about 38% higher per communication link per week. Total communication levels, including communication with non-team members, was higher for the non-QFD team, by 14%. Neither difference is statistically significant ($p > .05$).

• While the QFD team's within-function communication level per week per communication link was 2.1 times the non-QFD level ($p < .05$), the non-QFD team had 22% higher levels of cross-functional communication ($p =$ ns).

• Analysis of the patterns of communication show significant differences between the two teams. The data are consistent with the hypothesis that while the QFD OEM and supplier personnel within one function talk directly to each other, communications between the functional (especially design) groups of the two companies for the non-QFD team are primarily channeled through an upper level manager at the supplier firm. While this flow dramatically increases the perceived amount of cross-functional communication in the non-QFD team, it has increased at the expense of putting in a filter between the within-function discussions.

These findings were obtained using a quasi-experimental case study for a single pair of projects at one stage (parts specification) of the total design process. They may not generalize to other phases of new product development, other firms or other (different) applications of QFD to projects.

D. Collecting the Communications Data

D.1. The Projects Investigated

Since QFD is in the early stages of U.S. implementation, no company has yet fully instituted QFD within or across all divisions. Most companies using QFD have some groups which have already adopted QFD as the process they use to develop new products, but others which have not yet changed from their current method for developing products. This study compared communication levels cross-sectionally for one project using QFD and one not using QFD within one division of a large US corporation.

The data were gathered at a manufacturer of complex consumer durables[2]. The two components studied are of comparable technical complexity: they serve similar functions, have about the same number of people involved in the project, and consist of about the same number of parts[3]. Both products are manufactured by outside suppliers, but designed by the OEM producer, and both are in the parts-specification stage of development.

The managerial aspects of the two projects are also ideal for this study. These components are designed by two different and completely independent teams, one of which uses QFD while the other does not. Both projects report to the same upper level manager (2 levels up). While the manager is supportive of projects using QFD (one of the requirements for QFD success) each supervisor is committed to the particular process he's using. The QFD project supervisor really wants to use QFD, it is not being forced on him. The supervisor of the traditional process project does not want to use QFD. His standard process "works just fine," and he's proud of that.

The members of the two teams can be categorized both functionally and by company affiliation (Table 3-1). As outlined by Dougherty (1987), different functional personnel live in different "thought worlds." The thought worlds, arising from educational and professional orientations, color the way functional personnel approach solving problems, completing tasks, and working with others, as well as the language they use. Each function contributes specific expertise toward completing the project. Depending on the phase of

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[2] For confidentiality reasons the name of the manufacturer, the specific products produced, and the particular components studied can not be identified. Items that fit into the general category of "complex consumer durable" include appliances, furniture, vehicles (boats, mobile homes/trailers, cars, and trucks), and personal computers.

[3] If the durable was a car or truck, an analogous set of components of "comparable technical complexity" might be the head light and tail light.

Table 3.1. Team Membership by Function and Company Affiliation

FUNCTION	QFD Team OEM	QFD Team Supplier	Non-QFD Team OEM	Non-QFD Team Supplier
Design	2	1	2	1
Manufact.	3	0	3	2
Field	0	1	0	1
Planning	2	0	2	1
TOTAL	7	2	7	5

the project, one function's contributions may be more crucial to success than another's.

In this research team members have been assigned to one of four functional categories. **Design** consists primarily of engineering design. **Manufacturing** includes process engineers, quality control, production personnel, and purchasing. **Field** personnel include those in marketing and sales. **Planning** includes management, finance, strategic planning, and market research staff members. All five Planning members of these two projects are managers. These categories seemed to capture the major differences in orientation without creating either an unwieldy number of categories for analysis, or a number of categories which contain no team members.

Team members work for either the component supplier (referred to as "supplier" members) or the durables manufacturer (referred to as "OEM" members). The biggest difference in membership between the QFD and non-QFD teams arises because the QFD team has only two supplier members, compared to five for the non-QFD team. It is the supplier members of the non-QFD team that change the functional membership numbers. While the OEM parts of the two teams are split identically between functional categories, supplier members swell the manufacturing and planning categories of the non-QFD team.

The non-QFD supplier fields a full complement of functional members to the team as compared to the QFD team which only sports supplier members in two of the four functions. I would expect the non-QFD supplier communications to therefore be more "interesting" or "complex" than for the QFD team.

The non-QFD supplier members can contribute to communications across many more boundaries than the QFD supplier members.

D.2. The Survey Instrument

Communication was measured using a modification of Allen's (1970; 1979; 1984) methodology which has been used repeatedly, primarily within R&D organizations, to quantitatively study communication between people and groups. The technique elicits the number of project-related communications per day between project members over a period of time using a one-page questionnaire listing all potential communicators. At the end of each day on which data is gathered, respondents indicate which persons on the list they talked to about the project that day.

In this research, core team members for the two projects, those contributing substantially to the project or assigned to it for a majority of their time, fill out a survey form on randomly assigned days once a week. The names of all the core team members are listed on the instrument. Also listed are all the other functions most likely to contribute, at some point in the development, to the project, but which may not currently have members on the team. The team members also indicate which, if any of these functions they talked with during that day, although those supporting personnel do not fill out the forms.

For this test, the instrument has been modified to include 12 areas of content which are of interest. These 12 subject areas have been chosen based on the information areas that Dougherty (1987) and Gupta, et al. (1985a) indicated contributed to successful new product development. The 12 categories listed can be broken into four content areas:

Design Issues	Customer Needs
Product Features	Expressed Needs
Competitor Product Features	Unstated Needs
Design Capabilities	Product Use by Customer
Manufacturing Capabilities	Cost/Pricing
Market Information	Business Planning Information
Competitor Strategies	Relationship to our Strategy
Segments/Sizes	Administrative/Logistics

As well as indicating who they talked with on a response date, respondents also indicated which content area(s) they felt were covered during the conversation. The content data have not been analyzed. A sample survey form is presented in Appendix 3.1.

D.3. The Data Gathering Protocol

The two teams filled out survey forms for the projects in the study on random days for 15 weeks from October 3, 1988 and January 13, 1989. Prior to the start of data collection, I met with the members of each team at the research site to introduce the project and instruct them on how to fill out the forms. At this meeting the team members were also given hard copies of the instructions (Appendix 3.1), a document defining what was meant by each type of conversation content (Appendix 3.1), and a set of survey forms with their name and the date each was to be filled in already indicated. Each form was paper-clipped to a pre-stamped return envelope.

On each morning that a survey form was to be filled out by the team members, I called each person to remind them it was a survey day. These reminders were used to obtain as high a compliance rate as possible for the study. A reminder was delivered by talking to the person directly, leaving a message with someone else, or leaving a message on voice mail or an answering machine.

D.4. Results of the Data Collection

Overall, response rates were 85% across both teams (Table 3-2), with the non-QFD team's rate consistently higher. While the reminder had a large impact on the QFD team's response rate, it had a much lower impact on the non-QFD team.

Table 3.2. Communication Study Response Rates

	RESPONSE RATES		
	QFD Team	Non-QFD	Combined
Overall	77.0%	91.1%	85.0%
% Reminders Delivered	93.0%	94.7%	94.0%
Response with Reminder	79.8%	91.3%	86.4%
Response, no Reminder	40.0%	87.5%	61.1%

E. Analyzing the Results of the Communication Study

E.1. The Measure: Conversation per Communication Link[4] in the Group

This communication study gathered the number of daily project-related conversations each project team member held with persons on his/her team, as well as with others not on the team. These individual numbers are aggregated to the group level for comparisons across projects. Groups are defined by both the functions and corporate affiliations of the two individuals communicating. Before aggregating the raw data to the group level, each individual's responses must be adjusted for their reliability in reporting conversations. Before the number of conversations per group can be used in any analysis of more general effects of the product development process, it must be adjusted for the number of communication links in the groups (group size).

The Basic Unit of Analysis: The Group

Verbal communication requires two people. Each team member has been characterized by a corporate (OEM, supplier) and functional (design, manufac-

[4] A "communication link" is the bond between the two people communicating. Communication is averaged or standardized by link, not by the number of group members.

turing, field, and planning) identity. Therefore any communicating pair can be identified by its two company affiliations and two functional designations. The basic units for analysis in this research are the groups of personnel with the same corporate and functional identities. The individual level data aggregate into 30 basic groups. The three combinations of the two corporate affiliations[5] join with the 10 pairwise combinations of the four functional designations[6] to produce the 30 units. Aggregate communication for broader aspects of the team, for instance communication amongst all OEM members, will be built up from the results for the smaller units with the appropriate designations.

Adjusting for Respondent Reliability

If participation in conversations could be automatically recorded by some magic means, respondent reliability would not be an issue. However, although Allen's technique tries to minimize recording errors by only requiring same day recall of conversations and providing team member names and functional designations as reminders, errors are still likely to arise due to lapses in respondent memory.

The reporting technique used in this research provides dual reports of all conversations between respondents within the team. Dual reporting can be used to check the "reliability" of each respondent in the study. Reliability, R^i, is the proportion of time that the communication situation respondent "i" reported with the other individuals on his project team matched the

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[5] The corporate designations for a communication pair will be: OO (OEM-OEM), OS (OEM-Supplier), and SS (Supplier-Supplier). The OS designation indicates cross-company communication has taken place.

[6] The four functional areas, Design (D), Manufacturing (M), Field (F), and Planning (P) combine to the following 10 pairs: DD, FF, MM, PP, DF, DM, DP, FM, FP, and MP. The four functional pairs with two identical functional designations are within-function or intra-function communication. Pairs with two different functional designations are cross-functional communication.

situation each of those individuals reported with him. Formulae for calculating R^i are in Appendix 3.2. The average reliability of the respondents was .947; on average, what respondent "i" said agreed with respondent "j" 94.7% of the time.

Completely reliable data would produce a symmetric raw data matrix for each response date where the number of conversations reported by person "i" with person "j" equalled the number "j" reported having with "i," or $C_{ij}=C_{ji}$. Data with reliability errors produces a non-symmetric raw data matrix; not all the C_{ij}'s equal the C_{ji}'s. A symmetric matrix of "adjusted conversations between individuals" (AC_{ij}) is produced from the asymmetric matrix using each individual's reliability to adjust the values of the asymmetric cells, cells where differences exist between two people's reports in whether or not a conversation took place or in how many conversations took place in one day. Reliability is also used to adjust the probability that a conversation took place when one of the two respondents did not return their survey form for a response date.

When both communicators returned their questionnaires,

$$AC_{ij} = AC_{ji} = \frac{(C_{ij}*R^i) + (C_{ji}*R^j)}{(R^i + R^j)} \quad . \qquad (3.1)$$

For cases where $C_{ij} = C_{ji}$, this formula implies $AC_{ij} = AC_{ji} = C_{ij} = C_{ji}$. When only one respondent's data is available to verify a conversation (the other did not return that day's survey): $AC_{ij} = AC_{ji} = C_{ij} * R^i$. Note that this is a conservative measure ($R^i < 1$), thus it underestimates reliability.

Adjusting for respondent reliability converts the asymmetric raw data into a symmetric matrix. Since $AC_{ij}=AC_{ji}$, the adjusted conversations matrix need only contain the values for $j<i$. The values in the adjusted matrix are aggregated to obtain total conversations by basic analysis unit.

Adjusting for Group Size

If total communication by group was the comparison measure used, differences in group size would bias the results because larger groups have more communications links, both within the group and between group members and other personnel outside the group. Therefore, before analyzing the results across the two projects, differences in the number of communication links in the basic units of analysis for each team will first be adjusted for.

The number of communication links varies depending on whether communication is within one group of people or across two different groups. The within group number of communication links, L_w, is (N)(N-1)/2, where N is the number of people in the group. Eight of the 30 basic analysis units measure communication within one group of people. The members of each of these units work at the same company in the same functional area. For example, within-group designations include OODD, SSPP, and OOMM.

The other 22 analysis units measure communication across different organizational units: corporate, functional, or both. Examples of cross-organization designations include OODM, OSDD, and OSDM. The number of links, L_x, between groups is: $L_x = (N)(M)$, where N and M are the number of members in each of the communicating groups.

Daily conversations per communication link, DC_w, for the eight within-function and company basic groups, adjusted for respondent reliability are:

$$DC_w = \frac{\Sigma_{i=2}^{N} \Sigma_{j=1}^{i-1} AC_{ij}}{L_w} = \frac{\Sigma_{i=2}^{N} \Sigma_{j=1}^{i-1} AC_{ij}}{[(N)(N-1)/2]} . \quad (3.2)$$

Daily conversations for the 22 analysis units whose members crossed organizational boundaries, DC_x, are:

$$DC_x = \frac{\Sigma_{i=1}^{N} \Sigma_{j=1}^{M} AC_{ij}}{L_x} = \frac{\Sigma_{i=1}^{N} \Sigma_{j=1}^{M} AC_{ij}}{(N)(M)} . \quad (3.3)$$

Each project team has 15 response dates of data for daily conversations, averaged by the number of communication links in each unit and adjusted by the intrinsic reliability of the respondents in that unit, for each of the 30 basic communication units.

E.2. Differences in Communication Levels

Differences in the average amount of communication for the two teams were identified through ANOVA tests across the 15 data gathering periods. Analyses were done at the level of the basic units of analysis and for a number of aggregations of the basic units. Statistical significance of the differences of the means is attained when $p<.05$ across the two project means.

E.3. Differences in Communication Patterns

Differences in patterns of communication among the various functions were identified using χ^2 goodness of fit tests between the non-QFD and the QFD sets of results, with the non-QFD team treated as the "expected" values for the model. Because the χ^2 test is sensitive to differences in the magnitude of numbers, an appropriate time frame for analyzing the model had to be chosen. Although the period of time chosen for analysis is important, the choice is arbitrary. I have chosen to use average weekly communication as the period which will be used in this research to determine whether differences in the patterns of conversations exist between the QFD and non-QFD teams. If a new product development process is to affect communication, I expect it to produce visible affects on a weekly basis. A process change producing effects visible only over a longer period of time is probably too subtle a process change to impact the results of new product development.

Statistical significance of the results is again defined as the cases where $p<.05$ for the χ^2 goodness of fit test.

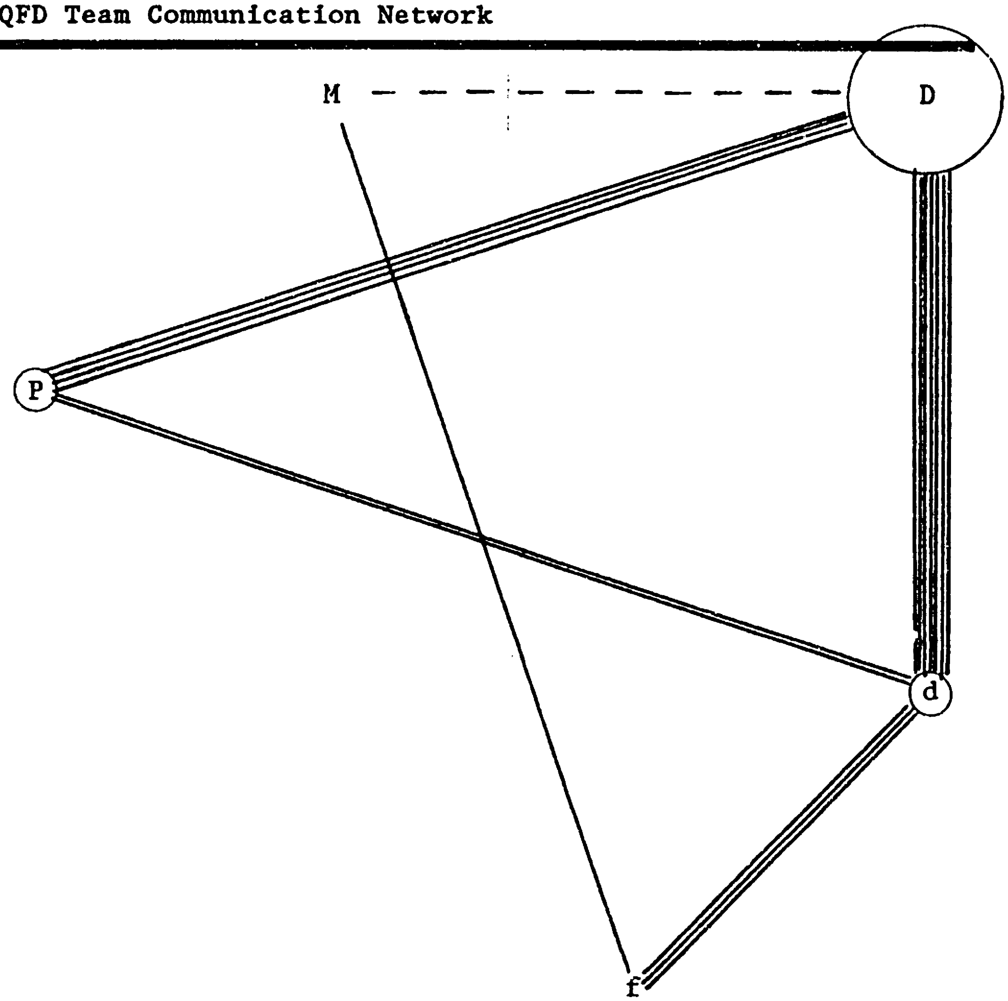
F. Results and Conclusions from the Communication Study

No previous research has ever correlated specific levels of communication to new product development success. The projects studied here are not completed yet. They won't go to commercialization until 1991, so correlating specific levels of particular types of communication with project success is not feasible (yet) even with this experimental technique. Thus, it's impossible to conclude after this one experiment whether using QFD will improve the team communication in ways beneficial to new product development.

This section analyzes and presents the differences in communication across the two teams and presents alternative explanations for the mechanisms which may be operating. The results from the research are presented first at the highest level of aggregation - total conversations per communication link - then parsed into various pieces of the total for further analysis. Three partitions of the total amount are of special interest: cross-functional versus within-function communication; the split between OEM, Supplier, and cross-company communication; and by-function communication (design versus manufacturing versus field versus planning). Appendix 3.3 presents supporting data by basic unit of analysis for the two teams.

The results of this field quasi-experiment are mixed. Whether QFD has improved new product development communication in total is unclear. While some of the aggregate results suggest that the non-QFD team is communicating more than the QFD team, the patterns of communication appear to be more efficient for the QFD team. The pattern of communication across the two projects, as shown in Figures 3-3 and 3-4, differs. In the QFD team, the design personnel communicate directly with all but one of the other functions involved in the project. They are better networked in than the other functional groups. On the non-QFD team, the field is better cross-functionally linked

Table 3.4. QFD Team Communication Network



Legends:
- .05 conversations/day/pair
- .1 conversations/day/pair
- size is proportional to strength of within function communication

Functions:
P - Planning
F - Field
D - Design
M - Manufacturing

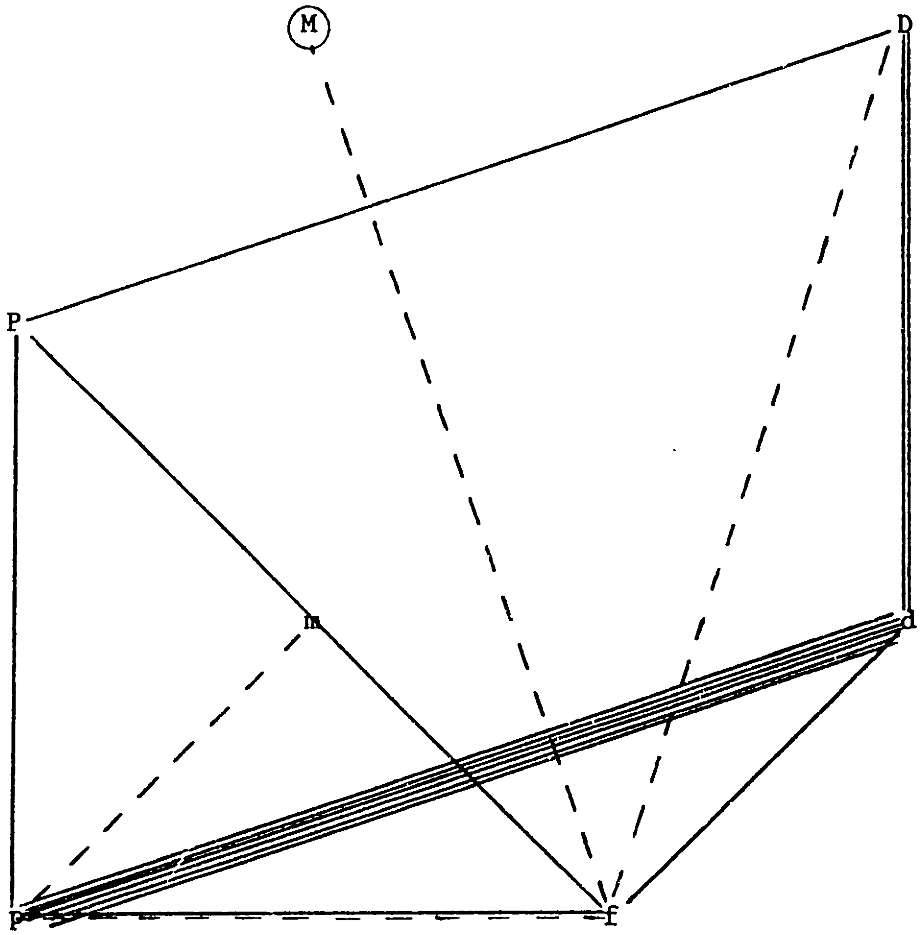
CAPS - OEM
lower case - supplier

higher levels of cross-functional communication than the QFD team. On the other hand, the QFD group may be working better as a team than the non-QFD team: there are more within-team and within-function conversations than for the non-QFD team. The two companies involved with the QFD project are also better tied together through communication.

F.1. Total Conversations by Team

The total number of conversations among team members by response date

Table 3.3. Non-QFD Team Communication Network



Legends:
— — — = .05 conversations/day/pair
——— = .1 conversations/day/pair
○ = size is proportional to strength of within function communication

Functions:
P = Planning
F = Field
D = Design
M = Manufacturing

CAPS = OEM
lower case = supplier

than any other group, followed by the planning personnel. While the QFD team has fewer different groups to link, each of the links is stronger than the corresponding non-QFD team link.

The aggregate level findings (Table 3-5) suggest that the non-QFD team seems to be better tied in with other organizational units across the two firms involved with the project than the QFD team. The non-QFD team also has

Table 3.5. Communication Performance Summary

AVERAGE COMMUNICATION LEVELS

QFD Team Higher	Non-QFD Team Higher
Total Intra-team	Total Intra-Organization
*Within-Function	Cross-Functional
*Design	Planning
Across Company	

* $p<.05$ for difference between averages

was obtained by summing the conversations per communication link for each of the 30 basic units of analysis (Table 3-6). When only the conversations among team members are included in the analysis, the QFD team talks about 38.6% more each day than the non-QFD team. However, the difference is not statistically significant. The pattern of the conversations across the 30 cells of the basic units does differ between the two teams, with the OODD (OEM/Design, within function) group accounting for much more of the total conversation in the QFD team than in the non-QFD team. This evidence suggests that QFD in fact may be drawing the development group together into a solid team, compared to the non-QFD development group.

Table 3.6. Total Daily Conversations per Communication Link

	Non-QFD	QFD	ANOVA[a]	χ^2 [b]
Intra-Team Total	1.97	2.73	ns*	$p<.05$
Total Intra-Team and -Organization	3.25	2.85	ns	ns

[a] ANOVA tests whether the difference across the means is statistically significant.
[b] χ^2 tests whether differences in the

The non-QFD team talks with many more outsiders about their project than the QFD team does. When these conversations are added to the intra-project totals for the two teams, the non-QFD team total daily conversation is now 14.0% higher than the QFD team's total, but again the difference is not statistically significant. Including outside team conversations in the analysis also eliminates any differences in the patterns of communication across the basic units. The non-QFD OEM Design group is actively conversing with other design engineers in their own company about their project, rather than talking about the design among themselves.

Compared to the non-QFD team, QFD might increase slightly total communication among new product development team members, and decrease the amount of communicating the team members do with others external to the team, although neither of these effects is statistically significant. These changes may be either detrimental or beneficial depending on the purposes of that external communication. If organizational communication is being used to gather information not available from members of the project team, then orienting the team inwardly using QFD may be detrimental to the project. A number of researchers (Allen, 1964; 1984; Allen, et al., 1980; Baker, et al., 1967; Pelz and Andrews, 1976) have shown that for development projects the best sources of technical information lie within the organization. More successful projects tap those organizational sources for technical information. Katz and Allen (1982) have also shown that long team tenures and lower project performance correlate significantly with decreases in organizational communications for development projects (the Not Invented Here syndrome). If QFD is reinforcing a tendency toward NIH, then its effects on project outcomes should not be beneficial.

However, if the non-QFD team is substituting information sources outside the team for internal ones as personal risk-reducing measures (Allen, 1984), then using QFD may prove beneficial because it promotes the efficient use of internal information sources. QFD may also prove beneficial to new product development if the increase in intra-team communication is due to earlier transfer of information along the paths needed for moving to the next stage of development, instead of having transfer take place all at once. Hayes and Wheelwright (1988) have suggested that the continuous transfer of a new product from function to function is preferable to a one-time mass transfer.

This research cannot determine which of these explanations obtains.

F.2. Cross-Functional versus Within-Function Communications

When company affiliations of the team members are ignored, the QFD team consistently exhibits higher levels of within-function communication and lower levels of cross-functional communication than the non-QFD team (Table 3-7). The only significant difference between the two teams is in the intra-project within-function communications, where the QFD team communicates at over three times the level of the non-QFD team. The non-QFD team only has about one within-function communication every other day, over all the functional areas. They seem to be holding their within-functional communications primarily with others outside the team.

Table 3.7. Comparing Within- and Across-Function Communication

DAILY CONVERSATIONS PER COMMUNICATION LINK	Non-QFD		QFD		ANOVA	χ^2
	Level	% Total	Level	% Total	p	p
Intra-Team Total	1.97		2.73		ns	<.05
Within Function	.47	23.9%	1.50	54.9%	<.05	<.05
Across Function	1.50	76.1%	1.23	45.1%	ns	ns
Intra-Org. Total	3.25		2.85		ns	ns
Within Function	1.29	39.7%	1.50	52.6%	ns	ns
Across Function	1.95	60.3%	1.34	47.4%	ns	ns

Whether this increase in within-function communication is an advantage of QFD is unclear, especially since the non-QFD team members communicate with others in their own functional areas off the team, but within the organization. While this may be an indicator that the non-QFD team is actively seeking ideas outside the team (correlates with more success), it also indicates that the non-QFD project members are not acting much like a team. The team members seem to be working relatively independently and drawing needed resources from contacts they have external to the team, not from others on the team. More than one pair of persons across different functions communicates each day for both teams. The balance between within and cross functional communication is more evenly split on the QFD team than it is for the non-QFD team, where over 75% of the intra-project communications are cross-functional. Again, because of the lack of previous research in this area, it's not known whether balance between within- and cross-functional communication will affect project success.

F.3. OEM, Supplier, and Cross-Company Communication

By ignoring the functional designations of team members, the aggregate influence of corporate affiliation, another measure of communication across organizational boundaries, on communication can be analyzed (Table 3-8). The QFD team communicates across the corporate boundary 90% more frequently than the non-QFD team, even though the difference is not statistically significant. Significant differences exist in the levels of OEM and Supplier communications between the QFD and non-QFD teams, with QFD OEM personnel talking more than non-QFD OEM personnel, and non-QFD Supplier personnel talking more than QFD Supplier personnel. The average levels are almost opposite - QFD supplier and non-QFD OEM values are almost

Table 3.8. Intra-Project Communication by Corporate Affiliation

DAILY CONVERSATIONS PER COMMUNICATION LINK	Non-QFD		QFD		ANOVA
	Level	% Total	Level	% Total	
Intra-Project Total*	1.97		2.73		ns
Within-OEM	.32	16.2%	1.28	46.9%	<.05
Cross-Company	.61	31.0%	1.16	42.5%	ns
Within-Supplier	1.03	52.3%	.28	10.3%	<.05

* The pattern of communication across the three categories differs at the p<.05 level between the two projects.

identical, as are non-QFD Supplier and QFD OEM values.

These results might be expected if the two projects were in different phases, say the QFD team at parts specification and the non-QFD team in manufacturing design. However, according to the project managers, both teams are actually in parts specification. Without analyzing other aspects of the communication patterns it is not possible to explain these differences, or to comment on which, if either, project is benefitted.

F.4. Communication By Function

None of the differences in communication levels across functions (ignoring the effects of both corporate affiliation and whether the communication was within- or cross-functional in nature) are statistically significant, nor is the pattern of distribution across the four functions (Table 3-9). The total communication by function was obtained by summing all the basic units with one or both communicators designated as belonging to a particular function. The larger amount of cross-functional communication for the non-QFD team contributes to increased levels of communication for all functional groups, compared to the QFD team. It is the higher level of non-QFD

Table 3.9. Intra-Project Communication by Functional Group

DAILY CONVERSATIONS PER COMMUNICATION LINK	Non-QFD		QFD		ANOVA
	Level	% Total	Level	% Total	p
Total Intraproject	1.97		2.73		ns
Design (Total)	1.35	68.6%	2.45	89.7%	ns
Within Function	.27		1.40		.01
Cross-Functional	1.08		1.05		ns
Manufact. (Total)	.34	17.3%	.25	9.2%	ns
Within Function	.10		.00		-
Cross-Functional	.24		.25		ns
Field (Total)	.51	25.9%	.46	16.8%	ns
Within Function	.00		.00		-
Cross-Functional	.51		.46		ns
Planning (Total)	1.27	64.5%	.79	28.9%	ns
Within Function	.10		.10		ns
Cross-Functional	1.17		.69		ns

cross-functional communication which produces the lack of differences in the patterns across the functions.

While none of the overall effects are statistically significant, the one difference of interest between the two teams is how much larger a percentage of the total the non-QFD team's planning group is compared to the QFD team's planning group. As a percentage of total intra-team communication, the non-QFD team's planning group is involved in twice as much of the communication as the QFD team's planning group. Non-QFD project managers are involved in well over half of the team's intraproject communications.

When the effects of the cross-functional nature of communication are broken out by function (Table 3-9), the QFD team's design communication is almost evenly split between the within- and cross-functional cells, while 80% of the non-QFD team's design communication is cross-functional. Only on one day out of four does one member of the non-QFD team's design group talk to another one, while this is a daily occurrence for the QFD team. The difference in these levels is statistically significant.

The second interesting finding is the high level of planning (management) participation in cross-functional communication, especially for the non-QFD team. Planners are involved in almost 60% of the non-QFD team cross-functional communications. Furthermore, Supplier Planners ac-

Table 3.10. Intra-Project Communication for the Design and Planning Functions

DAILY CONVERSATIONS PER COMMUNICATION LINK	Non-QFD		QFD		ANOVA
	Level	% Total	Level	% Total	p
Total Intraproject	1.97		2.73		ns
Design-Design	.27	13.7%	1.40	51.3%	.01
Cross-Company	.23		.71		.06
Design-Planning	.84	42.6%	.63	23.1%	ns
Cross-Company	.03		.23		ns
Planning-Planning	.23	11.7%	.10	3.7%	.05
Cross-Company	.23		.00		ns
Design + Planning	1.34	68.0%	2.13	78.0%	

count for over two-thirds of the total cross-functional Planning communication level (Table 3-8). If the communication ties between the functional groups were all even, one would expect to see the planners involved in 50% of the total cross-functional communication. If the communication were also evenly split between the OEM and supplier companies, the Supplier Planners could be expected to participate in about 25% of the team's total cross-functional communications. Instead, they participate in over 40% of the cross-functional communication for the non-QFD team. This group seems to be controlling more of the team's communication than one would expect.

The tables in Appendix 3.3 and their visualization in Table 3-3 suggest that one explanation for these results could be that the non-QFD team might be communicating more through the organizational hierarchy structure than directly across functions. Supplier Designers and Planners converse two out of every three days (cell SSDP), while OEM Designers and Planners talk about once every seven days (OODP). Both the Planners and Designers from the two companies talk about once a week (OSDD, OSPP). Neither company's Planners talks directly to the other company's Designers (OSDP). One company's Planners only seems to get information from the other company that has been filtered either through his own Design staff or through the other company's Planners.

The basic pattern of communication between the companies and functions differs extensively for the QFD team. The vast majority of communications, especially those involving both Planning and Design (Tables 3-4 and 3-10) seem to be direct and unfiltered through third parties. OEM and Supplier Designers interact extensively directly - more than two days out of three. While the OEM designers still talk to the OEM Planners almost every other day, OEM Planners still interact on a weekly basis directly with the supplier Designers.

If the non-QFD group is communicating using a less efficient communication mechanism, where the Planning function controls communication, then eliminating both Planning groups' cross-functional communications from the sum of each project's aggregate values should produce overall levels of communication that are consistently higher for the QFD team than for the non-QFD team. As Table 3-11 indicates, the QFD team's aggregate levels of communication are larger than the non-QFD team's when the cross-functional contributions of the planning function are eliminated for three important measures: intra-project, intra-organizational, and cross-functional. Communication seems to be consistently higher for the non-Planning part of the QFD team as compared to the non-QFD team.

Table 3.11. Effect of Planning's Cross-Functional Communication on Project Communication Aggregates

	Non-QFD	QFD
Planning Cross-functional		
Intra-Team	1.18	.69
Intra-Organizational	1.67	.78
INTRA-TEAM TOTAL	1.97	2.73
without Planning	.79	2.04
INTRA-ORGANIZATION TOTAL	3.25	2.85
without Planning	1.58	2.07
CROSS-FUNCTIONAL TOTAL	1.50	1.23
without Planning	.32	.54

F.5. Closing Remarks on Communication Differences

At the parts specification stage of new product development, product designers and planners appear to be most heavily involved in project communication. Field personnel communicate somewhat, and manufacturing communicate less than the other functions, although the QFD team's manufacturing personnel are more linked into the project than the non-QFD team's manufacturing personnel. These specific results are most likely applicable only to the parts specification of new product development, for a component type product.

The analysis of the data in this research demonstrates that it is not only important to look at the amount of cross-functional communication, but also what information flow processes are most likely producing it. By just looking at the aggregate level cross-functional communication levels one would conclude that the non-QFD team appears to be more cross-functionally tied in than the QFD team, the opposite of the claims made by QFD users. However, the indirect movement of the non-QFD team's communication from one company's Design function to the other company's Planning function through a third function increases the amount of total cross-functional communication attributable to the personnel on that team.

This indirect mode of communication is not efficient and the cross-functional communication it generates is not an overall contributor to effective information flow among team members. Given the lack of direct communication within the non-QFD team OEM Designers and Supplier Designers, I wonder if the Planning function is also serving as a filter between Designers in their own companies (this is pure speculation, although consistent with the numbers). If that were the case, then cross-functional communication would be increased at the expense of a very efficient direct communication path.

Looking at the communications paths that seem to have contributed to the non-QFD team's increase in overall cross-functional communication, if QFD were the mechanism that encouraged the OEM and Supplier groups and the various different functions to work together directly instead of filtering their communications through third parties (ie management), then QFD does seem to contribute to the efficient working of communication lines for new product development teams. Unfortunately, it is not possible to unquestionably credit the QFD process with this success. These communication paths, although they may be attributable to QFD, may also have arisen from other sources, such as the personal style of the supplier manager in the non-QFD team.

Previous research in the importance of cross-functional communication to the success of new products has dealt only with the entire new product development project (Dougherty, 1988; Souder, 1978; 1988). This thesis investigated communication for just one phase of a project, the parts specification phase. Communication for the projects in this development phase concentrated within and across the Design and Planning functions, with over two-thirds of the total non-QFD and over three-quarters of the QFD communication occurring in the 30% (9) of the 30 basic communication groups that deal only with Design, Planning, and their interaction. Since no prior research has been done on the variation of communication by phase of the commercial development project and correlation between project success and communication pattern by project phase,[7] it is impossible to determine whether "too much" of the total communication for the QFD project resides in these functional cells, or "too little" for the non-QFD project. The preliminary findings in this study open up whole new vistas of research on new product development.

G. Future Research Plans for New Product Development Communications

The long-term objective in the communication study is to investigate differences in input (resource balance, simultaneity across development phases, and communication), process, and output measures in companies where QFD or one or more other integrating new product development processes have been implemented in one or some projects (test) but not others (control). Such a study must be an ongoing project of four to five years duration. For

[7] Allen (1970 and 1984) has performed this research for different phases of R&D projects.

example, Eureka (1987), states that Toyota's experience with QFD indicated that institutionalizing took at least four years. Thus, a longitudinal study following one company's experience from project start to full commercialization comparing product development performance across different process types is one avenue future work should take. As a start down this avenue I hope to repeat the study with these two groups one or more times again at various later phases prior to product commercialization in 1991. After commercialization I hope to be able to gather data on product quality, process start-up indicators and total project expense for the two products compared.

A second research area of interest is identifying whether different project phases require communication between different functional groups of personnel. Are there periods in a project when within-function communication should be emphasized over cross-functional communication? Or should more cross-functional communication always be encouraged? Is there an optimal level of communication? How do "optimal levels" change over the course of the project, or do they? Because this research technique produces quantitative measures of communication levels, trying to obtain answers to these questions is now in the realm of possibility.

A third area of interest is how communication changes with the nature of the product development project. Since designing a car door differs from designing a subsystem for a complex instrument or a new shampoo, the communications needs may differ across the different types of product complexity.

Future work will also try to demonstrate which kinds of changes in new product development processes improves new product development process performance. I hope to use the University of Chicago's new product development lab and ARCH Corporation to opportunistically study and try to correlate product development process parameters to specific communication level and pattern changes.

CHAPTER 4. INTRODUCTION TO THE MARKETING RESEARCH METHODS STUDIES

A. Background and Impetus for the Research

Gupta et al., (1985a) found that the most important tasks in integrating new product development across R&D and marketing are communicating customer requirements and feedback on product performance from marketing to R&D. The research also revealed the current level of integration supporting these tasks is a source of great dissatisfaction for both marketing and R&D members of new product groups in industry.

Dougherty's (1987) research indicated that marketing and planning staffs do not think traditional market research inputs are adequate for the needs of new product development projects. Taken from Dougherty's thesis, Table 4-1 shows product designers feel market research on customer needs is very important, but unavailable. Either they don't get enough input from market research, or the input is not in a usable form. These frustrations were also observed in the field research of this thesis.

Table 4-1. Opinions of Market Research by Function

OPINION	Functional Area			
	Technical	Marketing	Planners	Total
Can't do it	19%	6%	33%	20%
Is inadequate	13%	63%	52%	36%
Positive attitudes	69%	31%	14%	43%
				100%
TOTAL	n=32	n=16	n=21	n=69

Source: Dougherty (1987)

The questions these frustrations raise is: What form should marketing research inputs to product designers take? How can marketing inputs be most useful to engineers?

The engineers and product teams using QFD have built Houses of Quality to help them analyze and use data describing enormous numbers of customer attributes. On average, a House of Quality contains around 150 attributes.

QFD groups have developed predominantly team-based solutions for dealing with this number of attributes which assume team members have good knowledge of the customer. The challenge this thesis undertakes is to come up with techniques for working with large numbers of customer attributes which do not assume intimate knowledge of the customer.

This phase of the thesis studied three aspects of providing marketing research results to product designers: identifying a list of customer attributes for the product area, organizing that list into a hierarchy from the most to the least detailed, and assigning importance measures to the attributes that can be used in specifying design parameters. This investigation differs from other inquiries because it seeks a market research method that can accommodate over 100 customer attributes.

B. Key Findings

- Eliciting attributes from customers by qualitative use-based one-on-one interviews can generate a large number of detailed customer attributes covering many functional aspects of a product. Special care may have to be taken in the interviewing process to elicit general needs as well as situation-specific ones.

- The optimal number of people to interview to generate attributes efficiently is around 20. This produces over 90% of the attributes generated by interviewing 30 people. It also puts the cost of obtaining a list of attributes for QFD purposes on a par with the cost for a set of Focus groups.

- At a minimum, 3-4 analysts should be used to extract attributes from a set of transcribed interviews. One analyst only identifies about 55% of a total set of attributes.

- Clustering across customer-derived attribute similarity matrices seems to provide more interesting and intuitively appealing hierarchies than those generated by factor analysis or management consensus for a large number of attributes.

- Hierarchies produced by teams for a familiar consumer packaged good were more similar to customer-derived hierarchies than the hierarchy produced by a team for a low cost durable good.

- Products developed using measurements of importance generated by different methods will probably differ greatly since there is little convergence across methods in which attributes are important.

- A direct measure of importance using an anchored scale seems to produce the "best" results when the goal is to deliver relative importance measures for numerous, detailed attributes to product development staffs.

C. The Product Investigated

The product example that is considered in all three parts of this study is "a food or drink carrying transporter." The product enables someone to prepare or purchase food or drink at one place and move it to a second place where the victuals are stored until consumed. Throughout the study this functional description was used to try to dissociate the functional need from its most frequent physical manifestations. Calling a product a cooler or picnic basket sets an image in a respondent's mind which may bias the information they provide. Using the terms cooler or picnic basket also might have eliminated from the samples people who carried food from one place to another without using a cooler or picnic basket (for example, some people routinely transport food on excursions in grocery store bags). The functional description investigates the needs of <u>all</u> people who transport food or drink from one place to another, whether or not they own a product specific to performing the task.

The food transporting device was chosen for two main reasons. First, a food transporter does not depend on any co-products for successful use. It's functional needs could therefore be investigated in isolation.

Second, graduate students are a reasonable target market for food transporters. Due to funding limitations field data had to be gathered as inexpensively as possible. Mailings to random or targeted samples of the overall population were not feasible. The strategy was to use a convenience sample for whom survey distribution could be done without using the US mail, but which still represented a reasonable potential market for the product area. Graduate students were our available target for low cost survey distribution, so the product area had to be something they would be very likely to use. A food carrying device seemed to fill that requirement.

The picnic basket data and results will be compared to other studies when possible, subject to confidentiality constraints on the other studies. One previous test of some aspects of the marketing methods was performed for the manufacturer of a complex consumer durable product. Another study of some of the aspects is proceeding at a manufacturer of consumer package goods.

The next three chapters deal with three separate aspects of the method. Chapter 5 provides a process for eliciting customer attributes from interviewees and the results of doing so. In Chapter 6 several processes are presented for building attributes into a hierarchy. The results are compared for two sets of attributes from different products. Chapter 7 discusses the findings of an experiment testing different methods for assigning measures of importance to attributes.

CHAPTER 5. ELICITING AND IDENTIFYING CUSTOMER ATTRIBUTES

A. What are the Research Needs?

Customer attributes serve two purposes. They determine the perceptual space of the competitive market area and the desired position of the product being developed. They also drive, implicitly or explicitly, the product's technical development. Customer attributes give product developers clues on how to design the product. The preponderance of research on marketing research methods has focused on developing techniques to address the global marketing uses for customer attributes. This research addresses the attribute needs of technical staff.

QFD was developed by engineers and therefore examining the QFD process should provide some indication of the information they need. QFD customer attributes explicitly and directly drive product functions and features; many attributes are included in the House of Quality needs analysis. This implies that engineers require detailed information about exactly how customers want a product to function. The challenge for an attribute gathering method is to obtain a full set of very detailed attributes relating to the product function for the technical staff. Optimally, the method would also obtain the more general types of attributes used in traditional marketing analyses for new product development.

At the same time, the product team needs an efficient and effective method to gather customer attributes. Field research suggests that the method should be one in which the product team can participate actively, perhaps perform independently. An expensive, time consuming technique performed by some other functional group, such as marketing research, would be unlikely to improve the information flow from customers and field-based staff (information sources) to product developers (information users).

I will now present data to justify the following conclusions:

- An attribute gathering technique using one-on-one in-depth interviewing covering as wide a range of specific use situations as possible is capable of eliciting large numbers of attributes from a relatively small number (around 20) of interviewees.

- At least 3-4 analysts should be used in extracting attributes from the qualitative interview data. One analyst identifies only about 55% of the attributes contained in the total data set.

B. Existing Practices for Obtaining Attributes

B.1. Existing QFD Practices

Users of QFD try to develop explicitly a list of customer attributes for use of the technical staff developing a product. Development teams using QFD gather attributes using a number of mechanisms. Brainstorming sessions pool customer attribute ideas from all corporate personnel in a product area. Other attributes may be added from defect reports, customer complaints, and quality control reports. When time permits or the project is important, primary market research might be used to ask potential customers what they want in a particular product function. This set of techniques would seem to provide a wide net that has the potential for capturing an enormous number of attributes of many different types.

B.2. Existing Market Research Practices

The objective of existing marketing practices for gathering attributes is to identify the 25 or 30 major customer attributes associated with a product area. Generally a larger set of attributes is obtained initially, and then winnowed down to the 25 or 30 most critical ones.

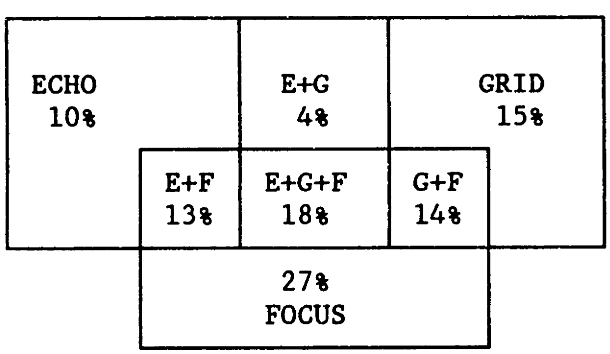
The dominant attribute generating technique for marketing purposes is the focus group. Groups of 8 to 12 customers spend one to two hours discussing their needs and perceptions about a product area (Calder, 1977). Focus group advantages include availability, low expense, rapid turnaround, and acceptance by the field.

However, in 1982 Fern demonstrated that individual interviews generate more ideas than the same number of persons do in a focus group format. In an unrelated study, focus groups and two one-on-one, or individual interview, techniques, ECHO and Repertory Grid, have been used to identify customer attributes for marketing purposes. The ECHO Method (Barthol and Bridge, 1968) probes on "good things" and "bad things" about a product area. ECHO can generate unexpected (from the company's point of view) information about product use or perceptions when customers think about the product differently than corporate personnel (Barthol, 1976).

The Repertory Grid Technique evokes similarities and differences between product class brands (Frost and Braine, 1967). A full set of Grid attributes for marketing use can be obtained with somewhere between 20 and 40 individual interviews.

Each of the above techniques elicits attributes in different ways. As might be expected, the output from each method therefore differs somewhat. In an unpublished 1983 study by MIT and Industrial Research Institute (IRI) investigators comparing attributes generated for pasta by focus groups, the Echo technique, and the Repertory Grid, the authors found that each method generated some unique attributes. As Table 5-1 illustrates, only 18%

Table 5-1. Overlap Between Attribute Generation Methods



Source: unpublished MIT study, 1983

of the 111 attributes were identified by all three techniques. A total of 52% of the attributes were identified by only one of these three techniques. The focus groups, which generated the largest number of attributes, identified 80 attributes, or 72% of the total.

One other interview technique used for generating marketing attributes which was not included in the MIT study is the Hustad et al., (1975) method for generating attributes by in-depth respondent interviews across specific use situations. Respondents describe their functional needs for a range of potential use scenarios.

The Custom Projects Group of IRI,[1] which had been providing market research for companies using QFD, had been seeking a single technique that cost-effectively generated large numbers of attributes, effectively used both the interviewer's and respondent's time, and allowed detailed probing on particular functional aspects of the product. Several proprietary projects had demonstrated that one-on-one interviews based on Hustad's technique produced long attribute lists detailing specific functional needs that were readily accepted by their clients.

C. Critique of Existing Attribute Generating Practices

Even though QFD purports to use a cross-section of techniques to generate attributes, field research indicates that the predominant mechanism remains the brainstorming session of corporate personnel. Of the 35 projects in the field research sample, only 6 (17%) gathered attributes by means other than brainstorming. Brainstorming is easy, fast, and inexpensive, with little or no out-of-pocket cost, and only a small cost in team time.

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[1] Located in Waltham, MA, the Customer Projects Group (1986-1989) was a high-powered group set up within IRI to pioneer new market research methods for industrial practice.

The major concern is whether these brainstorming sessions generate the "Voice of the Customer" or the "Voice of the Team." If the product team is very familiar with the customers and their needs, brainstorming corporate knowledge may produce a "Voice of the Team" which closely represents the "Voice of the Customer." On the other hand, even team members familiar with customers can approach a brainstorming session with a corporate instead of a user mindset, which can lead to a form of "marketing myopia."

In some cases it is highly unlikely that a product development team is familiar with customers and their needs because the product area is new to the members of the team, the company as a whole, or to the world. It is unlikely that these teams would be able to reproduce the "real" "Voice of the Customer" using brainstorming techniques dependent on their own knowledge.

While the techniques used in generating customer attributes directly from customers for marketing purposes initially identify larger numbers of attributes, the objective is to identify the 20 to 30 "most important" attributes for continuing market research use. Focus groups, ECHO, and the Repertory Grid technique are each capable of producing enough attributes for market research needs. However, in comparing the performance of the three methods, a total of 52% of the attributes were generated by only one of the methods. It is unlikely therefore that any <u>one</u> of the three attribute generating methods studied could generate by itself a full list of detailed attributes of the sort needed for technical product development. Using all three for the task is far too expensive and time-consuming to be feasible.

Faced with this concern and based on the experience of IRI's Custom Projects Group, it was felt that a modification of Hustad's attribute gathering technique could produce acceptable attribute lists for use in a QFD new product development framework. The one problem with the IRI method was expense, relative to other market research techniques. To ensure that all the attributes were captured, IRI and its clients arbitrarily chose to interview at least 30 people per market segment. Relative to other qualitative market research methods, this proved expensive.

Because IRI had already demonstrated that a qualitative one-on-one technique leading customers through use scenarios produces large lists of attributes, this technique was chosen for this investigation over other attribute generating methods. One objective of this research was to try to determine whether the process could be made less expensive. This exercise was therefore used to investigate ways to optimize this attribute eliciting and identifying process as well as generate the attributes to be used in other portions of the marketing methods study.

D. Data Collection: Gathering the Customer Attributes

The first task in this methods study for large numbers of attributes was to obtain a list of attributes describing customer needs for a food or drink carrying device. Large numbers of specific, detailed attributes about customers' functional requirements were needed which could be used by a technical staff in designing a new product. The goal was to try to identify all possible attributes that would affect product design with just one attribute gathering technique.

A product development team knowledgeable about their customers was not available. Complaint data, defect reports, and quality control reports were also not available as potential data sources. Therefore, attributes were obtained directly from product users instead of in more typical QFD ways.

The thesis uses the IRI method to gather attributes and then analyzes several aspects of its performance. These analyses can be used to apply this technique more efficiently and cost effectively in the future, as well as provide an analysis base for future comparison with other techniques.

Thirty interviews lasting between 45 minutes and 1 hour were conducted of MIT graduate students[2] who transport food and/or drink from one point to another before consuming it. A copy of the interview guide can be found in Appendix 5.1. The interviews were transcribed to hard copy and xeroxed.[3] A full set of the thirty interviews and the coding instructions in Appendix 5.2 were given to four teams of Sloan School students, two MIT Undergraduate Research Opportunities Program (UROP) students, and one executive vice president of a local marketing research firm for coding. Each team independently developed a list of all the customer attributes they could identify from the transcribed interviews. The lists were then compiled into one comprehensive list of all customer attributes identified (Appendix 5.3).

E. Results of the Attribute Gathering Process

The primary result is the comprehensive list of 220 customer attributes. This attribute list was used in all subsequent analysis and research. That a large number of attributes was generated from the in-depth use situation interviews suggests that this technique might be appropriate for generating customer attributes for use by the technical staff in developing products.

F. Efficiently Applying the Technique

QFD can only produce new product development benefits if the process is

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[2] The graduate students were part of an executive education program at MIT; the Management of Technology Master's Degree. The students predominantly have engineering backgrounds, average 35 years of age with 10 years of work experience, and are multinational in nature.

[3] Funding for transcribing tapes and xeroxing transcripts was provided by the director of the Management of Technology program.

actually used. In many instances QFD is more likely to produce benefits when customer attributes are obtained from customers instead of from the team's (biased) experiences. However, attributes will be drawn from customers instead of from team experience only when it can be done without excessive cost. The optimized process analyzed in this research phase brings the attribute generation cost to a level comparable to other market research methods.

F.1. Optimizing the Number of People Interviewed

Qualitative one-on-one interviews are expensive and time consuming to perform. Companies using them to elicit customer attributes must balance the expense against the expected improvement in the set of attributes from interviewing just one more respondent. Information derived from the food transporter transcripts was used to estimate an optimal number of interviewees for an efficient yet effective process for eliciting attributes. These data indicate that interviewing 20 people will produce over 90% of the attributes generated by interviewing 30 people.

Collecting Data for Optimizing the Number of People

Each of the 30 transcripts was coded against the already identified list of 220 attributes by one analyst to determine which attributes each respondent contributed. The raw data from this step is an attribute by respondent matrix with 1's in the cells corresponding to the attributes contributed by a particular respondent and 0's elsewhere. The data indicate only that a respondent identified an attribute, not the number of times it was cited. The raw data matrix can be found in Appendix 5.4. Many of the analyses were performed on both the full data set as well as the subset of "important" attributes. The "important" attributes are the set of 150 attributes whose importance values, computed from the anchored measure (see Chapter 7, sections E and H) and standardized in a 1 to 9 range, are greater than 3. The "important" attribute raw data matrix is provided in Appendix 5.5.

Each of these sets of data was put into a simulation program which randomly selected permutations of customers to calculate the percent of the attributes that would be identified for different numbers of people. That is, the simulation program randomly selects one customer from the set of 30 and calculates and stores what percentage of the 220 attributes that customer identified. The program then randomly selects a second customer, combines their two attribute sets, and calculates and stores what total percentage of the 220 attributes were identified by one or both of them. The process continues until all 30 customers have been randomly selected, attribute sets combined, and percentages calculated and stored. In all 40,000 permutations of the process were run.

Analysis and Results: How Many People to Interview

Figure 5.1 illustrates what proportion of the set of attributes (out of 220 total or out of 150 important) would be generated by interviewing fewer than the 30 people interviewed for this research (based on the average over the 40,000 permutations). Once more than 15 or 16 persons have been interviewed, the number of additional attributes contributed by the next interviewee decreases rapidly. By the time 18 people have been interviewed, over 90% of the total number of attributes which could be obtained by interviewing 12 additional people are contained in the interviews.

Identifying the "important" attributes for this product area does not appear to take fewer respondents than obtaining a full set of attributes, including those less important. The percent of the attributes identified is consistently higher for the subset of more important attributes than for the entire set of attributes for any number of interviewees. However, the per-

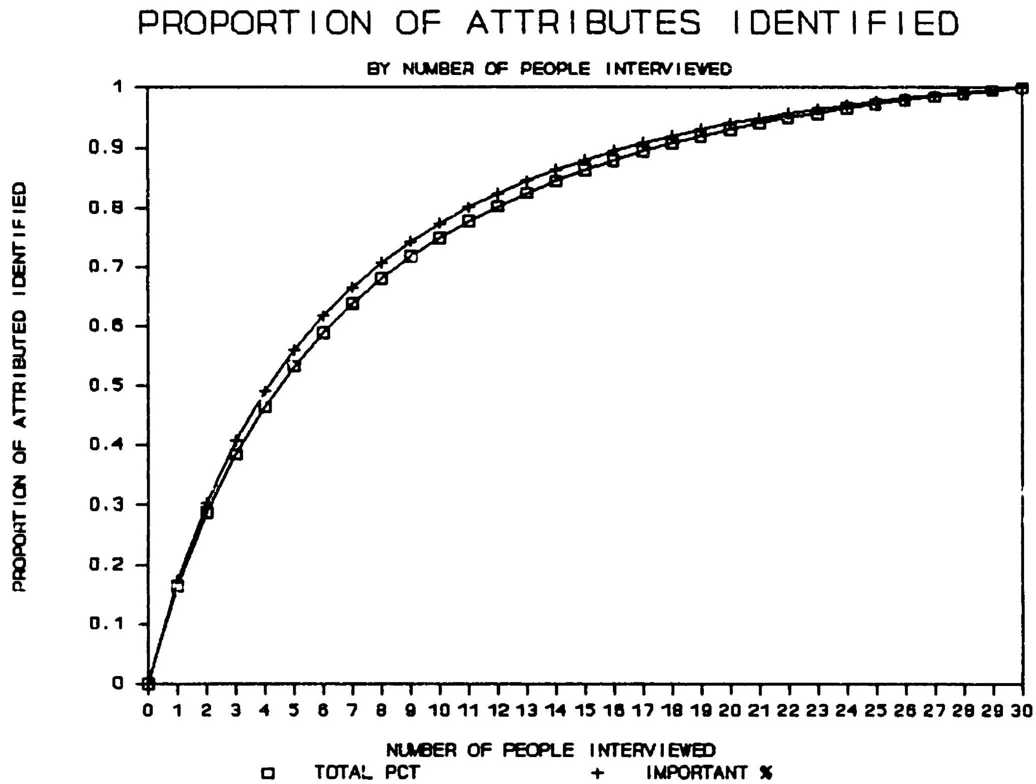

Figure 5.1. Proportion of Attributes Identified

cent of the important attributes identified is never more than 6% higher than the percent identified for the entire attribute population, and the two cumulative distributions do not differ at a statistical significance level of p=.05 as calculated from a Kolmogorov-Smirnov test.

On average, respondents cited about 17% of the attributes (Table 5-2). The range of the numbers of attributes provided by this sample ran from 7% to around 35% of the attributes. The descriptive statistics, as a percent of the total attributes analyzed, are nearly identical whether the analysis is done a-

Table 5-2. Descriptive Statistics: Number of Attributes Cited by Respondent

	ALL ATTRIBUTES		IMPORTANT ATTRIBUTES	
	Number	% Total	Number	% Total
Total	220		150	
Average	37.6	17.1%	26.1	17.4%
σ	14.8	6.7%	11.1	7.4%
Low	15	6.8%	10	6.7%
High	69	31.4%	54	36.0%

cross all the attributes or only across the important ones.

Future Research Plans: Interviewing Respondents

These research findings open up several additional issues associated with efficiently generating attributes from customers. One research issue of interest is whether the list of attributes generated differs if different populations of respondents are interviewed in the qualitative market research. While the persons interviewed for the food transporter attributes were a convenience sample (a marketing class of 30 executive MBA students), they represent a fairly random sample in terms of food transporter use. Figure 5.2 shows the distribution of the number of attributes generated across all respondents. Based on their ability to provide attributes for

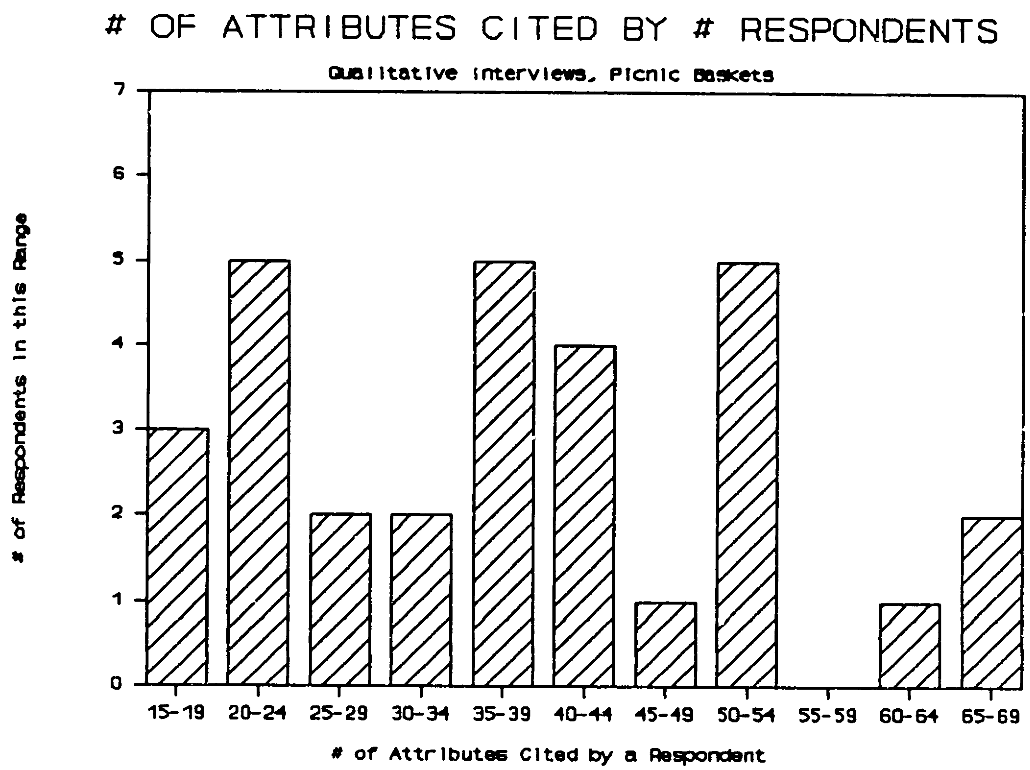

Figure 5.2. Distribution of the Number of Attributes Cited by Respondents

food transporters, the respondents seem to fall into the four separate segments of Table 5-3, with the very vocal respondents able to identify three to four times the number of attributes from inarticulate respondents. Do there seem to be any intrinsic differences in the aggregate set of attributes generated by each of these segments? In order to get a full list of important attributes, must inarticulate as well as very vocal persons be interviewed? The data already gathered can be analyzed to answer these questions for this product area.

Table 5-3. Segments of Qualitative Respondents (Based on Ability of Provide Attributes)

SEGMENT NAME	RANGE	% OF TOTAL	# RESPONDENTS
Inarticulate	15-27	< 15%	10
Familiar	32-42	15% to <20	11
Vocal	49-54	22% to 25%	6
Very Vocal	61-69	> 27%	3

If there do not seem to be any differences in the attribute sets across the segments of respondent ability to provide attributes, then the interviewing process might be streamlined by only interviewing the more vocal respondents, which opens up another research issue. That issue is trying to decrease further the number of interviews that must be done by better targeting the persons interviewed. A more efficient process might interview only the vocal and very vocal segments. This could be done by developing a set of measures identifying the more vocal persons before any interviewing is done. Attitudinal and behavioral data surrounding food transporter use, indoor and outdoor activities, and eating were collected from the respondents. This data will be explored for correlations between segment membership and respondent characteristics, in hopes of determining which kinds of characteristics are most important in producing articulate respondents.

F.2. Optimizing the Number of Analysts Who Code the Transcripts

Total cost of the attribute generating method to the user is also affected by the number of analysts who must code the interview transcripts to ensure that all the attributes elicited from interviewees are identified by the coders. Minimum cost results from using just one analyst. However, analysts bring their own biases into identifying attributes. A statement may be considered an attribute by one analyst, but not another.

The 1983 study on pasta attributes indicated that when analyzing focus

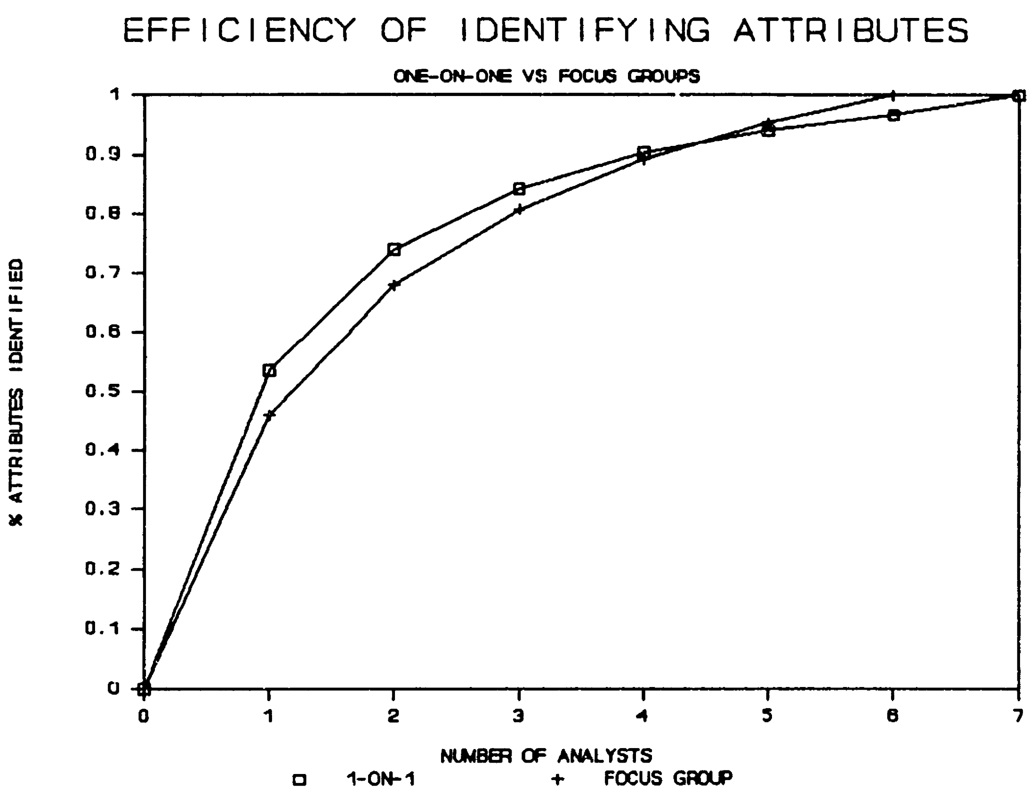

Figure 5.3. Number of Analysts Required to Code Transcripts

group transcripts, each analyst only picked out a subset of the overall attributes contained in the transcripts. On average, each analyst only recognized about 45% of the total number of attributes obtained across the six analysts looking at the data. The food transporter data indicate that qualitative one-on-one transcripts also should be coded by multiple analysts. Four analysts are needed to identify over 90% of the attributes elicited. These results are consistent with the pasta study findings (Figure 5.3)[4]

F.3. The Optimized Method - Managerial Implications

When respondents are randomly drawn from a pool of target market customers and interviewed using situationally-based one-on-one interviews, the food transporter data suggest that about 20 interviews are probably sufficient. The transcripts should be coded by at least four analysts so that a majority of the attributes elicited are identified. Using 20 respondents and four analysts generates about 85% of the attributes obtained from 30 respondents and seven analysts.

An estimated cost for contracting this more efficient process to a market research firm is $20,000, which is comparable to the cost, including the report, for a series of focus group sessions for obtaining attributes for strategic marketing purposes.[5] Generating the attributes using team brainstorming sessions is still much less expensive. Even if the services of a neutral facilitator are used, out-of-pocket brainstorming costs should be less than $3,000. In order for companies to use a customer-based attribute generating process, they must believe that the increased value of going to customers for attributes is worth at least $17,000. At a 5% profit level, expected sales increases to cover this expense should be $350,000 to $400,000 to make the customer-based technique worthwhile.

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[4] The proportions of the attributes identified by the analysts for the focus group technique are based only on the total number of attributes identified by the focus group technique.

[5] Estimates from Customer Projects experience.

G. Modeling the Attribute Elicitation Process

G.1. Why Modeling the Process is of Interest

The relationship between number of respondents and proportion of attributes identified was obtained empirically for food transporters. The data in this study describe a low-cost durable item that is not used daily or even weekly in most households. It probably represents a product with which people are, on average, "somewhat familiar" and about which they are "somewhat articulate." Users may be generally more less familiar with other products, and more or less articulate about their needs in other product areas.

These differences in familiarity could result in shifts in the average proportions of attributes identified by a sample of people across different products. Less familiarity could shift the curves of Figure 5.1 to the right, indicating that more than 20 respondents should be interviewed. More familiarity could shift the curves to the left, with commensurately higher interviewing efficiencies.

As Figure 5.2 illustrated, articulation differences exist even within one product. Some of the respondents interviewed were able to relate many specific needs they had for food transporting devices. Others were not at all articulate. As with higher levels of familiarity, increased ability to articulate needs shifts the curves of the number of respondents needed (Figure 5.1) to the left (fewer interviews). The number of people who must be interviewed to obtain a substantially full set of attributes will be affected by both the average number of attributes provided by respondents, as well as the dispersion of that number across the sample (how tightly grouped the sample is).

Not only do people seem to differ in their ability to articulate attributes, attributes differ widely in the innate propensity with which people

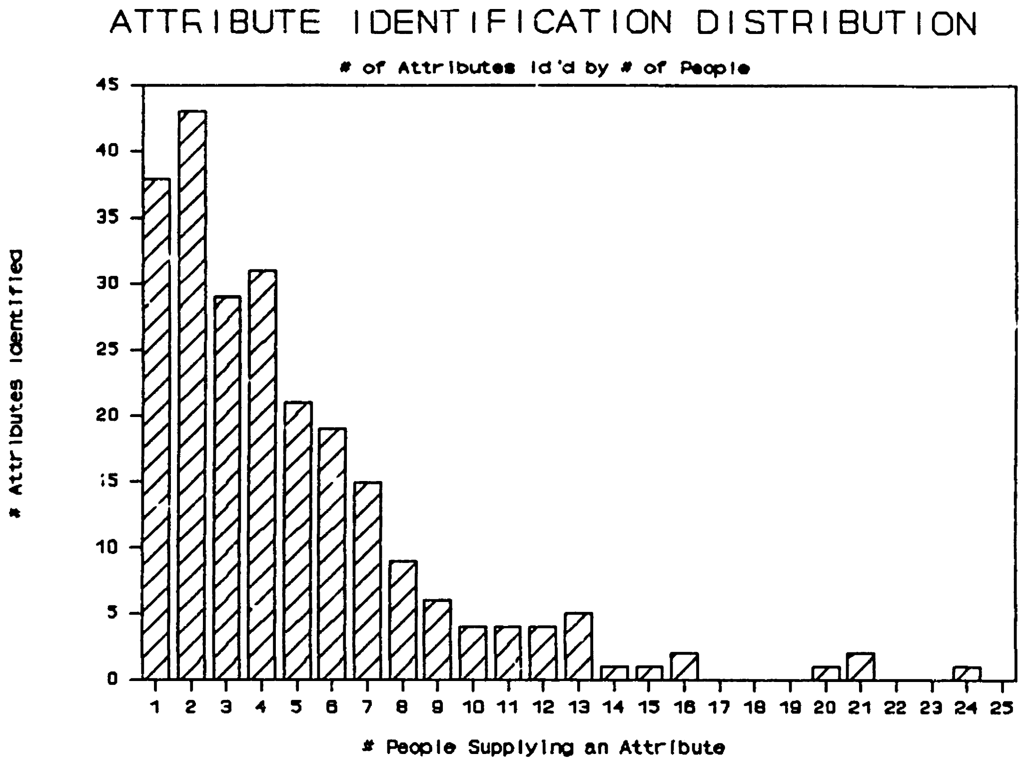

Figure 5.4. The Distribution of the Number of People Who Identify Particular Attributes

cite them (Figure 5.4). Four of the 220 attributes were identified by at least two-thirds of the respondents, but 38 attributes (17.3% of the total) were identified by only one respondent of the 30 interviewed (3.3%). For a different product area, however, or for different subsets of the respondent population, like the very vocal subset, the distribution of the number of respondents that cited each of the attributes might differ greatly from the distribution found in this study. The number of people who must be interviewed to obtain a substantially full set of attributes will be affected by the average of the number of people interviewed who provided an attribute as well as the dispersion of that average across the attributes. Distributions that are tighter around a higher overall average will require fewer interviews than attribute distributions with lower averages or those that have higher variances around the average.

One way to ensure that enough people have been interviewed to obtain a substantially full set of attributes is to start with the assumption that 20 interviews will be adequate. Perform the interviews, fully code the transcripts, and rerun the simulation which produced the relationship in Figure 5.1. As long as the percent increases in attributes added for each additional person interviewed is in the same range as in Figure 5.1, enough interviews probably have been done to ensure most of the attributes have been elicited. This is an analyst-intensive (expensive) and lengthy process. While interesting from a research point of view, it is not something that practitioners generally will be willing to do.

A more elegant (and probably less costly) check to ensure that enough interviewing has been done for data with different distributions than this set is to stochastically model the process of attribute elicitation. That is, develop a model which produces the curves of Figure 5.1 based on parameters that can be obtained from the data. By changing the parameters of the model commensurate with changes in the distribution of the data, curves of interviews versus proportion of total attributes can be drawn and inspected for shape without having to run a simulation. If the parameters can be estimated without having to fully code all the interviews, for instance by relating them to familiarity with the product, this method could be significantly less expensive than the full-coding method suggested above.

G.2. Modeling How Attributes are Elicited

The number of attributes identified by any set of interviewees is a combination of the distributions of the number of attributes respondents are able to provide during a one-hour interview and the proportion of respondents who can provide each particular attribute. To date, the avenues investigated for coupling two distributions describing these phenomena to directly generate curves similar to Figure 5.1 have not proved tractable. In an effort to make some progress on the problem, models for the two phenomena have been independently investigated with some success, although the independent models do not lead directly to the curves of Figure 5.1.

A Model for Attribute Elicitation Rates

The distribution of the number of attributes cited by respondents is not

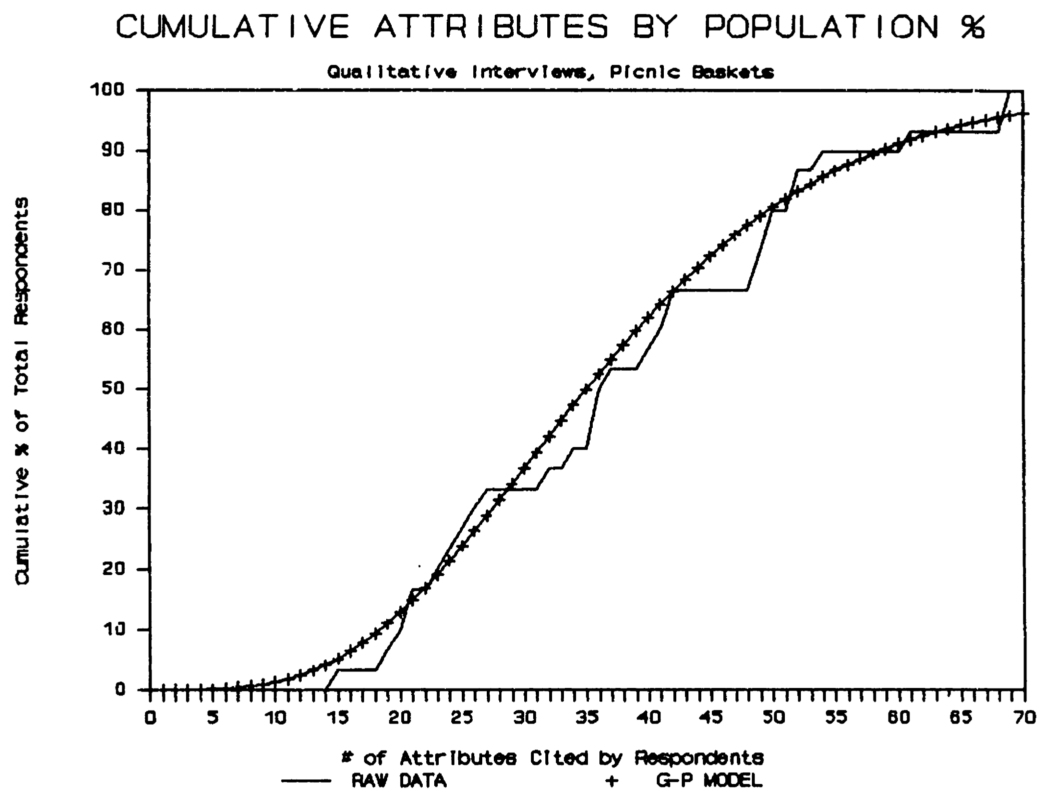

Figure 5.5. Modeling Elicitation Rates as Gamma-Poisson Distributions

inconsistent with a Gamma-Poisson distribution (Figure 5.5) where the parameters have been estimated from the data using the method of moments (Kolmogorov-Smirnov test of the two cumulative distributions, $p>.05$). The distribution assumes each respondent has a characteristic elicitation rate, "r" (number of attributes per hour interview) for a particular product area, which is a Poisson distribution around the rate of attributes generated that day for the interviewer. This rate is Gamma distributed across people.

The Gamma-Poisson probability distribution function is:

$$f(r) = \frac{1}{\Gamma(a)} (a/c)^a \; e^{-(ar/c)} \; r^{a-1} \tag{5.1}$$

where $\Gamma(a) = \int_0^\infty e^{-(ar/c)} (ar/c)^{a-1} \; d(ar/c)$ (5.2)

The model parameters are a and c, which are calculated as:

$c = E(r)$; the mean of the attribute elicitation rate (5.3)

$$a = (E(r)/\sigma_r)^2. \tag{5.4}$$

For this data, $a = 6.47$ and $c = 37.6$. These two parameters and the time period over which attributes will be elicited can be used to calculate $F_r(r|T,c,a)$, the proportion of people estimated to provide r attributes over time T (one hour), given parameters c and a, which is graphed in Figure 5.5.

$$F_r(r|T,c,a) = \frac{\Gamma(a+r)}{r!\;\Gamma(a)} \{a/(a+Tc)\}^a \{Tc/(a+Tc)\}^r. \tag{5.5}$$

For $r = 0$: $F_r(0) = \{a/(a+Tc)\}$ (5.6)

For $r > 0$: $F_r(r) = F_r(r-1) \dfrac{(a+r-1)}{r} \dfrac{Tc}{(a+Tc)}$ (5.7)

This model of attribute elicitation rates makes no assumptions about the total number of attributes in the "full set." The values in the model have been estimated independently from the distribution of the inherent propensity for respondents to produce a particular attribute.

Modeling the Probabilities for Citing Attributes

While the rate with which attributes are elicited can be modeled as an independent phenomenon, the proportion of people citing each attribute depends on the rate attributes are elicited as well as the total number of attributes in the full set. For any given number of attributes in the "full set" a higher elicitation rate leads directly to higher average probabili-

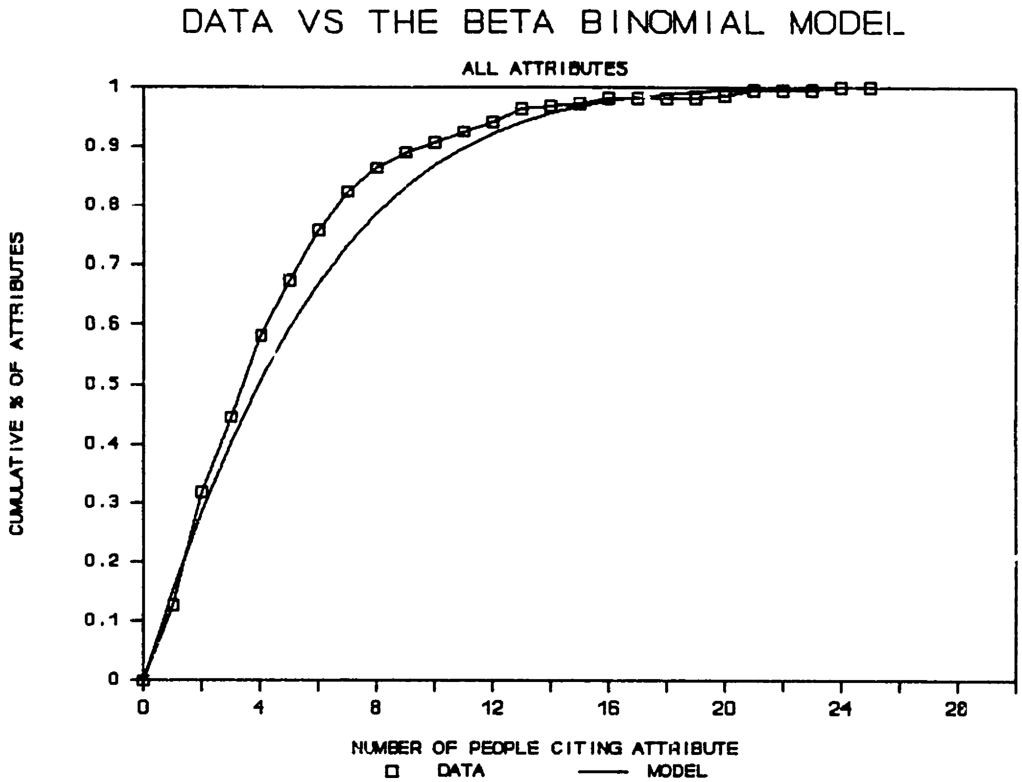

Figure 5.6. Attribute Probabilities as Beta-Binomial Distributions

ties (Table 5-4).

The data available for modeling include the effects of <u>both</u> the rates of elicitation and any inherent attribute characteristics which affect probabilities. As a first cut, I attempted to fit the data to a model ignoring the impact of elicitation rate on overall probabilities. The data

Table 5-4. Elicitation Rates and Proportions by Segment

SEGMENT	p	r	σ_r	CoV	Model Parameters A	Model Parameters B
INARTIC.	.09	21.2	3.5	.16	.38	3.84
FAMILIAR	.16	37.4	3.2	.09	.67	3.59
VOCAL	.22	51.2	1.7	.03	.57	2.06
VERY VOCAL	.28	66.3	3.8	.06	.43	1.10
ALL DATA	.16	37.6	14.8	.39	1.08	5.68

were tested against a Beta-Binomial distribution. Fit with a Beta-Binomial distribution was investigated because of the distribution's flexibility and its prior success with modeling analogous (but not identical) situations in marketing research (Greene, 1982). In this case, while statistical tests indicate the model is not inconsistent with the data, it does not seem to fully describe the interactions.

The Beta-Binomial model assumes that each attribute has a characteristic probability that it will be cited by any respondent. Different attributes have different characteristic probabilities, which are Beta distributed across all the attributes.

The Beta-Binomial probability distribution function is:

$$f(p) = \frac{p^{a-1}\,(1-p)^{b-1}}{\beta(a,b)} \tag{5.8}$$

where $\beta(a,b) = \int_0^1 p^{a-1}\,(1-p)^{b-1}\,dp.$ (5.9)

The model parameters, a and b, are calculated from the mean and variance of p, the proportion of people who identify each attribute, from the Maximum Likelihood Estimation equations:

$$E(p) = a/(a+b) \tag{5.10}$$

$$Var(p) = ab/((a+b+1)(a+b))^2. \tag{5.11}$$

For this data, $a = 1.08$ and $b = 5.67$. Given these two parameters, the proportion of the attribute population with n respondents who identify an attribute out of N who could possibly identify it can be obtained from:

$$F_n(n|N,a,b) = \int_0^1 (N/n)\;p^n\;(1-p)^{N-n}\;f(p)\;dp \tag{5.12}$$

or

$$F_n(n|N,a,b) = \frac{N}{n}\,\frac{\beta(a+n,\;b+N-n)}{\beta(a,b)};\quad n = 0,\,1,\,\ldots\,N. \tag{5.13}$$

For $n = 0$:

$$F_n(0) = \prod_{n=1}^{N} \frac{(b-1+n)}{(a+b-1+n)}\,. \tag{5.14}$$

For $n > 0$:

$$F_n(n) = F(n-1)\,\frac{(a+n-1)}{n}\,\frac{(N-n+1)}{(b+N-n)}\,. \tag{5.15}$$

The distribution of the average probabilities that respondents will cite particular attributes (Figure 5.6) is not inconsistent with a Beta-Binomial distribution (p>.05, Kolmogorov-Smirnov test). However, the model underpredicts how many attributes were cited in the seven to 12 respondent range. Some attributes are more common than predicted by this Beta-Binomial distribution, indicating, perhaps, that the distribution might need to explicitly account for differences in the rates attributes are elicited.

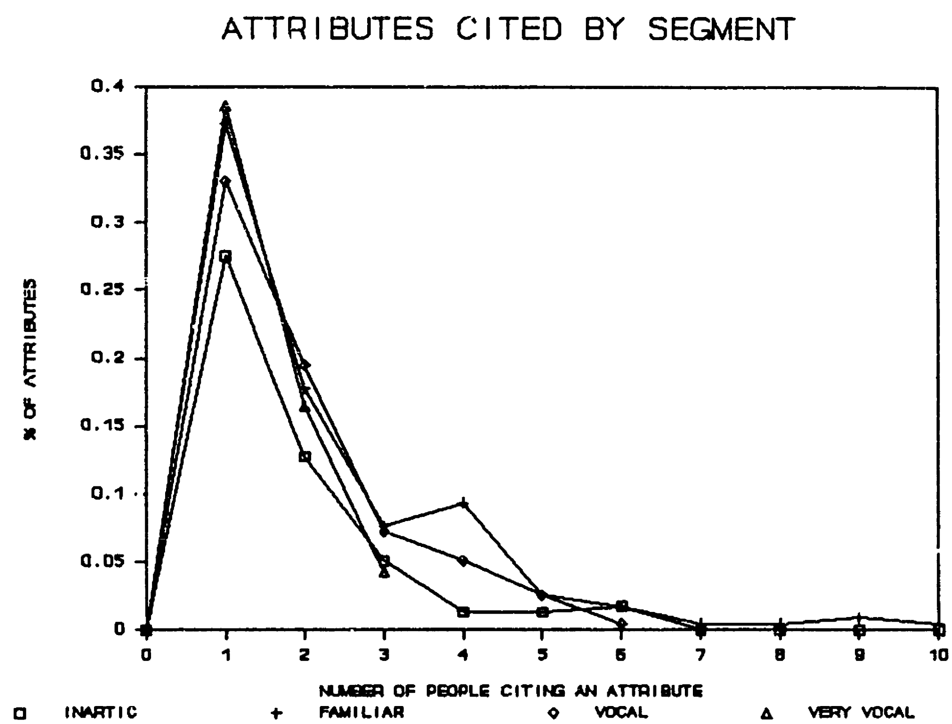

Figure 5.7. Attribute Elicitation Proportions by Segment

To test whether underprediction might be caused by wide ranges in elicitation rate, the data were split into the four elicitation rate segments identified in Section F (Figure 5.7). As Table 5-4 shows, the variability of the rates attributes are elicited are much smaller for the segments than for the total sample. It was assumed that the variation in these rates was small enough to be insignificant. The Beta-Binomial distribution parameters were calculated for each segment and the data compared to the model's r-

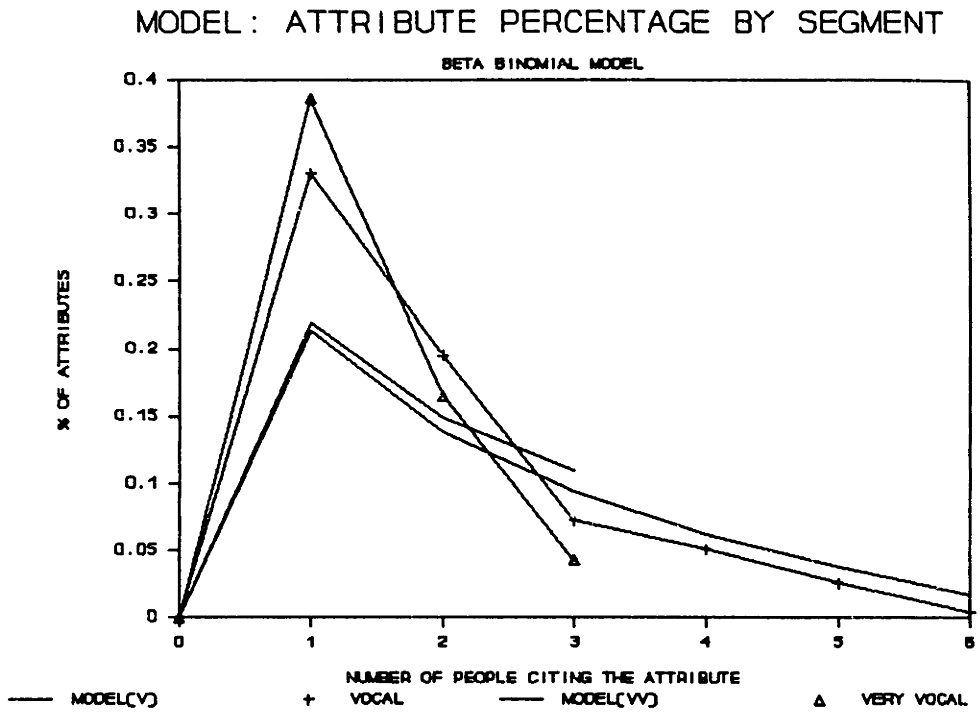

Figure 5.8. Data and Model for Eliciting Attribute Proportions - Vocal and Very Vocal Segments

esults by segment. The by-segment models all underpredict the proportion of attributes identified. (Figures 5.8 and 5.9). Therefore, elicitation rate variation does not seem to cause underprediction (if it did, one wold expect less underprediction by segment, not more).

Modeling the rate attributes are elicited from respondents in situation-based qualitative interviews as a Gamma-Poisson distribution appears to produce an acceptable representation of the data. An appropriate model has not been developed for the joint process which produces a set of attributes across a number of respondents.

G.3. Future Efforts Planned

Continuing research is planned along several efforts which may streamline the field based marketing research. I intend to pursue the effort to develop a model which closely replicates the results from field data. If the elicitation process can be well enough understood to model, aspects of

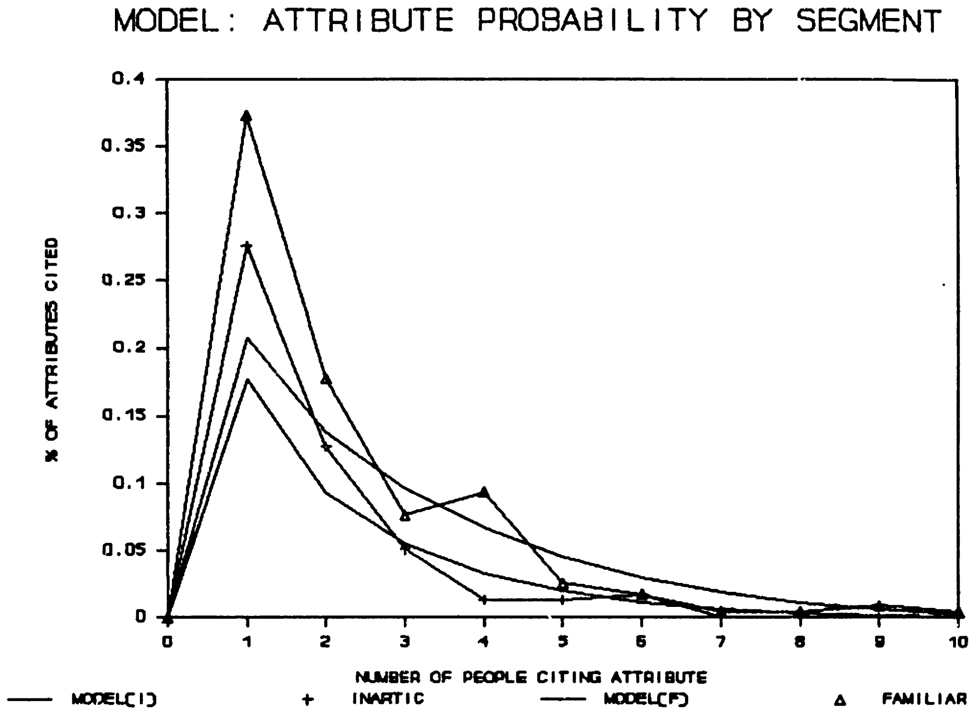

Figure 5.9. Model and Data for Elicited Attribute Proportions - Inarticulate and Familiar Segments

it are likely to be identified for optimizing.

Using the behavioral and attitudinal data gathered from the interviewees I will try to determine if any measures or groups of measures discriminate between the very vocal and inarticulate respondents. If discriminating measures can be identified, and if the sets of attributes obtained across the segments do not differ in any predictable way, then prescreening respondents based on similar measures for other product areas should provide a way to interview only very vocal respondents. This may allow the number of respondents interviewed to be decreased below the 20 recommended based on the data analyzed in the food transporter study.

CHAPTER 6. BUILDING HIERARCHIES FROM CUSTOMER ATTRIBUTES

A. What are the Research Needs?

QFD uses an enormous number of customer attributes. In practice Houses of Quality contain between 50 and 350 attributes, averaging around 150 for most products. It is doubtful that any engineering designer could systematically deal with a random list of 150 attributes. To be useful, they must be arranged into a structure that allows the product development team to understand which attributes are components of the same overall idea.

For example, the Toyota rust analysis (Eureka, 1987) had an eight level attribute hierarchy. Attributes such as "spilled fruit will not rust the bed of a pickup truck" were at the most detailed (eighth) level of the hierarchy. This attribute spells out for the designer what kind of potential rust agents he must be concerned with in his design (citric and acetic acids) in which areas of the vehicle (a pickup truck bed). The spilled fruit attribute might belong to the more overall idea "pickup bed doesn't rust from ordinary use." The global idea covering the entire customer need might be "my car (truck) doesn't rust as long as I own it." This is the customer problem the whole design effort tries to solve.

The attribute structure is important in QFD because importance measures of only those attributes at the lowest level of detail in the hierarchy impact the engineering design characteristics of the final new product specification. The importance to the customer of any attribute not at the lowest level of detail will not guide engineering design, although they will be used for the market positioning of the product. The final hierarchy structure detailing which attributes reside at the lowest level(s) of the hierarchy thus determines which attributes drive product development. If the hierarchy does not reflect the customers' structure, using it may lead to products that do not meet the customers' needs.

The research challenge is twofold. The first challenge is to devise an efficient and effective method for constructing large numbers of elicited attributes into a multi-tiered hierarchy that seems to represent the structure held by customers. The second challenge is to compare the utility of hierarchies produced different ways. Is management's structure similar to the customer's structure, or does it differ?

The next several sections will provide justification for the following conclusions:

- A Customer-driven method has been developed for organizing large numbers of customer attributes into a hierarchy based on direct inputs from customers.

- Customer-driven Hierarchies differ from the hierarchies developed through product team consensus.
    - Product team hierarchies have more variance in attribute group size and levels of structures across groups.
    - Customer-driven hierarchies seem to be more product specific (less generic) and "interesting" than those constructed by development teams.

- The Affinity Hierarchies for product development teams more familiar with a product or its customers might come closer to reproducing a Customer-driven Hierarchy for a product area than the Affinity Hierarchy of teams less familiar with the product or customers.

B. Existing Practices for Building Hierarchies

Existing marketing practices build two-level hierarchies by factor analyzing customer perceptions across 20 to 30 product attributes (Urban and Hauser, 1980). Attribute lists are typically factored into two or three orthogonal "dimensions" of attributes.

QFD's solution for building a hierarchy of customer attributes is team-based. In all Japanese and most US applications of QFD, the new product development team forms the hierarchy using an Affinity Chart or K-J[1] diagram, two variations of one of the Seven New Tools used in Japanese planning processes (King, 1987). These techniques use group consensus to first organize a list of attributes into related groups, then impose a structure on the attributes within each overall group. Generally no direct customer input is used in forming the hierarchy of customer needs; the resulting "Affinity Hierarchy" represents how management perceives customers think. As illustrated by the Toyota rust study hierarchy (Eureka, 1987), these managerially-constructed hierarchies can become quite complex.

C. Critique of Current Hierarchy Building Practices

Factor analysis works splendidly for small numbers of attributes (<30), where the data needs to perform the correlations are not onerous. This technique is efficient and simple to perform. A one-page questionnaire provides the dimensional structure of attributes and the relative importance of both the dimensions and attributes.

Factor analysis results are well accepted across the marketing community. However, two aspects of factor analysis may limit its use in providing marketing data to technical staffs. First, factor analysis is very costly to use with large numbers of attributes because of the need for large sample sizes. For 220 attributes, factor analysis utilizes the results of over 24,000 correlations, which means that the sample must be at least that large. Repeated factor analysis on small subsets of the full attribute list might be used to construct pieces of the hierarchy iteratively, with smaller sample sizes. This process would probably require significant prior judgments about

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[1] K-J is the registered trademark of Jiro Kawakita for his version of the Affinity Diagram.

which attributes might "go together" and which are more general versus more detailed. The complexity of the iterative nature of the process needed to deal with many attributes probably mitigates its use for this purpose.

The second concern about factor analysis for development purposes is that the data usually structures into rather generic dimensions like "easy to use" and "works well," both per unit cost. These generic dimensions may help marketing position products, but they are far less useful to an engineering design team looking for specific design directions.

The team-based QFD hierarchy building methods also have some inherently troubling aspects. The most worrisome is whether they actually reflect customer beliefs. When a product development team fully understands customers and how they think about the product area, their hierarchy may accurately reflect the customers' hierarchy of needs. However, if the product team is not well attuned to customers or their needs, a managerially developed hierarchy may not accurately reflect the customers'. In that case using a managerially-developed hierarchy to drive product development is inappropriate; it might actually lead to a product with low customer preference.

Neither technique seems particularly appropriate for building customer-based hierarchies from large numbers of attributes. I tested and refined a method originally developed again at IRI that overcomes the problems associated with the other two techniques, while utilizing the useful aspects of each. The method gathers data directly from customers on the similarity between large numbers of attributes. Cluster analysis is then used to identify groups of similar attributes across the aggregate of the cases.

In the next three sections attributes for food transporting containers are structured into hierarchies using different techniques: development team consensus, customer-driven attribute similarity clustering, and factor analysis of the upper levels of the hierarchy. The final section compares the resulting hierarchies and the implications for using them.

D. Building an Affinity Hierarchy

D.1. Data Collection

A seven person student team role playing as a new product development team constructed an "Affinity Hierarchy" using the Japanese consensus technique.[2] No team member had ever designed a food transporting device or worked for a picnic basket or cooler manufacturer. The team's total familiarity with customer needs in this functional area came from their individual experiences, listening to qualitative interviews of two other user's needs, and collectively extracting and compiling customer attributes from 30 customer interviews. This role-playing team represents a product development team which is not particularly aware of their customers or those customers' needs.

The process the team used to build the hierarchy was as follows. Each team member initially was given about 30 cards with one of the 220 already identified customer attributes written on it. A team member selected a card from his stack, read the attribute written on it aloud, and placed that card in the middle of a table. The other team members then riffled through their cards, looking for attributes they believed were "similar" to the card on the table. Similar cards were read aloud and placed on the table near the first card. When the team agreed that the new cards were similar (in some way) to those already in the pile, the cards stayed in that grouping. When someone felt the new card was dissimilar, the team discussed the similar and

[2] Additionally, two affinity hierarchies were built using the same process for the 211 proprietary attributes of a consumer packaged good. The results from these hierarchies will be compared to the food transporter hierarchy in section G.3.

dissimilar points of view until the whole team either agreed or disagreed on the similarity between the cards. Dissimilar cards were placed in other existing piles or used as seeds for new piles. This procedure continued until all 220 cards had been divided into piles that contained cards similar to each other and different from cards in other piles.

A structure was then imposed on the attributes within each pile. The team reviewed all the cards in one pile. By consensus, they organized the cards in that pile into a hierarchy from the most general idea to the most detailed. Sometimes the group identified a number of attributes within a pile that they felt belonged together in a subgrouping. Titles for these subgroupings were often, but not always, found among the cards already within the pile. When the team felt a subgrouping needed a title that was not among the attributes in the pile, they wrote the new attribute on a card and added it to the structured pile. The team reviewed the groupings of attributes at each level of the hierarchy before agreeing on the final structure.

D.2. Affinity Hierarchy Results and Interpretation

The resulting Affinity Hierarchy in Appendix 6.1 contains 247 attributes organized into five primary groups. In some branches the hierarchy extends to 5 vertical layers of detail; in others, just two. The team added 27 attributes (12.3% of the original total number of attributes) as group and subgroup titles during the group process.

As shown in Table 6-1, the major groups are: thermal characteristics, Physical characteristics, overall utility, container convenience, and price. While some phrases added by the team are in "Voice of the Team" jargon (can you imagine Joe Customer saying "it has good thermal characteristics?"), this categorization seems to make sense, at least on the surface. However, it is not a particularly interesting or informative set of characteristics about

Table 6-1. Affinity Hierarchy Complexity

PRIMARY ATTRIBUTE	NUMBER OF ATTRIBUTES BY LEVEL SECOND	THIRD	FOURTH	FIFTH	TOTAL
Price	4	0	0	0	4
Container Utility	2	14	0	0	16
Physical Charact.	10	24	6	0	40
Thermal Attributes	4	18	9	7	38
Convenience	5	21	66	52	144
TOTAL	25	77	81	59	242
Per Primary:					
Average	5.0	15.4	16.2	11.8	48.4
σ	3.0	9.4	28.1	22.7	55.5
Coef. Var.	0.6	0.6	1.7	1.9	1.1

food transporter functional needs. All categories except thermal characteristics are completely generic - they apply to almost any product. The naive management team has essentially added one generic dimension (physical characteristics) and one dimension specific to one product function (thermal characteristics) to the generic dimensions frequently identified in a typical factor analysis of product attributes.

The complexity of the Affinity Hierarchy varies drastically across different primary groups, as can be seen by the summary information in Table 6-1. The simplest of the five primary groups is price, with only four attributes at the secondary level. Container utility extends to the tertiary level, physical attributes to the fourth, and both the thermal and convenience groups extend to the fifth level of detail.

The most complex primary grouping is container convenience, with over 58% (145 out of 247 total) of all the attributes in the "Voice". Almost 36% of the convenience attributes (52 out of 145) are fifth level attributes, those which describe aspects of the container in greatest detail. To the management team "convenience" encompassed all the concepts surrounding access to the container, its organization, the ease with which it can be transported, what kinds of things it should be able to hold, and how easy it is to keep between uses. This primary group included all the customer attributes except those associated with price, temperature maintenance needs, defining what kinds of excursions the container can be used for, and describing the physical specifications of the product.

Are large differences in the size or complexity of parts of a hierarchy a problem? Differences in the numbers of levels in the hierarchy across different primary groupings creates questions about determining the relative importance of attributes. Should an attribute that directly drives engineering design at the secondary level have the same relative weighting as an attribute at the fifth level, or is it inherently "more important" than the fifth level attribute? Current QFD practices treat all attributes equally, regardless of level in the hierarchy. Current marketing practices circumvent the problem by comparing only within-level importance. The marketing solution - constraining comparisons within hierarchy levels - is probably a safer approach until the basic question can be answered. This research will not address that research question.

One piece of anecdotal evidence suggests that primary group size might be a problem to design teams. One student team using this hierarchy to develop a food transporter product concept for a class project decided that the "convenience" group encompassed too many issues. They eliminated the overall concept of "convenience" and introduced the five "convenience" secondary areas as primaries in their own right. Thus, they used a hierarchy of nine primary groupings (five promoted from secondary status) in guiding their product design. (Their design also just happened to be the product most preferred by the customers surveyed.) At least one development team worked better with a structure that clearly separated different concepts.

Are large differences between the size or complexity of primary groupings a problem from the customer's point of view? Do customers consider one aspect of a food transporter much more complex than another? This issue is explored by constructing a Customer-driven hierarchy.

E. Building a Customer-Driven Hierarchy

The method used is a marketing application of a variation of the procedure Miller (1969) used in a psychological study of how lexical information might be organized and stored in memory. The customer-driven hierarchy was constructed by clustering "similar" attributes across the individual Affinity Charts of a number of target market respondents to obtain an "average" hierarchy representing the whole group of customers.

E.1. Data Collection

Data collection consisted of three parts: prescreening, attribute sorting, and exemplar identification. The interviewer prescreened a potential respondent to determine target group membership and willingness to participate. Prescreened respondents were given a randomly shuffled deck of 3" x 5" cards printed with the attributes (a number was written on the back for coding ease) and read instructions asking them to sort the cards into piles of similar phrases. While the instructions did not define "similar," examples were provided using phrases associated with apple characteristics. Respondents were explicitly told that the number of piles they formed was at their discretion; they should feel free to form as many or as few as they wished. Through these instructions each respondent formed an Affinity Chart from the unorganized stack of attributes.

Once all attributes were grouped into piles the interviewer asked the respondent to return to each pile, review the cards in it, and place on its top the card with the phrase most representative of that pile. "Most representative" was purposely not explicitly defined so that respondents could interpret it as they wished. This attribute is called the "exemplar."

After this task was completed the interviewer coded the data, writing the numbers from the backs of the cards onto a coding sheet by pile and indicating the exemplar for each pile. A copy of the prescreening protocols, instruction sheet read to each respondent, coding instructions, and coding sheets can be found in Appendix 6.2.

For each respondent, these raw data were transformed into a 220 by 220 similarity matrix (because there are 220 total attributes) with 1's in cells corresponding to cards piled together and 0's elsewhere. Data was collected for a total of 60 respondents.

E.2. Analyzing the Customer Hierarchy Data

The hierarchy of customer requirements was derived from the aggregate of individual respondent data. An aggregate matrix was obtained by summing the individual 0-1 matrices. The value in any cell, n_{xy}, of the resulting matrix is the number of respondents, out of 60 total, who grouped attributes "x" and "y" together. Aggregate values ranged from 0 to 58. The aggregate matrix can be found in Appendix 6.3. The aggregate matrix is a similarity Matrix for customer attributes. This matrix can be cluster analyzed like any other similarity matrix by any number of standard statistical packages.

Clustering looks for natural groupings among the items clustered. Determining which numerical algorithm is most appropriate for this analysis and identifying the "proper" end point of clustering are rather judgmental and often depend on the goals that clustering was undertaken to achieve. Clustering should be undertaken with a good idea at the outset of just what the goals of the process are and how the results will be judged.

Judging Outcomes From Cluster Analysis

According to Romesburg (1984), the primary measure of the validity of clusters is how well a cluster analysis achieves its research goal and generates interesting and useful conclusions. My goal for clustering the customer attribute similarity matrix is to construct a multi-level hierarchy of attributes which reflects the way customers structure these attributes (as opposed to the way management structures them). Since the "real" customer structure is unknown, even after clustering, there is no direct way to measure the overall goodness of fit of the clustered hierarchy to the customers' internally-held structure.

Because a measure of this "primary" validity is not available, the clustering algorithm and number of clusters decisions were made based on composite results from several "secondary"[3] measures of validity (Romesburg, 1984), statistical outputs provided by the clustering program, cross-method contingency table measures of similarity (Hartigan, 1975), and indications of cluster complexity from exemplar distribution. Secondary validity includes the ability to 1) produce well-structured clusters, 2) agree with expert intuition and 3) agree with the researcher's "priors."[4] The "well-structured clusters" criterion was operationalized as several items:

- each primary characteristic must contain both secondary and tertiary attributes
- each secondary must contain at least two tertiary attributes
- "reasonable" distribution of numbers of attributes across clusters

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[3] Romesburg (1984) uses the terms "primary" and "secondary" in conjunction with validity measures for clustering. The "primary" validity measure seems to be stronger and more direct than those he labels as "secondary."

[4] An earlier test of forming Customer-driven hierarchies also judged results on their agreement with existing classifications of attributes, another measure of secondary validity suggested by Romesburg (1984).

- no excessive chaining
- the "complexity," defined as the number of different ideas contained within a grouping, is approximately the same across all primary groupings.

The cluster analysis provided an icicle plot[5] (Appendix 6.4) and several statistics associated with the agglomeration schedule. The statistics provided by cluster generation from the SAS clustering output were used as a starting point for decision-making. Heuristics based on the secondary validity criteria listed above and intuition were used in interpreting statistical values for the following measures:

- R^2, Expected R^2, and Semipartial R^2. The Semipartial R^2 is the de crease in the proportion of variance accounted for resulting from joining 2 clusters. Mathematically, it is the between cluster sum of squares divided by the corrected total sum of squares.
- Pseudo F. This statistic provides a measure of the separation among all clusters for the current cluster generation.
- Pseudo t^2. This statistic provides a measure of the separation between the 2 clusters most recently joined.
- Cubic clustering criterion, a frequently-used guide to optimal cluster number.
- Eigen values of the covariance matrix.

Contingency tables were set up arraying the comparative contents of the clusters across two hierarchies. Two measures were used to compare content similarities between any two structures, say the solutions for Ward's and the complete linkage algorithms for these contingency tables. The first similarity statistic is S_{ab}, a pseudo-R^2 measure of the proportion of similarity between hierarchies "a" and "b". The null hypothesis is that the two hierarchies are completely uncorrelated; A_{ij}, the number of attributes residing in both the row i and column j cluster, does not vary across the cells in the contingency table. The statistic is calculated as $S_{ab} = E_{ab}/E_p$, where E_{ab} measures the change in the distribution of attributes across cells from the distribution that would be found if the null hypothesis pertained. E_p is

[5] An icicle plot is a map of which attributes or groups of attributes come together by agglomeration step.

the same measure for two perfectly correlated hierarchies.[6] As with R^2, $S_{ab} = 1$ for perfectly correlated hierarchies, while for completely dissimilar hierarchies $S_{ab} = 0$.

The second measure of similarity is Kruskal's λ, a measure of association for nominal variables based on the idea of proportional reduction in error (Goodman and Kruskal, 1954). The λ represents the reduction in the error of predicting the value of a variable by including a second variable as a predicting aid. The λ reported is a symmetric version of the measure which does not assume which hierarchy is the predictor and which is predicted. The Higher the λ (maximum = 1), the better the predictive ability of one hierarchy for the structure of the other.

Exemplars can be indicators of the complexity of a cluster. By complexity I mean the number of (unrelated) functional ideas contained within one cluster. A gross example of this concept might be if attributes describing customer needs for maintaining food temperatures, ease of access, and the need for transportability were contained within one cluster. This is a more complex cluster than one containing attributes describing the customer needs for maintaining food temperatures and coolant requirements. One piece of evidence that might suggest a cluster contained multiple concepts (was more complex) is the number of exemplars associated with the cluster. The distribution of exemplars across clusters can be used to indicate whether one or more clusters is more complex than the others.

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[6] $$E_{ab} = \Sigma_{j=1}^{J} \Sigma_{i=1}^{I} \frac{A_{ij}}{M} \ln \frac{A_{ij}}{(M/IJ)} ; \quad E_p = \ln J; \quad \text{and } J = I.$$

Where a and b denote the two hierarchies compared, M is the total number of attributes, I is the number of clusters in hierarchy a, J is the number of clusters in hierarchy b, and A_{ij} is the number of attributes in both cluster i of hierarchy a and cluster j of hierarchy b.

Various aspects of all these ways for judging clusters were used in choosing the specific clustering parameters and determining the most appropriate number of clusters. The next two sections review the process and logic used in these two pieces of analysis.

Choosing Clustering Parameters

When Miller (1969) used cluster analysis to identify similarities between nouns only one clustering algorithm, single-linkage, and one distance measure, Euclidean, were available in computer clustering packages. Today many distance measures, classification strategies and numerical algorithms are available. Decisions must be made concerning which ones will be used in the clustering routines. Before embarking madly with a gleam in one's eye on a wild clustering spree, it is useful to pre-select as much of the clustering strategy as possible by matching the properties of the various methods to the goals of the analysis. Logically preselecting some clustering aspects based on research goals reduces the comparative analysis of the results from different ways of performing the clustering.

In this research, distance measures and clustering strategies were logically preselected. Preselection also narrowed the number of clustering algorithms compared to four. Choosing a specific numerical algorithm required comparing the results from all four algorithms against the criteria set up in the previous section.

Good clustering results were achieved with Euclidian distance measures, an agglomerative hierarchical strategy and either Ward's minimum variance or the average link algorithm. Ultimately, Ward's method was used as the numerical algorithm.

Of the several different choices for distance measures, Euclidian distances were deemed appropriate for several reasons. The scales for the numbers in the data matrix were identical across all variables, a form appropriate for calculating Euclidian distances without standardizing variable values (Norusis, 1988). Emphasizing attribute similarity makes giving larger variable differences more weighting desirable in the distance calculations (Jackson, 1982), as occurs when Euclidian distances are used. Finally, the particular clustering algorithm used has been developed with Euclidian distances as the standard distance measure.

An agglomerative hierarchical strategy was chosen because an analyst can develop a multi-level hierarchy by making multiple cuts in the agglomeration procedure and because he need not set, *a priori*, initial seeds or group numbers. Clustering strategies are either hierarchical or "hill-and-valley." Hierarchical strategies are either divisive or agglomerative. Divisive strategies begin with all attributes in one cluster and repeatedly create smaller subgroups until all attributes stand alone as independent clusters. Divisive strategies maximize dissimilarity between clusters, and therefore were not deemed appropriate for this cluster analysis.

Agglomerative hierarchical strategies work just the opposite of divisive strategies. They start with individual attributes and step by step build them into fewer and fewer clusters. Cuts can be made in the data at any step of the agglomerative process, even at multiple steps to create multiple levels of the hierarchy. Both agglomerative and hill-and-valley strategies are appropriate for the similarity-within objective.

Hill-and-valley strategies require initial group partitions or seed selections. Group membership of the remaining attributes depends somewhat on the initial partition. Hill-and-valley is especially useful with significant amounts of data noise (Jackson, 1983). However, these data are fairly clean. Less than 5% of the attributes fall into the "somewhat similar" range (20 <

$n_{xy} \leq 40$). Because of its flexibility an agglomerative, hierarchical method was preselected.

Algorithm performance was compared at seven clusters - the number of primary attributes in the final Customer-driven Hierarchy. Four algorithms spanning possible cluster objective ranges were investigated (Table 6-2).

The single-link, or nearest-neighbor, algorithm is the simplest possible

Table 6-2. Summary of the Clustering Algorithms Investigated

ALGORITHM	WARD'S	SINGLE	COMPLETE	AVERAGE
Cluster Shape	Globular	Long, Stringy	Spherical	Globular
Criteria: Merging Clusters	Minimize Error Sum of Squares	Closest Points	Furthest Points	Smallest Average Distance
Objective Maximized	Similarity Within	Difference Between	Similarity Within	Neither
Chaining Starts	6 Clusters	200 Clusters	4 Clusters	6 Clusters

clustering algorithm (Anderberg, 1973). At each stage a new cluster merges from two groups based on the two closest points between different groups across the data. While single linkage is capable of delineating poorly separated clusters (Anderberg, 1973), it is also the technique most likely to produce "chaining," clusters which are long and stringy in nature. Chaining is not desirable in the context of this analysis because one end of a chain can be markedly dissimilar from the other.

The single link algorithm begins chaining with these data almost immediately. By seven clusters, one cluster contains 212 attributes (96% of the total), two contained two attributes, and four consisted of only one attribute (Table 6-3). Based on this rather "unreasonable" distribution and un-

Table 6-3. Cluster Algorithm Comparison

CLUSTER	Number of Attributes WARD'S	SINGLE	COMPLETE	AVERAGE
1	24	212	9	28
2	34	1	61	33
3	43	2	28	40
4	32	2	24	30
5	31	1	41	34
6	24	1	31	24
7	32	1	26	31
AVERAGE	31	31	31	31
σ	6.5	79.6	16.2	5.0
Coef. Var.	0.2	2.5	0.5	0.2

helpful structure at the primary level, the single link technique was immediately eliminated as a potential attribute clustering algorithm.

Complete link, or farthest neighbor, joins clusters at each stage based on the minimum of the distances between the most distant points of each pair of clusters (Anderberg, 1973). Complete link is the least likely algorithm to produce chaining. The resulting clusters are most likely to be spherical. However, the method gives little information about the differences between clusters. Clusters can be interpreted only in terms of the similarities within the clusters, which will be maximized.

The two other clustering algorithms investigated, Ward's and average link, lie between the single and complete link techniques in their propensity to produce chain-like clusters (Romesburg, 1984). Average linkage characterizes a cluster by the average distance of all the links in the new group formed. It does not depend on extreme values for defining clusters, therefore nothing can be said about the minimum or maximum similarity within a cluster. The results are frequently similar to those obtained with the complete linkage method, although this does not appear to obtain herein.

Ward's algorithm calculates the distance between two clusters as the ANOVA sum of squares between them, summed over all variables (SAS Institute, 1985). Ward's method merges the clusters that result in the smallest increase in the overall sum of the squared within-cluster distances (Norusis, 1988). This algorithm is therefore one of the strongest for the similarity-within objective. Ward's operates directly on similarity matrices such as the one generated by the customer sort data (Anderberg, 1973).

From both statistical and content measures, complete link, average link, and Ward's produced amazingly similar structures, especially Ward's and average link. Specifics for the complete link hierarchy differ a bit from the other two. The statistical outputs are all a bit lower, though not significantly so, for the complete link algorithm. As expected, chaining is not the major mechanism by which clusters aggregate. Complete linkage chaining does not begin until two groups come together to form cluster 4. Neither of these factors eliminates complete link as a clustering algorithm.

Cluster sizes vary more in number of attributes for the complete linkage method (σ = 16.2, CoV = .5), with standard deviations about 2.5 times greater than those for Ward's and average linkage (Table 6-3). While the overall distribution is not "unreasonable," and does not *a priori* eliminate complete link as a possible cluster algorithm candidate, one of the clusters (# 2) is rather large, consisting of more than 25% of the total attributes. It is the size and composition of this cluster that suggests either of the other two algorithms might be "better."

The major structural difference between complete linkage and the other two algorithms comes from a more complex structure in the group describing the container's convenience, utility as a container, and size and shape. Of the 61 attributes in this complete linkage primary group, 14 (23%) are exemplars. The average number of exemplars per cluster for any seven cluster Solution is 5.9, with a standard deviation of 2.8 (calculated for exemplar dispersion for the Ward's algorithms, see Table 6-4). Thus, the number of exemplars in the largest complete link cluster is 2.9 standard deviations a-

Table 6-4. Exemplars by Cluster

CLUSTER	WARD'S	SINGLE	COMPLETE	AVERAGE	AFFINITY
	Number of Exemplars				
1	9	39	0	10	2
2	9	0	14	9	21
3	6	2	6	6	10
4	7	0	10	6	3
5	6	0	7	6	6
6	1	1	1	1	-
7	4	0	4	4	-
Average	6.0	6.0	6.0	6.0	8.4
σ	2.8	14.6	4.9	3.0	7.7
CoV	0.5	2.4	0.8	0.5	0.9

way from the expected average, suggesting that this cluster might encompass multiple primary ideas. It has a higher complexity than most other structures. The Affinity Hierarchy (previous section) also had a very complex structure across these functional areas, which as discussed previously, is worrisome. Due to the complexity of this group, the complete linkage algorithm was not used to develop the Customer-driven Hierarchy.

Similarity measures show a very high measure of agreement between the structures of the average linkage and Ward algorithms at the primary level. Only seven of the 220 attributes are in different primary groupings across the two structures. This is enormously high similarity (S_{Wa} = .95) between the two structures. At .89, λ_{Wa} is also very high: knowing one of the two structures reduces the error in predicting the other by 89%.

The above analyses provide logical reasons to prefer the average linkage and Ward's algorithms over either the single link or complete link. However, differences between the average linkage and Ward's structures are trivial. The algorithms produce very similar results. Ultimately, Ward's was used for two reasons. In general Ward's method is more "popular" and is used more than the average linkage algorithm in industry (Romesburg, 1984). Other users generally have found this algorithm produces intuitively acceptable groupings of similar items. Secondly, two other proprietary developments of

Customer-driven Hierarchies have also used Ward's method, with management concurring that the resulting structures made sense (Romesburg's 1984 "agreement with expert intuition" validity criterion). This other usage provides a series of comparably-developed data sets.

While this particular investigation was completed using Ward's, that does not necessarily mean that it always should be used in developing future Customer-driven Hierarchies. It would probably be worthwhile to assume going into the process that Ward's would be used, but cross-check the results at least with the complete and average link methods.

Building The Customer-Driven Hierarchy

> A substantial practical problem in performing a cluster analysis is deciding on the number of clusters in the data... The literature contains a lot of wishing for mechanical methods of determining the number of groups. It can be a difficult choice. (Anderberg, 1973)

The decisions of how many clusters should be in the hierarchy were made first at the primary level, then at the secondary level, given the primary structure. The primary and secondary groups within the hierarchy were then given names or titles.

From scree charts of various statistics by cluster generation, such as those sho in Figures 6.1 through 6.5, ranges were identified where breaks in the slopes of curves indicated potential levels for primary groupings. Large changes in slope occurred between 3 and 5 clusters, 7 and 9 clusters, and 11 and 13 clusters. These three ranges of clusters were thus considered as candidates for numbers of primary groups.

To make the final assessment for number of primary clusters, a horizontal icicle plot of the agglomeration schedule and the specific contents of the various groupings were reviewed. Aggregating from the 7 cluster solution to the 1 cluster solution proceeds by chaining. The 6 remaining clusters are added to the "works well as a container" cluster one at a time. While Ward's

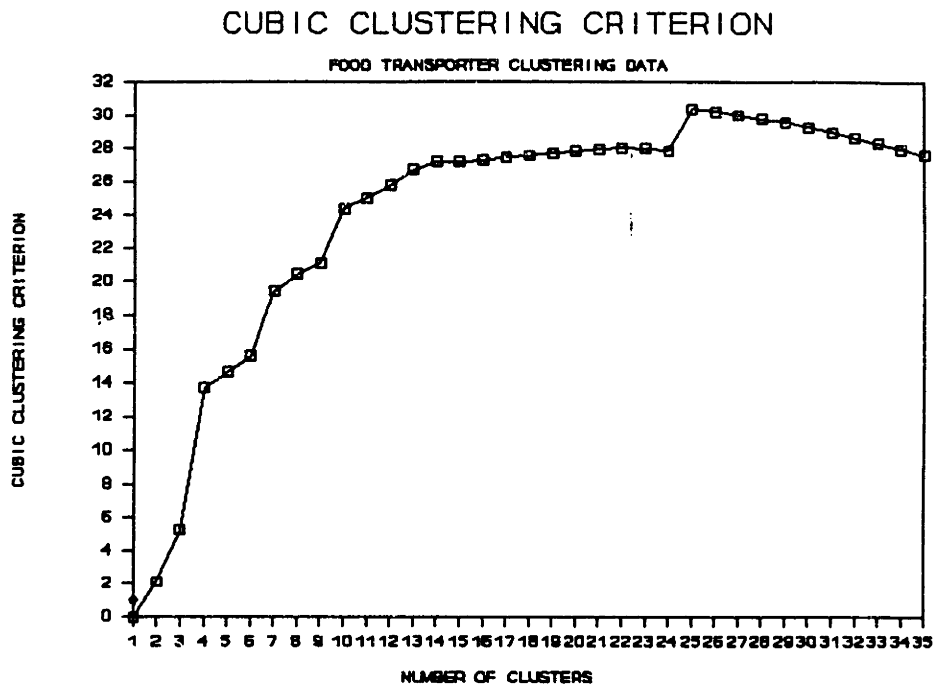

Figure 6.1. Food Transporter Clustering Statistics

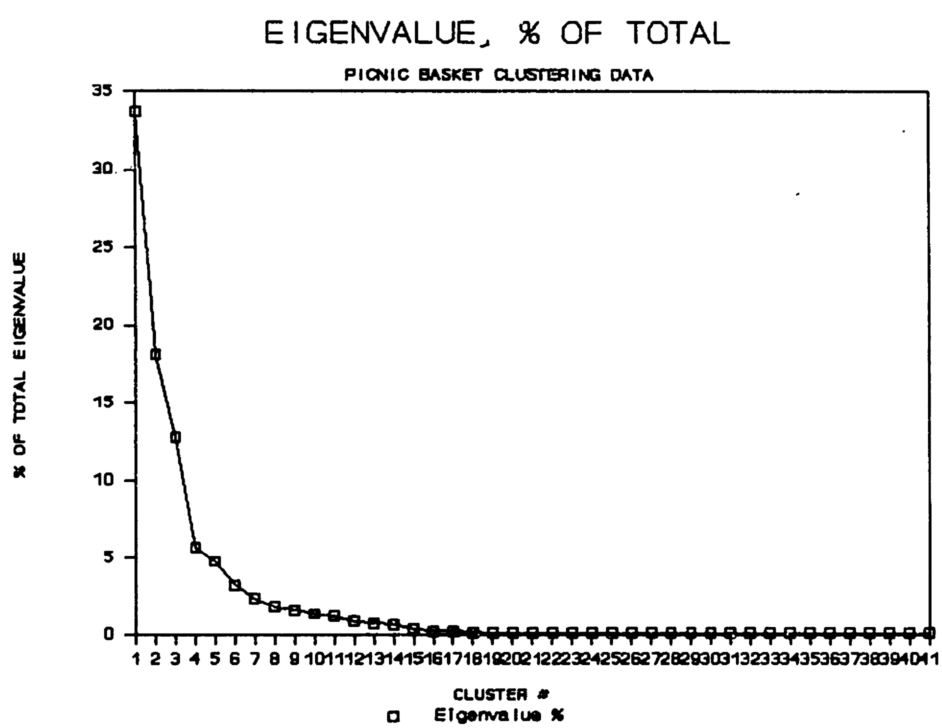

Figure 6.2. Food Transporter Clustering Statistics

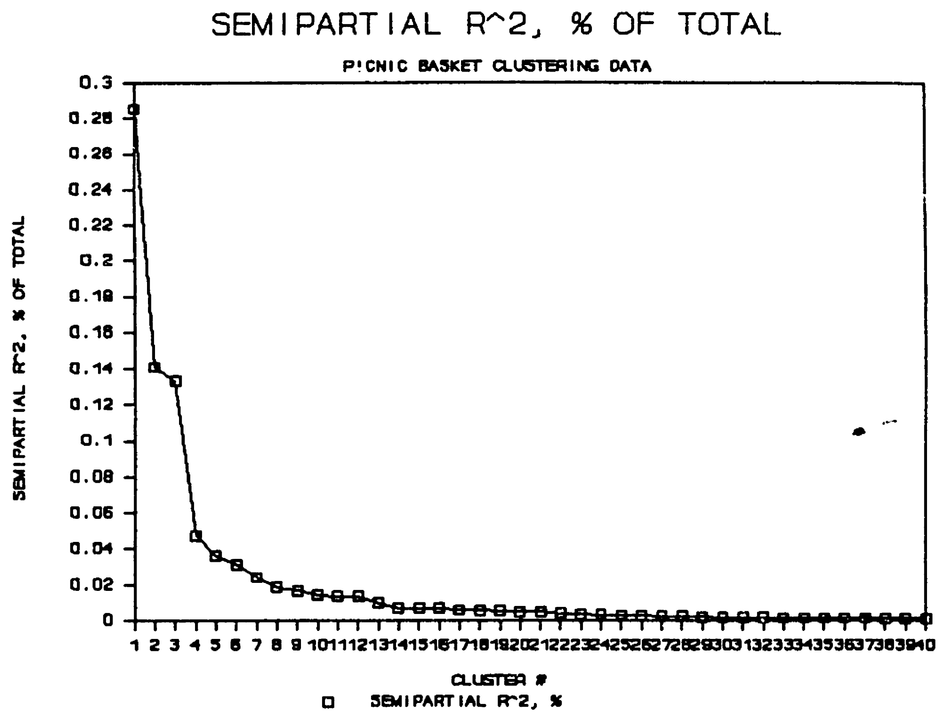

Figure 6.3. Food Transporter Clustering Statistics

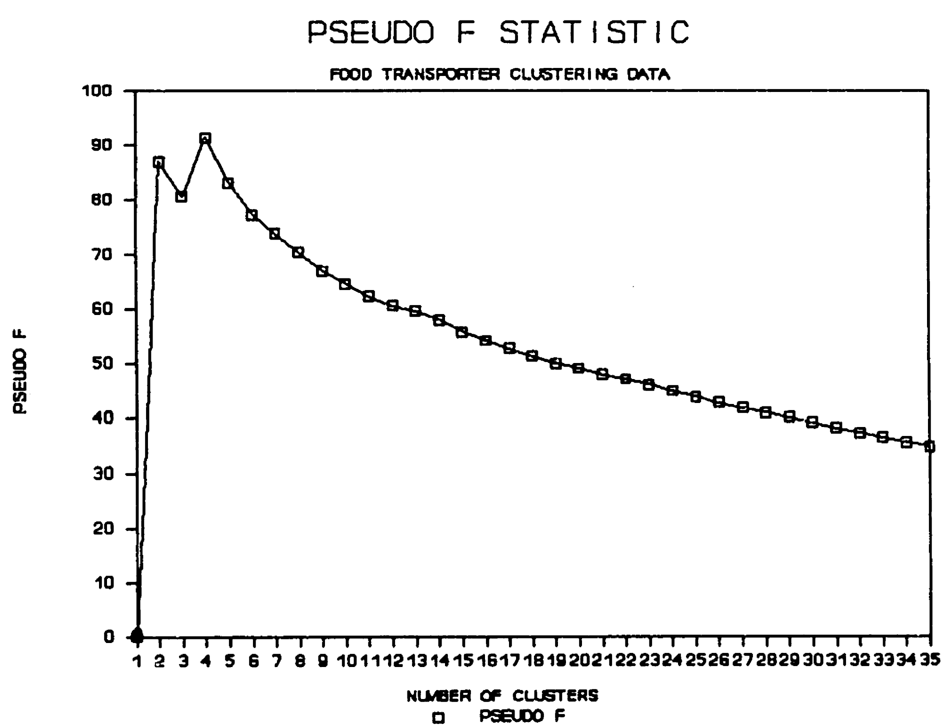

Figure 6.4. Food Transporter Clustering Statistics

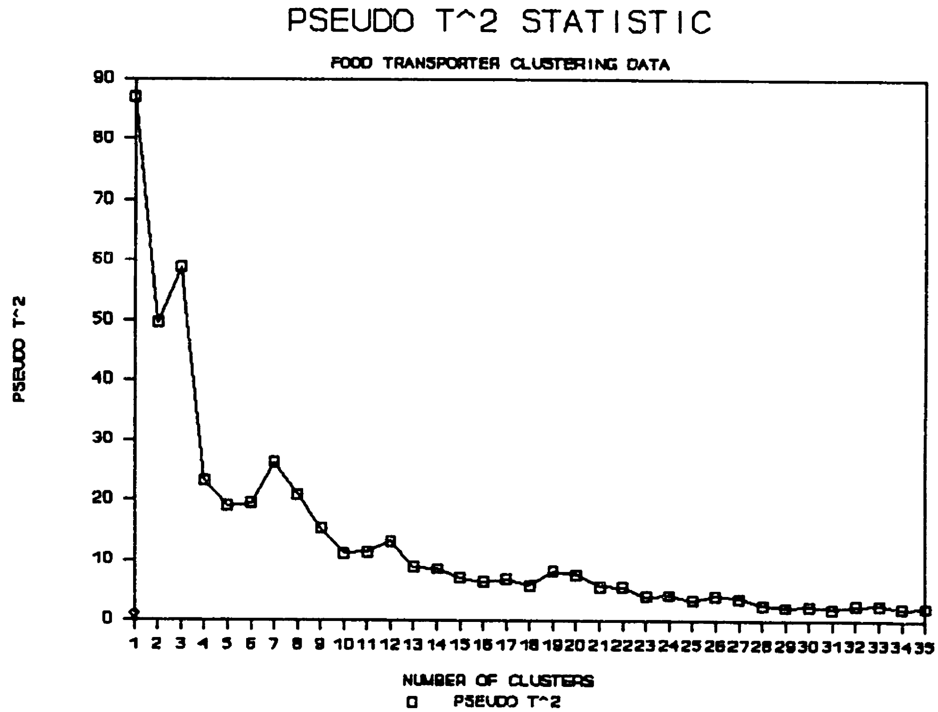

Figure 6.5. Food Transporter Clustering Statistics

algorithm tends to form somewhat spherical clusters, the agglomeration beginning with the step to six clusters operates chain-wise instead of with multiple branches that ultimately come together. The change in apparent mechanism suggests that the clusters being joined together are no longer very alike, which is verified by the huge jump in the value of the pseudo t^2 between cluster generations five and three. The clusters joined after cluster six are too dissimilar to constitute primary categories.

Moving from seven clusters in the final solution to eight clusters is accomplished by splitting the cluster describing cooling material requirements from the one describing temperature regulation requirements. Moving to nine clusters in the final solution would require separating the aspects of ease to transport from how easy it is to carry. Not only do each of these sets seem to be two halves of one overall concept, splitting them would create at least one and as many as three primary groups with no tertiary level attributes. To eliminate the possibility of clusters without tertiary attributes, seven primary groups were chosen, even though both the cubic clustering criteria and the pseudo t^2 indicate that eight clusters might be statistically preferred to the seven cluster solution. In this case, cluster content overrides statistical suggestions. From the R^2 values, seven clusters retains over two-thirds of the variance across all the variables in the data set.

The number of secondaries in the final hierarchy is determined from the agglomeration schedule, icicle plot, and various scree charts for the range under consideration. The first task is to set an appropriate range within which to look. From the agglomeration schedule, the last independent attribute, "easy access with one hand," joins a cluster at aggregation step 41. If the final hierarchy contained more than 40 secondary groups, one secondary would have no tertiary descriptors, violating one of the heuristic rules. To eliminate that potential, the maximum number of secondaries was set at 40.

The final hierarchy should also consist of at least 16 secondary clusters to eliminate primary clusters that contain no tertiaries. The two sub-clusters of "carries many things" come together as the fifteenth cluster. For 15 or fewer secondary groups, "carries many things" would become a cluster of 24 secondaries, with no tertiary attributes describing them, violating the heuristic rules.

The eigen value scree chart in Figure 6.6 has been redrawn to enlarge the scale for the change of the eigen value slope between clusters 16 and 35. From this figure, possible ranges for secondary groupings are 21-23, and 25-27. The graph of the pseudo t^2 statistic, Figure 6.7, is not particularly helpful in determining clusters. Part of the problem is that the number of clusters under consideration is so large that the differences in distances, eigen value proportions, and other statistical guidelines are very small and

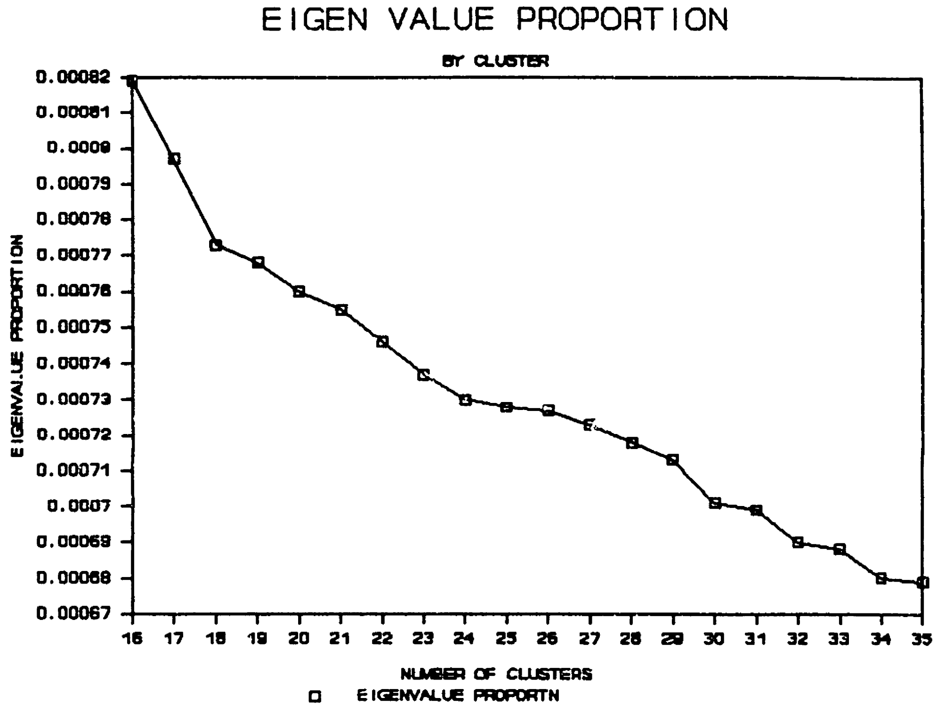

Figure 6.6. Scree Chart for Secondary Level

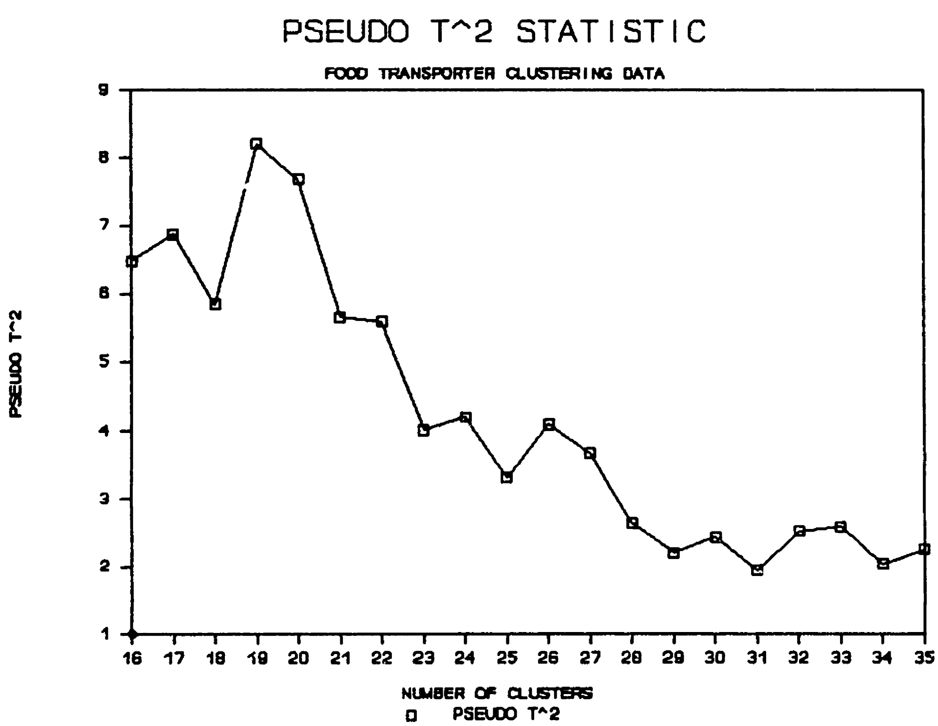

Figure 6.7. Pseudo T^2 Statistic for the Secondary Level

not particularly helpful in making the final decisions. Therefore, the number of secondary clusters was determined primarily from the content of the clusters, the agglomeration schedule, and the icicle plot, starting at the structure with 21 secondary clusters.

Moving from 21 to 22 clusters is accomplished by splitting off a group of "ease of use" type attributes from ones dealing with the way the lid works on page two of the icicle plot in Appendix 6.4. Moving from 22 to 23 secondary clusters is done by separating some specific attributes about cooling capabilities from attributes about general thermal capabilities, including some cooling aspects. While the move to 22 clusters does seem to make sense because that generation joins two somewhat different aspects, going to 23 clusters does not make as much sense. Looking at the splits to 24 and 25 clusters, they also seem to split very similar groups of items.

None of these moves to more clusters splits off groups with exemplars. If there are exemplars in the original cluster, they all remain in only one of the two offspring. This suggests that the offspring separated at this level do not differ significantly. Therefore, the 22 cluster solution will be used as the secondary category groupings in the final hierarchy. These 22 clusters aggregate up to the seven primary categories (Appendix 6.5).

The remaining task in structuring the Customer-driven Hierarchy is naming the primary and secondary categories. Attributes frequently identified as exemplars were candidates for becoming secondary and primary level attributes. Of the 22 secondary clusters in the final hierarchy, 17 (77.3%) contain attributes identified by at least 20% of the respondents as category exemplars. That is, only five secondary clusters in the final hierarchy did not have attributes identified as exemplars by respondents that could be considered for the title for the secondary or primary category. Not all exemplars seemed appropriate as subtitles or titles. In cases where the exemplar did not fit or there was none, an appropriate label was created and used. Overall, one-third of the titles were added; two-thirds were derived from exemplars identified by respondents.[7]

According to Anderberg (1973), cluster analysis requires the active participation of the analyst to interpret the results and judge their significance. Determining the final cluster structure for this application has indeed taken significant judgment.

E.3. Customer-Driven Hierarchy Results and Interpretation

Ward's algorithm generated a three level hierarchy which is proposed as one structure that "fits" the data. The final hierarchy derived from the customer sorting data consists of seven primary groups, 22 secondary groups, and 201 tertiary attributes. Ten attributes (4.5% of the original number) were added as titles for primary and secondary groupings. All primaries extend to three levels of detail due to the process and rules used to develop the hierarchy. The distribution of attributes across primary groups is fairly even (CoV = .2). The full Customer-driven Hierarchy is presented in Appendix 6.5, a summary in Table 6-5.

The seven primary groups, "attractiveness," "carries many things," "maintains food temperatures," "right size," "easy to move," "convenience," and "works well as a container," make sense as general functional areas for food transporters. Of these, three ("attractiveness," "right size," and "convenience") might be considered generic needs for almost any product. The other four groups describe specific functional areas for food transporters. Romes-

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[7] The Affinity Hierarchy contains 62 primary, secondary, tertiary, and fourth level attributes as titles for groups of lower level attributes. Of these titles, 27 (43.5%) were added by the team. Thus, having respondents identify exemplars in the customer sort task may in fact help decrease the number of attributes added to the original attribute list.

Table 6-5. Customer-Driven Hierarchy Summary

PRIMARY ATTRIBUTE	NUMBER OF ATTRIBUTES BY LEVEL SECOND	THIRD	TOTAL
Attractive	4	20	25
Convenient	4	31	36
Works Well As a Container	5	39	45
Right Size	3	29	33
Carries Many Things	2	23	26
Maintains Food Temps.	2	29	32
Easily Movable	2	30	33
TOTAL	22	201	230
Average/Primary	3.1	28.7	32.9
σ	1.2	6.1	6.7
Coef. Var.	.4	.2	.2

burg (1984) claims that clusters defined using Ward's method usually have a well-defined look - they jump out at the eye. I contend that this is the case with these data, especially at the primary level, but also for determining the secondary cluster cut.

It is not assured that this particular structure represents the "real" structure held by customers. It is not even possible to determine how far off this structure is from reality. However, the particular clustering algorithm was chosen to work to the objective (maximizing similarity within), the results have face validity (the structure makes intuitive sense), and based on agreement with four measures of secondary validity, I feel that the attribute hierarchy constructed from the Customer-driven method is representative enough to provide good data on relative importances among attributes.

F. Building a Hierarchy Using Factor Analysis

The objective of factor analyzing the secondary attributes identified from the cluster analysis into dimensions was to see if factor analyzed dimensions 1) reproduced the primary groupings obtained from the cluster analysis or 2) were more interesting or useful than the groupings obtained with any other hierarchy building technique.

F.1. Data Collection and Analysis

Data for factor analyzing attributes into dimensions was abstracted from the performance rating data collected for determining the relative importances of attributes (see section 7.G for specifics of how these were collected). Performance ratings, r_a^n, for the 22 secondary attributes identified in the Customer-driven Hierarchy were standardized across all attributes by respondent using the formula $R_a^n = (r_a^n - r_{ave}^n) / \sigma^n$ for each of the 73 respondents in the sample. The superscript "n" refers to the respondent, while the subscript "a" refers to the secondary attribute. The factor analysis was performed using a principle components algorithm with varimax rotation.

Table 6-6. Statistical Output for Factor Analyzing Secondary Customer Attributes

FACTOR	EIGEN-VALUE	% of VARIATION	CUMLATIVE VARIATION
1	4.28	19.5%	19.5%
2	2.21	10.0	29.5
3	2.06	9.3	38.8
4	1.76	8.0	46.8
5	1.53	7.0	53.8
6	1.31	6.0	59.8
7	1.13	5.1	64.9
8	1.06	4.8	69.7

The eigenvalue scree chart indicates break points at 3, 5, and 7 clusters. Table 6-6 lists eigen values, percent variation, and cumulative percent variation for eight factors. To satisfy the rule of thumb that each factor should account for at least 10% of the variation in the data, only two factors would be used. However, seven of the 22 attributes (31.8%) do not load significantly (loading < |.4|) on either factor of a two-factor solution.

Dimensions for both the 3 and 5 factor solutions were reviewed. As with other applications of factor analysis to product attributes, the 3 factor solution produces very generic dimensions: "Works well," "Easy to use," and "Good design." Three attributes do not load significantly on any factor, several attributes seem misplaced and the resulting dimensions do not communicate any of the specific functional needs of a food transporter.

F.2. Factored Dimension Results and Interpretation

The five factor result provides the "best" set of factors from the secondary attributes, but even this result, shown in Table 6-7, is difficult to

Table 6-7. Dimensions and Attribute Distribution from Factor Analysis

FACTOR 1 "No Hassle"	FACTOR 2 "Works Well"	FACTOR 3 "Can Use it Lots"
Durable	Reasonable price	Easy to use
Water drains out	Organized, neat	Lide works well
Doesn't leak	Protects things	Usable year-round
Conv. Cooling Mech.	Multiple Purposes	Useful for traveling
Easy to Transport	Carries non-foods	
Convenient to Carry	Carries food items	

FACTOR 4 "Design"	FACTOR 5 "Works for All"
Elegant design	No problems
Separates things	All in one container
	Efficient Use of Space

interpret. While possible dimension names have been supplied for each factor, a number of attributes seem out of place. The dimensions would make more sense if some attributes had loaded on different factors.

Results from the factor dimension structure are not as good as the results from the primary attributes from the clustered hierarchy (Table 6-3). The factored dimensions account for less variation in overall satisfaction than do the primaries of the Cus-

Table 6-8. Regression of Satisfaction Versus Indices of Satisfaction Calculated from Preference Regression and Factor Analysis Importance Weights

Satisfaction on:	t-value	R^2	F
Preference Index	6.4	.366	41.0
Factor Score Index	5.3	.297	28.3
Both Preference and Factor Score Indices:			
Preference Index	3.7	.419	23.8
Factor Score Index	2.4		

Number of cases = 73

tomer-driven Hierarchy.[8] When overall satisfaction is regressed against the factor scores for the five factor solution, only Factor 3, "Usable," and Factor 4, "Design," enter into the regression equation, with the resulting equation accounting for 30% of the variation in the data. When the ratings of the primary attributes are regressed against overall satisfaction, three of the Customer-driven primary attributes enter into the regression equation: "Attractive," "Works well as a Container," and "Right Size," and 37% of the variation in the data is explained by the equation.

Direct comparisons of the relative performance of factor analysis and preference regression can be made from Table 6-8, which demonstrate that preference regression outperforms factor analysis in predicting overall satisfaction. When both indices of satisfaction (calculated as the sum across all primaries or factors of the importance weights times factor scores or primary ratings) are regressed against self-stated satisfaction, the t-statistic for the preference method is larger than for the factor analysis. Including two explanatory variables in the equation reduced the F statistic over that for the preference method alone by 41%, a much larger reduction than the 16% from the factor method alone.

G. Comparing Attribute Hierarchies

This section compares and contrasts Affinity and Customer-driven Hierarchies for several sets of data with an eye to finding the answers to three sets of questions.

- How do hierarchies derived from various methods differ, and can some hypothesis be developed to explain those differences?

- Which parts, if any, of the hierarchy's structure are stable across various construction methods, and which are more questionable? It is probably fair to assume with a higher degree of confidence that more

[8] The specifics of this analysis are covered in Section 7.F.

stable aspects of the hierarchy more closely represent consumers' "actual" attribute structures.

- Is the effort and expense of field research always required in order to construct a hierarchy of customer attributes?

Customer-driven and Affinity Hierarchies differ in several ways:

- Customer-driven Hierarchies are inherently more expensive and time consuming to develop than Affinity Hierarchies

- Affinity Hierarchies are more variable in complexity across primary groups than hierarchies constructed using this clustering technique.

- Affinities Hierarchies tend to have more Voice of the Team jargon, and a higher proportion of category labels added throughout the hierarchy.

- With more category labels, fewer attributes of the Affinity Hierarchy will actually drive engineering design.

It is not known how closely the Customer-driven structure represents the customers' hierarchy. It is therefore not possible to definitively conclude that structuring hierarchies from customer data is always preferable to using management's knowledge for the task. The comparisons do suggest that fewer similarities might exist between the Customer-driven and Affinity Hierarchies when the product team is not well-acquainted with their customers. I therefore recommend that teams not familiar with the product area construct hierarchies from customer data.

Actually, it's probably a good idea to construct both an Affinity and Customer-driven Hierarchy for any product area. The two structures can be used to discover on which content areas the two groups think most alike and in what parts of the attribute structure there are major differences. Areas of difference may indicate that more information is needed on some structural aspects or that the product team should be very careful in its operationalization of the design targeted at achieving some functional needs.

G.1. Differences Across Hierarchies

Differences across hierarchies will be investigated by looking at specific differences between the hierarchies with respect to time and expense for hierarchy development, structural differences, and content differences.

Time and Expense Differences for Constructing Hierarchies

Unquestionably, the Affinity Hierarchy requires much less time and expense to develop than the Customer-driven Hierarchy. Given a list of attributes, constructing an Affinity Hierarchy absorbs ½ to 1 day for however many people are on the team (generally 6-10) and can be completed as soon as a meeting with all the principals can be scheduled. An average figure for cost of product team time might be $5,000[9].

The Customer-driven process gathers data from at least 50 potential customers through field-based marketing research. Given a list of attributes, this process requires about three weeks to accomplish; 1-2 weeks in the field and 1-2 weeks to code and computer analyze the data and get buy-in to the results from the team. In addition to requiring about the same amount of product team time as the Affinity Hierarchy, the Customer-driven hierarchy will also use about one week's time of a reasonably competent market researcher/statistician (worth perhaps $5,000) and incur an estimated $10,000 in out of pocket field expenses. Constructing a Customer-driven Hierarchy requires longer lead times and significantly more corporate expense, both indirect and out of pocket, than constructing Affinity Hierarchies.

Structural Differences Between the Hierarchies

Table 6-9 summarizes the structural differences between the two food transporter attribute hierarchies. The Affinity Hierarchy contains 7.4% more attributes than the Customer Hierarchy (247 versus 230), because the team added over 2.5 times the number of attributes as labels than were added to the Customer Hierarchy. The addition of this many labels to the attribute

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[9] Calculation: ($200,000/yr/person)/(250 days/yr)x(.75 days)x(8 people)

Table 6-9. Comparing Hierarchy Structures

	AFFINITY HIERARCHY		CUSTOMER-DRIVEN HIERARCHY	
	#	% Total	#	% Total
# Attributes	247	100.0%	230	100.0%
# Atts. Added	27	12.3%	10	4.5%
# Primaries	5	2.0%	7	3.0%
# Secondaries	25	10.1%	22	9.6%
# Levels	5		3	

list is troubling because they are not strictly customer-derived attributes. They are attributes provided by engineering and management and they often smack of engineering jargon, not customer language. A good case in point is the primary label "thermal characteristics."

Also troubling is where attributes were added, as shown by Figure 6.8. At the primary level, four out of the five in the Affinity Hierarchy were added by the team, and almost half (three out of seven) were added for the Customer Hierarchy. On a percentage basis, more attributes were added at the secondary level for the Customer than for the Affinity Hierarchy. However,

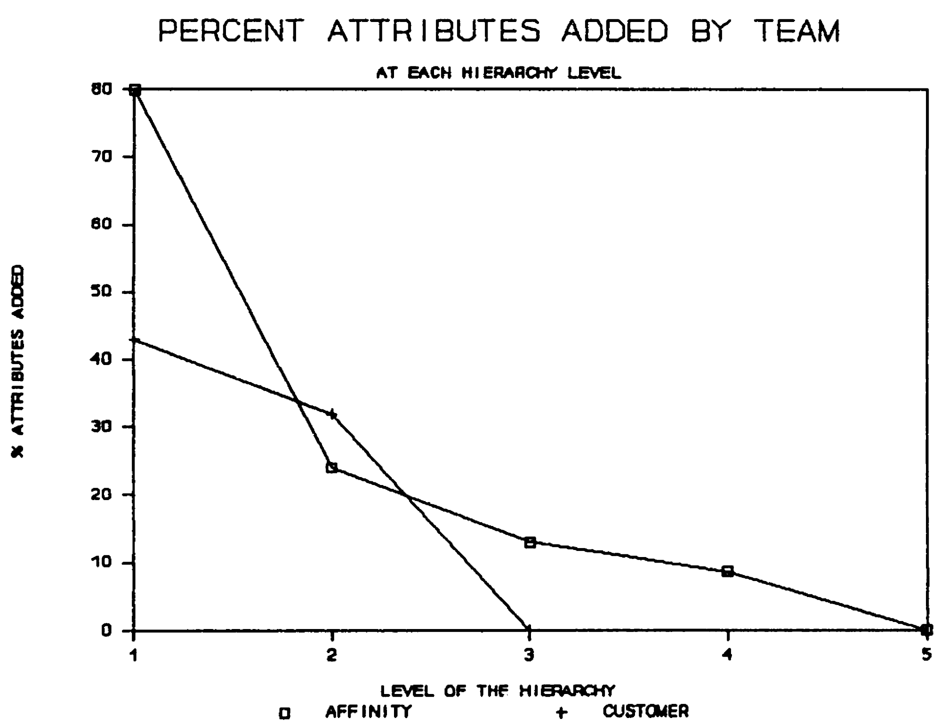

Figure 6.8. Attributes Added by the Teams

the team also added attributes to the Affinity Hierarchy at the third and fourth level of detail. Almost 10% of the fourth level attributes were added by the team. In all, almost half of the Affinity Hierarchy categories containing more levels of detail are labeled by attributes added by the development team. The comparable number for the Customer Hierarchy is about one-third. These are both high percentages.

Why in this study were so many upper level attributes added by the team? One explanation is that this is a problem inherent to developing Affinity Hierarchies. A second possible answer may be that the lack of customer denoted upper level attributes was an attribute extraction, not a hierarchy development problem. The qualitative interviews drew out detailed information through talking respondents through specific use situations. Questions surrounding general likes, dislikes, and global wants were not explicitly asked, even in the wrap-up. The process should be changed in the future to explicitly draw out general, as well as situation specific needs.

Table 6-10 compares the primary groups for the two hierarchies. Overall,

Table 6-10. Comparing the Hierarchy Primary Structures

AFFINITY HIERARCHY		CUSTOMER-DRIVEN HIERARCHY	
Primary Group	# of Attributes	Primary Group	# of Attributes
Price	5	Attractiveness	25
Utility	17	Carries Many Things	26
Thermal Characteristics	39	Maintains Temperatures	32
Physical Characteristics	41	Right Size	33
Convenience	145	Easy to Move	33
		Convenience	36
		Works Well as Container	45
Total Attributes	247		230
Average/Primary	49.4		32.9
σ	55.5		6.7
Coefficient of Var.	1.1		0.2

the customer sort hierarchy has a much more balanced set of primary groups, in terms of group size. The coefficient of variation for the number of attributes per primary for the Affinity Hierarchy is 5.5 times the that of the Customer Hierarchy (1.1 versus .2). The difference in the coefficient of variation is primarily attributable to two groups. The "price" group of Affinity Hierarchy attributes, which, with a total of five, is only 3.5% of the size of the "convenience" group, which contains 145 attributes. The Affinity convenience primary is three times (300%) the average group size. The largest Customer-driven primary is only 37% bigger than the expected average size. The smallest Affinity and Customer-driven primary groups are 10% and 76% of their respective average group sizes. While the size of the Customer-driven primary groups does vary, this hierarchy does not produce the huge variations in group size that the Affinity Hierarchy does.

Another troubling structural aspect of the Affinity Hierarchy is the attribute distribution across hierarchy levels. The dispersion of attributes across levels affects the engineering design of the product. Figure 6.9 shows how attributes in each hierarchy are distributed across the various levels. More of the attributes in the Customer Hierarchy than in the Affinity Hierarchy will directly drive the engineering design. Attributes that are labels for groups of lower level attributes (more detailed attributes) do not directly drive engineering design. Only attributes with no further levels of detailed needs located beneath them are matrixed against engineering design parameters in the QFD matrices. All 201 tertiary attributes (91.6% of the total) in the Customer Hierarchy will be matrixed against engineering attributes. In the Affinity Hierarchy, only 185 attributes (74.9% of the total) will be crossed with engineering attributes. Many more attributes of the Customer than of the Affinity Hierarchy will drive engineering design

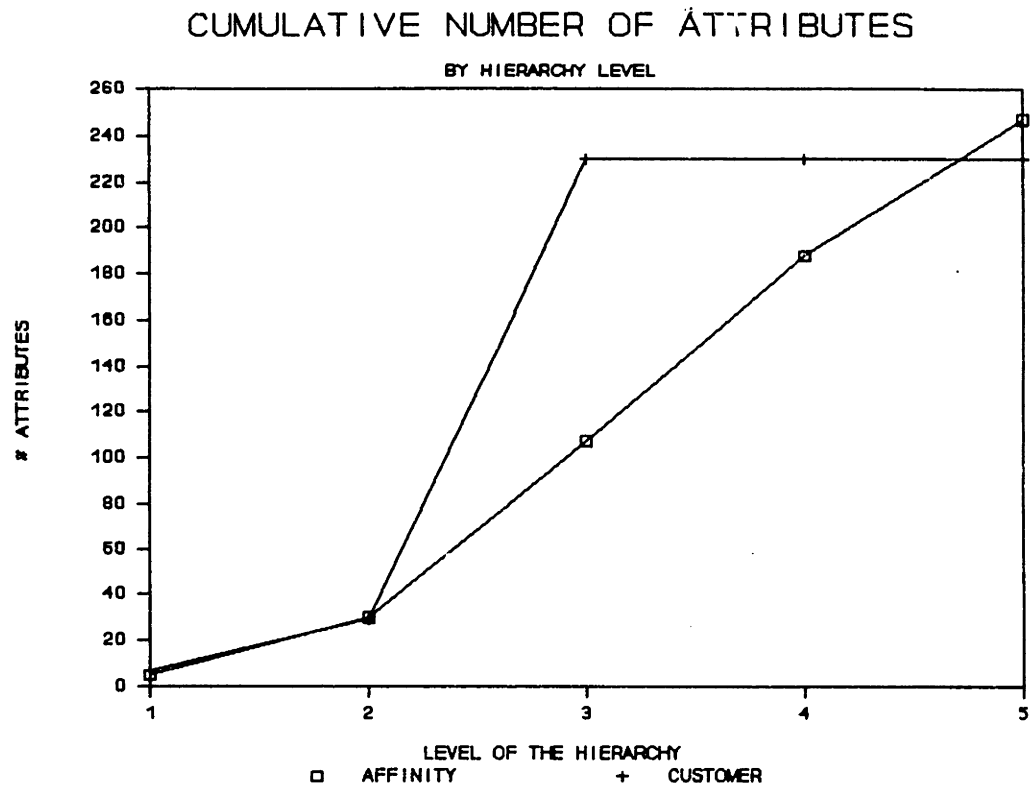

Figure 6.9. Number of Attributes by Hierarchy Level

directly.

While all matrix-crossed Customer Hierarchy attributes are tertiary level attributes, the Affinity attributes driving engineering design reside at all levels of the hierarchy between two and five. Current QFD practices treat the relative importance of attributes at any level of the hierarchy equally, but it is unclear whether that policy makes sense. If the Affinity Hierarchy is used for structuring attribute importances, some means for balancing the relative importance of second level versus fifth level attributes crossed with engineering design variables might have to be developed.

Content Differences And Similarities Across Hierarchies

Not only are there several general structural differences between the two hierarchies, they also differ in their specificity to the product function, average complexity across primary group, and content similarity across specific primary and secondary groups.

The Affinity Hierarchy is almost completely generic in nature (only one out of five categories addresses issues not generic to almost any product). Over half (four out of seven) of the Customer-driven primary categories describe functional aspects specific to this product category. This difference should make the customer hierarchy more useful. It definitely makes it a more interesting structure, which coincides with one of Romesburg's (1984) primary validity measures for a set of clusters or groups.

Table 6-11. Exemplars per Primary Group by Hierarchy Type

	HIERARCHY	
	Affinity	Customer
Exemplars	8.2	5.9
σ	7.3	2.8
CoV	0.9	0.5

Group complexity across the Affinity primary groups shows far more variance than it does across the Customer-driven primary groups, as indicated by the exemplar data. Customers identified 41 attributes as exemplars in the customer sort field research. Table 6-11 indicates that the coefficient of variation of the Affinity number of exemplars per primary is almost twice the Customer-driven value. This is primarily because the development team felt that food container convenience was a multi-faceted concept. Of the 41 total exemplars, 20 (48.8%) reside in the Affinity Hierarchy convenience primary group. As mentioned previously, the high complexity of a group like this may pose problems to a development team.

Overall content similarity between the two hierarchies is again measured via S_{AC} and Kruskal's λ as it was in comparing clustering algorithms. Similarity analyses were carried out at two different levels of hierarchy structure. The first analysis compared the hierarchies at the primary level, ignoring any underlying structural differences at the second, third, or lower levels. Attributes were merely lumped into categories corresponding to primary hierarchy groupings.

The second analysis investigated similarity one layer down, at the secondary level of category structure. This analysis maintains early patterns of attribute agglomeration but ignores the manner in which secondary groupings are structured into primary clusters. Hierarchies more similar at the secondary than at the primary level may indicate that while the development team brings together some detailed aspects of needs much as customers do, they may not aggregate those detailed aspects into more general constructs of product function like customers. A primary level similarity much higher than that at the secondary level may indicate that the team understands generally how customers sort attributes into overall functional needs, but does not grasp how to operationalize general concepts into functional specifics that define a product to achieve those concepts.

Similarity data for both sets of hierarchies investigated are presented in Table 6-12. From λ, knowing the primary groups of attributes for one food transporter hierarchy only decreases the error in predicting the structure using the other hierarchy development method by 28%. S_{AC} indicates there is about a 42% similarity between the two structures at the primary level. At the level of secondaries, however, the similarity is much stronger between the two hierarchies. That suggests that the "naive" development team reasoned more similarly to the customer on the detailed level than at the more general construct level of food transporter needs.

Table 6-12. Similarities between Affinity and Customer-driven Hierarchies

KRUSKAL'S λ		SIMILARITY	
Primary Level	Secondary Level	Primary Level	Secondary Level
.28	.51	.42	.81

G.2. Content Stability Across Hierarchy Development Methods

This question requires comparing food transporter structures of the Affinity, final Customer (Ward's), and other investigated clustering algorithm structures. The picnic basket data analysis of different clustering methods suggested that the most stable primary groups of attributes even across different clustering methods were the "attractive," "maintains food temperatures," "carries many things," and "is easily moved" categories. The structure of the attributes within the three final clusters in the Ward's derived hierarchy, "convenience," "works well as a container," and "right size," is less stable across different clustering methods.

If the major difference between the Affinity Hierarchy and the Customer-driven hierarchy existed in the way these three clusters were structured, I think it would be safe to conclude that our confidence in understanding how these attributes are structured is lower, while the confidence in the remainder of the structure is much higher. However, the picnic product development team did not reproduce the majority of even the most stable portion of the hierarchy. The only two primary groups in the picnic basket data which are very similar are "maintains food temperatures" (Customer) and "thermal characteristics" (Affinity). The "attractive" and "physical characteristics" categories show some similarity.

The primary cause of the lack of stability across the two structures is again the Affinity "convenience" category which contains major portions of five customer categories: "convenience," "works well as a container," "right size," "carries many things," and "easily movable." However, if the five secondary groupings of the "convenience" Affinity category are treated as primary groups and the resulting structures compared, the only increase in similarity is between the two "easily movable" groups, the Customer primary cluster and the Affinity secondary grouping. None of the other Affinity secondaries is made more similar to the remaining Customer primaries.

While, overall, I feel fairly confident that four primary groups of the Customer-driven Hierarchy represent accurately the structures held by customers, I have less confidence that the Affinity Hierarchy reflects the customer structure. Since the product team didn't even reproduce the stable portions of the Customer-driven structure, it seems unlikely that their structures for the less stable portions reflects the customers'.

G.3. When are Customer-Driven Hierarchies Recommended?

The analysis from investigating just the picnic basket data can not provide the answer to the global question of whether the effort and expense of field research is really required to construct a representative customer attribute hierarchy. It addresses only the segment of new product development projects in which the development team does not understand much about potential users or their needs. This could be the case if little or no market research is done by a firm, as occurs in many high technology companies, if a firm is entering a product area or market segment that differs significantly from areas or segments the firm is already familiar with, or if the members of the product development team are, for any other reason, not familiar with the customers of the target product function.

However, management and product development teams in many firms are very familiar with customers and their needs. Especially in consumer package goods firms, significant numbers of focus groups and other qualitative data gathering techniques have been used over the years to probe those needs. The development team's innate understanding of customers may lead to Affinity Hierarchies very similar to the ones derived from customers. Therefore, results between the picnic basket data and a second set of data with a more knowledgeable product development team will be contrasted.

My conclusion is that project teams unfamiliar with customer needs should be urged to spend the time and money to gather data directly from customers to construct an attribute hierarchy. The picnic basket Affinity Hierarchy differs significantly from the Customer-driven Hierarchy and has some troubling features. While the knowledgeable product team's Affinity and Customer Hierarchies were more similar than the student-developed hierarchies, the measures indicate that there are still significant dissimilarities between the two structures.

Data for Comparing Across Customer Knowledge Level

The food transporter Affinity and Customer-driven Hierarchies constitute the data for the product development team with "low knowledge of customer needs." The similarity between the two food transporter hierarchies will be compared with three hierarchies constructed for a consumer packaged good product area. The packaged good is such that the majority of the population is expected to have some familiarity with its use, functions, and image. A development team highly knowledgeable about their customers thanks to years of exposure to enormous numbers of attributes generated directly by customers[10] constructed an Affinity Hierarchy from 211 attributes. A Customer-driven Hierarchy was also generated from these attributes by persons in the target market using the clustering method of the previous section. A third Hierarchy was generated with the packaged good attributes by a group of MIT engineering students not familiar with the product customers, except as the product has directly affected them as individuals over the years. This third hierarchy is another Affinity Hierarchy that can be considered as being gen-

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[10] The company name and specific product area must remain confidential to protect the proprietary nature of the data.

erated by a "low knowledge" product development team.

Results and Conclusions

Table 6-13 presents content similarity results for the low and high customer knowledge data sets. The similarity measures for the primary level of analysis show that <u>both</u> consumer package good Affinity Hierarchies are in general much more similar in structure to the Customer-driven Hierarchy than the food transporter Affinity Hierarchy is to its Customer Hierarchy. The MIT engineers performed about as well as the packaged good product development team. Given that the engineers should have been less knowledgeable than the product team, this result is unexpected. One possible explanation might be that the function and use of the particular consumer packaged good investigated is familiar enough to the general public (including the MIT engineers) to allow the team to act like the a knowledgeable product team.

Table 6-13. Low and High Knowledge Affect on Hierarchy Similarity

	PRIMARY LEVEL		SECONDARY LEVEL	
	Kruskal's λ	Similarity	Kruskal's λ	Similarity
Food Transporter				
M - C	.28	.42	.51	.81
Packaged Good				
M - C	.60	.74	.53	.68
E - C	.59	.74	.53	.79
M - E	.62	.94	.56	.94

Hierarchy Legend: M - Management; C - Customer; E - Engineering

Knowing one hierarchy of any Affinity-Customer set reduces the error in predicting the other by slightly over 50% at the secondary attribute level for all data sets. However, the similarity between the structures of the knowledgeable packaged good product team and their customers is not quite as high on the secondary level as it is on the primary level. This seems to suggest that while the packaged good team has a good feel for the general constructs, they may have a bit more difficulty operationalizing general constructs to product specifics.

The food transporter team, who knew very little about their customers, does a better job of constructing the hierarchy on the secondary level than they do at the primary level. They seem to recognize which detailed functional aspects of the food transporter go together more easily than they seem to be able to structure detailed aspects into more general marketing constructs. The MIT engineers also seem to be able to group detailed aspects of the packaged good product at the secondary level about as well as the food transporter group, and slightly better than the knowledgeable product team.

From these comparisons, I can only conclude that teams form hierarchies more similar to customer-derived hierarchies for a consumer packaged product than they do for a low-cost durable good. If the general uses and functions of the consumer packaged good are indeed much more well-known to the general public than the needs for food transporters then the data also provide preliminary evidence that more knowledgeable development teams may construct hierarchies somewhat more similar to those constructed from direct customer inputs. The analysis also provided evidence to suggest that performing both an Affinity and Customer-driven Hierarchy may provide higher confidence in some parts of the attribute structure. This work has also developed a reproducible Customer-driven Hierarchy construction method and two measures of content similarity. Future research in this area can use these measures to consistently extend the study of hierarchy development across more cases.

CHAPTER 7. DETERMINING THE RELATIVE IMPORTANCE OF CUSTOMER ATTRIBUTES

A. Research Needs for Determining Customer Attribute Importance

As a next step this study tested different methods for assigning attributes relative importance values. Several marketing research studies (Tigert, 1966; Lehmann, 1971; Hughes, 1970; Schendel, et al., 1971) have investigated this issue for the small numbers of strategic marketing attributes. While marketing strategies for a product can be developed and implemented from aggregate product dimensions like "performance" and "easy to use," these phrases do not provide the development staffs with any clue about which technology choices will most effectively deliver the aggregate dimension, which is typically made up of many different aspects. They need more details on what kinds of performance are needed and for which applications.

For instance, computer developers need to know the relative importance to the users of performing numerical calculations, accessing and manipulating data, and performing logic operations before they can determine the most appropriate architecture to improve the "speed" aspect of performance. To them, speed is only one of the aspects of performance they must simultaneously design into the product, using the right combination of the technical tools available (chips, architecture). Providing more detailed information to technical staffs improves their chances of designing a product right on target for delivering the best mix of customer benefits.

QFD Houses of Quality are developed specifically as development aids for making tradeoffs between product aspects. The number of customer attributes in a House of Quality generally ranges from 50 to over 300. The challenge addressed in this research is to obtain measures of relative importance for the many customer attributes needed by the technical staff in operationaliing from product concept to final product design. This requires obtaining importance values for the many attributes structured into a multi-tiered hierarchy that predict overall satisfaction adequately and are straight forward to administer and analyze. Which of a myriad of potentially useful techniques provides the most valid estimate in the most efficient manner?

This research is of more than just intellectual interest. In one proprietary QFD application importance measures collected by two different methods correlated negatively. More importantly, the products that each technique suggested were very different; a multimillion dollar investment decision depended upon identifying the most accurate measurement method.

B. Key Findings

- Overall, the best method for determining customer attribute importance seems to be a direct measure using an anchored scale, with importance of the upper levels of the hierarchy "cascaded" down to the lower levels.

- Self-stated and constant sum techniques perform a little less well than the anchored scale. Importance values obtained by using the self-stated technique are more similar to the anchored results than are the constant sum, making it overall the second best technique.

- Revealed preference measures of importance perform surprisingly poorly even at the primary level of the hierarchy. Only three of the seven primary attribute importance coefficients differs significantly from zero. Predicted satisfaction on the sample used to calculate the regression coefficients is no better than cross-sample predicted satisfaction obtained using the anchored and constant sum techniques at the primary and tertiary levels.

C. Existing Practices for Obtaining Importances

C.1. Marketing Practices

Three kinds of techniques have been used routinely by marketing researchers to obtain measures of the relative importance of customer attributes. Preference regression statistically estimates the model that "best" reproduces observed satisfaction from attribute ratings (Urban and Hauser, 1980). The resulting importance coefficients are "average" weightings across the survey sample. Importance weights are derived from regressing overall satisfaction on their product's performance ratings across the attributes. The regression coefficients are the importance weights.

Conjoint analysis, a decompositional method that estimates the structure of a consumer's preferences, can be used to obtain importances for attributes as well as the feature operationalizations of those attributes. Decompositional methods measure respondent reactions to a set of "total" profile descriptions or concept statements. Overall satisfaction is modeled based on the set of part worths for each attribute in the profile (Green and Srinivasan, 1978).

Expectancy value models are compositional methods for determining satisfaction. In these models, overall utility for a multi-attribute object is built up from the combination of the weighted sum of the product's perceived attribute performance ratings and associated value (importance) ratings. Importance weights are separately and explicitly judged by respondents for each attribute. Many different techniques can be used to obtain importance weights directly from consumers for multiple attributes, including overall rankings of attributes, paired attribute comparisons, 1 to 5, 7, 9, or 10 Likert, bipolar, or semantic differential scales, constant sum, and anchored scales. Past research has demonstrated:

- rankings and paired comparison methods produce very similar results (Tigert, 1966)

- rank orders and bipolar scales predict overall preference equally well (Lehmann, 1971)

- constant sum is superior to a 1 to 7 semantic scale because it forces tradeoff variations among attributes (Hughes, 1970)

- good agreement for the final rank order of attributes based on their importance as obtained by yes/no, rank order, 1 to 6 rating scales, and constant sum methods (Schendel, et al., 1971).

C.2. QFD Practices

Relative importance values for attributes are determined in one of two ways by QFD teams. Frequently, especially when pressed for time, the new product development team develops through consensus and assigns to each attribute the value they think represents the importance held by their customer segment. Sometimes a questionnaire is used to survey existing or potential customers, eliciting attribute importances for the functional need area using a self-explicated unanchored 1 to 5 scale.

Only the attributes residing at the lowest levels of the QFD hierarchy are assigned importance levels, since they are the only attributes arrayed against engineering attributes to determine which engineering design functions should be emphasized. Relative importance values among the upper levels of the hierarchy generally are not determined.

D. Critique of Current Methods for Measuring Attribute Importance

Preference regression is extremely easy to implement and can often be done (for marketing purposes) in the same survey that collected the data to obtain the structure of the attributes via factor analysis. However, preference regression is limited in the number of attributes that can be handled. To even be able to regress large numbers of attributes against overall satisfaction, an extraordinarily large sample size would be needed. Research has also found that preference regression predicts at least as well and frequently better at the level of reduced dimensions (or at the primary level) than it does across the more detailed attributes (Urban and Hauser, 1980). While this is great news for marketing researchers who would like to work with aggregate dimensions and not individual attributes, it is not helpful for development teams interested in the importance of large numbers of attributes.

The direct measures of importance used in expectancy value models are easily obtained for large numbers of attributes, although gathering the data requires an additional field research step over obtaining structural dimensions. Most of the specific techniques have both advantages and shortcomings. Self-stated importances are very easy for respondents but tend to have a high overall average and low variance (everything's important). Constant sum is "difficult" for respondents to do, although it explicitly forces tradeoffs between attributes. Ranking attributes conveys nothing about the distance between them, just their order. The number of paired attribute comparisons a respondent must make increases exponentially as the number of attributes increases. The research summarized in the previous section investigating differences between results obtained using one or two of these methods is all based on small numbers of attributes acquired for marketing (as opposed to technical staff) purposes.

In QFD, the main advantages of arriving at importance levels by consensus are that it is quick (the team can usually chew through the discussions in one day or less) and, whether or not the values are "right," the team firmly believes in them. However, the validity of team member perceptions of the importance customers assign to product attributes remains an open question. If the team is not familiar with the customers, there is no reason to believe that the importance levels the team assigns attributes are close to or even correlated with the importance held by customers. Even if the product development team understands their customers, the group consensus technique is open to any internal bias the team has. These biases are frequently not visible to the team members or their managers.

The surveys used to directly gather measures of importance for QFD attributes from customers raise methodological issues. QFD surveys do not measure importance for attributes in the upper levels of the hierarchy. Nor do QFD teams account for imbalances in number of attributes across hierarchy groups when matrixing customer to engineering attributes. Thus, a primary group with a large number of tertiary level attributes matrixed to engineering attributes may have a larger impact on overall product design than a primary attribute consisting of just a few tertiary level attributes, even though this second, smaller primary might be more important to customers overall. The current way importance is measured in QFD surveys does not determine which groups of product benefit are more important to the customer at higher levels of the hierarchy. The importance of attributes at lower levels of the hierarchy does not depend in any way upon the importance of the attributes above them in the hierarchy, nor does the relative number of attributes in a group affect the overall importance of a customer attribute matrixed with the engineering attributes. These policies are inconsistent with standard marketing policy and at least intuitively may cause problems.

E. Importance Determining Techniques Tested

I tested a total of six different methods for determining customer attribute importance values using data collected from four different surveys. Three surveys collected direct measures of importance while the fourth collected data for preference regression.

The direct measure survey collecting self-stated importance used a 1 to 9 scale, "Not at all Important" to "Extremely Important." The scale was not tested for interval linearity. The 230 attributes of the Customer-driven Hierarchy were presented in a random order in the survey.

The constant sum (CS) direct measure survey required respondents to divide 100 points among all attributes within each primary, secondary, and tertiary attribute group commensurate with each attribute's relative importance to them. The data from this survey was used in two importance variations. The first variation, referred to as the constant sum cascaded (CSC) importance values, "cascades" the importance of the upper levels of the hierarchy down onto the lower levels of the hierarchy using the formulae:

$$I_p^{CSC} = I_p^{CS}; \quad I_s^{CSC} = I_p^{CSC} * I_s^{CS} / 100; \quad I_t^{CSC} = I_s^{CSC} * I_t^{CS} / 100. \qquad (7.1)$$

In these equations I is the importance measure. The superscript CS denotes the constant sum, or raw survey data while CSC refers to the constant sum cascaded importance measure used in the analysis. The subscripts p, s, and t denote primary, secondary and tertiary, respectively.

The second constant sum variation, the constant sum cascaded and scaled (CSCS) method, modified the cascaded importance values to eliminate the affects of differences in the number of attributes across groups. The primary groups contain three secondary attributes, on average, with a range from two to five. In a constant sum method this variation in the size of groups means that smaller groups of attributes intrinsically have higher expected values than larger groups. The expected value of the importance for a group with two attributes (50), is 2.5 times the expected value of the importance for groups with five attributes (20). This constant sum variation rescales importance values to the mean number of attributes per group; three for secondary, and nine for tertiary attributes. The formulae for calculating the constant sum cascaded and scaled importance values are:

$$\begin{aligned} & I_p^{CSCS} = I_p^{CS} \\ & I_s^{CSCS} = (I_p^{CSCS} * I_s^{CS)} * (A_{sp}/3)/100 \qquad (7.2) \\ & I_t^{CSCS} = (I_s^{CSCS} * I_t^{CS}) * (A_{ts}/9)/100. \end{aligned}$$

A_{sp} refers to the number of secondary attributes in the primary group and A_{ts} denotes the number of tertiary attributes in the secondary group.

In a third direct measure, anchored importance, respondents were asked to select the most important attribute out of a group and assign it a value of 100. They were then asked to assign values between 0 and 100 to the remaining attributes within the group that reflect their overall value compared to the attribute they rated most important. Anchored importance measures of the lower levels of the hierarchy were cascaded down from the upper levels of the hierarchy as in (7.1). Modifying the attributes to account for differences in the number of attributes per group was not required because the most important attribute all groups was anchored at a value of 100.

Attribute groups for the constant sum and anchored methods were defined by an attribute's level and position in the hierarchy. Of the 30 total attribute groups, one consisted of the seven primary attributes. Seven other groups consisted of the sets of secondary attributes that made up each primary grouping. Twenty-two groupings comprised the sets of tertiary attributes that made up each secondary grouping. A copy of the cover letter, instructions to respondents and illustrations of question phrasings for each survey can be found in Appendix 7.1.

Derived importance measures were obtained from a linear regression of "overall satisfaction" on self-stated performance ratings for a currently used product. Two measures of the dependent variable overall satisfaction were used in the regressions: self-explicated overall satisfaction on a 1 to 9 scale, and probability of repurchasing the same brand and model for next purchase. A copy of the instructions and question phrasings for attribute rating and overall satisfaction also can be found in Appendix 7.1.

The survey data gathered for these importance measuring techniques could also be used in other, hybrid, combinations of direct and derived methods. For instance, while derived importance values can be calculated for primary level attributes in the hierarchy, there are too many tertiary attributes for regressing. It is even likely that many of the secondary level derived importance coefficients do not differ significantly from zero. However, a hybrid technique could be tested which uses primary level derived importances and some self-stated technique to obtain importance at lower levels of the hierarchy. The "hybrid" technique used in this research cascades the primary level derived importance measures down to anchored values for lower hierarchy levels.

F. Judging the Results of the Research

This research collected importance values in several different ways for one set of customer attributes. The results were compared across one measure of external validity, several measures of internal validity, and several issues associated with the cost and difficulty to administer the surveys and analyze the data to identify which method seems to work best.

F.1. The Measure of External Validity: Predicted Satisfaction

As a measure of external validity, the methods were compared for their ability to predict overall satisfaction. Average importance weights were calculated for each of the 230 customer attributes by each of the six methods identified in the previous section. Using the attribute performance ratings obtained in the preference regression survey, an overall importance index (I) was calculated based on the expectancy value model for each of the three attribute levels in the hierarchy for each individual in the sample. For instance, at the primary level for the anchored method for measuring importance, for individual k, $I_p^k = \Sigma_{p=1}^{7} (I_p^{ANC} * R_p^k)$, where R_p^k is the rated level of performance for primary attribute p for person k and I_p^{ANC} is the average anchored importance level for primary attribute p. Average importance weights are used in the measure instead of individual importance weights because standard QFD practice uses average weights. The ability of a method to predict overall satisfaction at the primary level is measured by the correlation between I_p^k and self-stated satisfaction by individual. By definition the correlation between the calculated revealed importance index and self-stated satisfaction will always be higher than the correlation for any other method because revealed importance coefficients were calculated from the same data that the predictive validity test was run on.

F.2. Measures of Internal Validity

Variability of Importance Measures Across Attributes

The amount of variability in importance measures was used to identify which methods produce an "appropriate" level of variability. To obtain comparability across importance methods, the range of the average importance value for each method was standardized to fill a 1 to 9 scale. Importance variability is measured as the coefficient of variation (CoV)[1] of the importance mean across all attributes. A very low variability indicates that a technique does not let customers discriminate well between important and unimportant attributes. Other summary statistics (range, mean) were also compared overall, and by hierarchy level.

Convergent Validity Within Hierarchy Levels

The convergent validity of the methods within hierarchy levels helps indicate whether attribute importance differs by method. Within level conver-

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[1] The Coefficient of Variation, CoV, = $\sigma/\bar{x}$ (Tabachnick and Fidell, 1983).

gence is the correlation between average importance values calculated by two different methods across all attributes in that level of the hierarchy. If average importance values are highly correlated for most or all methods, then one might have less confidence in the results for the one or two techniques less highly correlated. Naturally, the one uncorrelated method could be the "truth." Thus, convergent validity is only a guide to be used in concert with other validity tests. These results are most important at the primary level, used by marketing in product positioning, and at the tertiary level, used by the technical staffs to operationalize product design.

Stability Across Hierarchy Levels

The stability of the results across hierarchy levels is an important measure of internal validity if one believes the assumption that importance values flow down from more general constructs of the product area to more specific operationalizations of those constructs as product functions (in other words, that lower level attributes exist as pieces of upper level attributes). While this theory underlies the way QFD Affinity Hierarchies are constructed, it is abandoned in the way QFD traditionally assigns importance values to attributes. This assumption also underlies constructing marketing hierarchies using factor analysis. Therefore, the stability of attribute importance values across levels of the hierarchy will be used as an indication of internal validity in this research. Correlations between attributes across hierarchy levels were calculated three ways: attribute ranks, average importance weights of the lower hierarchy level, and the sum of the importance weights for the lower hierarchy level. Spearman rank order coefficients between two levels of the hierarchy provide a measure of how many of the lower level attributes are "out of order" compared to the way they would be ordered if 1) all the lower level attributes grouped together and 2) the groups of lower level attributes were in the same order that the higher level attributes were in.

The correlation between the importance weights of the upper level attributes in the hierarchy and the average of the lower level attributes for each of the upper level groups measures the correlation between hierarchy levels under the assumption that the number of attributes in a lower level group should not affect the product design. The upper level importance should be partitioned or distributed across the lower level attributes, eliminating the affects of the number of attributes in the group.

Correlations between the importance weights of upper level attributes in the hierarchy and the sum of the lower level attributes for each of the upper level groups assumes that the number of attributes in each group is important and that the effects of their numbers should not be eliminated in determining importance weights. If the cross-level correlations obtained with the "average" method above were routinely better than the correlations obtained with the "sum" method, this would suggest that importance weights need to be modified to eliminate the effects of the number of attributes in a group (like the constant sum scaled method).

Stability Across Sub-Samples

The stability of importance values at the primary level was also investigated across a random split of the data into two subpopulations. Stability was measured in two ways: correlation coefficients between the importance value means across the two random samples, and the number of attributes with statistically different means (F test with $p < .05$). These two stability measures were also investigated for a non-random population split. The objective of this analysis was to see which, if any, technique readily identified any gross segment differences which might be intuitively expected. Respondents were segmented by sex for this analysis.

F.3. Other Methods Issues

Other issues that affect the desirability of using one importance measure over another include the field cost, and ease with which respondents can fill out the survey and analysts can analyze the data. These issues are affected by how many questions respondents must fill out, how complex the questions are to answer, and whether the analysis of the data is very straightforward or requires significant amounts of analyst judgment and creativity. One measure of how easy these methods are from the respondent point of view is the number of attributes left blank.

Prior research findings will also affect the general acceptability by other users of one method over another. Revealed importance measures are favored by quantitatively-based marketing science researchers. Self-stated measures of importance are more prevalent in social psychology but may be less acceptable to the marketing science academic community.

G. Data collection for Determining Attribute Importance

G.1. The Sample

A convenience sample of 2,460 MIT graduate students were sent copies of the survey. Since the results of interest are comparisons across measurement methods, not absolute importance values, using a convenience sample instead of a random sample should not present any methodological difficulties.

The major advantage of graduate student subjects is low distribution expense. Surveys could be distributed to graduate students without incurring any address list or mailing costs. The two pilot surveys were physically distributed to students living in MIT housing. Surveys were returned to boxes placed in the apartment building lobby. The full survey was sent to students at their campus offices. Addresses for graduate student offices were obtained from each department's graduate student administrator. Experiment approval was obtained from the Committee on the Use of Humans as Experimental Subject (COUHES).

G.2. Pilot Survey 1: Configuration and Results

This pilot of 200 physically distributed questionnaires used the 247 Affinity Hierarchy attributes. The survey went out under a cover letter from me appealing to fellow graduate students for help in finishing my thesis. Each survey gathered both direct and revealed importance data in four sections: introduction and demographics (nine questions), current product performance ratings (247 attributes), overall satisfaction measures (two questions), and attribute importance values (247 attributes). Only the constant sum and self-stated direct importance forms were distributed in this trial. This 30 page questionnaire had only a 12.5% response rate (25 out of 200) and engendered written and oral complaints from respondents about the overall survey length. Therefore, the survey was shortened and the pilot step repeated.

G.3. Pilot Survey 2: Configuration and Results

Pilot survey 2 was physically distributed to 400 MIT graduate students. It used the 230 attributes of the Customer-driven Hierarchy, again with the fellow graduate student appeal cover letter. The questionnaire was shortened to 17 pages by eliminating one of the long attribute sections from each survey form. Thus, an instrument either gathered importance data for one of two direct methods (constant sum or self-stated) <u>or</u> the revealed importance method, along with demographics and overall satisfaction. The response rate for this pilot was still a disappointing 11.3% (45 out of 400), too low for publication.

G.4. Final Survey Configuration

Several steps were taken to try to increase the return rate in the full study. The surveys were printed in booklet form (11" x 17", folded and center stapled) with proportional fonts to make them look more professional. The survey went out under Prof. Hauser's signature to try to maximize the legitimacy of the study. Responses were to be sent back to Prof. Hauser through interdepartmental mail; pre-addressed return mail labels were provided for respondent convenience. Due to budgetary limitations, however, no incentives were provided to the respondents.

Four survey forms were distributed: three collected importance values for a direct technique (self-stated, constant sum, or anchored) and one collected performance ratings for the revealed technique. The survey instruments used in the study had the configurations given in Table 7-1. Small sections of questions on product use, and, since the survey was positioned as a research tool in the cover letter, reactions to the survey itself were added. Final survey length ran 15 to 16 pages. Copies of the cover letter, demographic, product use, overall satisfaction, and questionnaire reaction sections can be found in Appendix 7.1.

Table 7-1. Contents of the Importance Surveys

	SURVEY			
SURVEY SECTION	**1**	**2**	**3**	**4**
1. Product Use Data	X	X	X	X
2. Anchored Importance	X			
2. Constant Sum Importance		X		
2. Self-Stated Importance			X	
2. Performance Ratings				X
3. Overall Satisfaction	X	X	X	X
4. Survey Reactions	X	X	X	X
5. Demographics	X	X	X	X

G.5. Data Collection Results and Implications for Future Research

The response rate data from this marketing methods study suggest that even if the results are critically important to product development staffs, "good" data are going to be much more difficult and expensive to obtain for large numbers of attributes than they are for small numbers of attributes. Market research using this method may require larger incentives for respondents or some gimmick to improve the response rate. The survey must be carefully designed, possibly breaking the attribute rating section into several pieces interspersed by the demographic and product use sections to decrease the burn-out rate among respondents.

Survey instruments were distributed to 2,060 MIT graduate students

Table 7-2. Marketing Methods Survey Response Rate

	Pilot 2		Survey		Total	
	#	%	#	%	#	%
Surveys Distributed	400	100%	2,060	100%	2,460	100%
Total Returned	45	11.3	180	8.7	225	9.1
Returned not Delivered	0	-	17	0.8	17	0.7
Incomplete Returns (unusable)	0	-	30	1.5	30	1.2
Usable Returns	45	11.3%	133	6.5%	178	7.2%

throı gh the interdepartmental mail. As shown in Table 7-2, the return rate of usable returns was 6.5%, even lower than either pilot test return rate. Data from both the pilot 2 study as well as the final survey were used in the analysis of importance methods, bringing the total number of surveys analyzed to 178, for an overall response rate of usable returns of 7.2%.

As disturbing as the low return rate is the high percent of returns that are unusable; 30 of 163 (18.4%) surveys returned by respondents who had actually received them were substantially incomplete. In all cases, the respondent had "given up: about half way through the attribute rating portion of the survey. Due to the length of the survey, even this shortened form, this market research method may not be appropriate for mail distribution without prescreening and incentives.

A major consumer packaged good firm is repeating this mail survey test of importance measures, but telephone prescreening potential respondents for willingness to participate and providing them with a $5 incentive in the mailing. Preliminary response rates are 62%, with only 3% of the returns (two out of 62) unusable.

Table 7-3 summarizes survey distribution and response rates by importance measure. The total percentage of the self-stated and revealed preference surveys returned was on average greater than the percentage of anchored and constant sum surveys returned, and the difference between these two levels was statistically significant (p<.01). For the anchored and self-stated methods, respondents only needed to circle responses; the other two surveys required respondents to write values in by hand. This difference in effort required of the respondent could account for the difference in response rates. However, the difference in means between the two groups was not significant for either the percent of usable or unusable responses.

Table 7-3. Survey Distribution and Response Rate by Importance Method

	ANCHORED	CONSTANT SUM	SELF-STATED	REVEALED
Surveys Distributed	404	390	409	857
RETURNS:				
Total	28	26	35	73
(%)	6.9%	6.7%	8.6%	8.5%
Unusable	5	2	6	16
(%)	1.2%	0.5%	1.5%	1.9%
Usable	23	24	29	57
(%)	5.7%	6.2%	7.1%	6.7%

Although the response rates are extremely low for this initial test of how to measure importance for large numbers of attributes, the total number of responses are probably sufficient for meaningful comparison across the methods. The analysis will be repeated for the larger samples (with higher response rates) of the consumer package good study.

H. Results from Investigating Different Importance Methods

The main question to be answered in the methodology study is "Which of several various methods for obtaining importance measures should be recom-

Table 7-4. Summary of Importance Technique Performance

IMPORTANCE MEASURE		DIRECT METHODS			REVEALED		HYBRID
	Self-Stated	Anchored	Constant Sum Cascaded	Constant Sum Scaled	Satis-faction	Repur-chase Prob.	Satisfac-tion/Anch-ored
External Validity Measure							
Predicted Satis.	0	0	0	0	0	0	0
Internal Validity Measures							
Rating Variability	+	+	0	-	0	0	-
Convergent Validity Within Level	+	+	0	0	-	-	-
Stability Across Hierarchy Level							
Attribute Ranks	-	+	+	+	-	-	0
Average Intervals	-	+	+	0	-	-	+
Sum of Intervals	0	+	+	0	-	-	+
Stability Across Sub-samples							
Random Samples	+	+	0	0	-	-	-
Expected Segments	+	+	0	0	0	0	0
Other Methods Issues							
Theory	-	+	0	+	+	+	0
Cost to Implement	0	-	-	-	0	0	-
Ease of Analysis	+	+	0	0	-	-	-
Easy for Respondent	+	0	-	-	+	+	0
Compliance	+	0	-	-	+	+	0

Legend:
+ Good Performance
0 Acceptable Characteristics or Performance
- Poor Performance

mended for organizations using many customer attributes in new product development projects?" Table 7-4 is a summary of the relative performance of each technique across all validity measures.

The anchored direct importance method seems to produce the best results across all the measures used in this study to differentiate performance. It is easy to interpret and theoretically justified, but more difficult and costly to implement. The self-stated direct method performs almost as well across most validity measures and results in similar importance ratings across attributes. It has the advantages of ease of implementation and slightly lower costs.

The remainder of this section will provide and discuss the specific data and analyses that led to the summary conclusions presented in Table 7-4.

H.1. Performance on the External Validity Measure

The only measure of external validity for each method is the correlation between a calculated satisfaction index and self-stated overall satisfaction with a currently used product. At the primary and tertiary levels, all methods correlate equally well. Revealed satisfaction correlates significantly better than any of the other

Table 7-5. Correlation With Overall Satisfaction

CORRELATION COEFFICIENTS:**
IMPORTANCE INDEX AND SELF-STATED SATISFACTION

IMPORTANCE METHOD	HIERARCHY LEVEL Primary[1]	Secondary[2]	Tertiary
Self-Stated	.56	.55	.53
Anchored	.54	.53	.52
Constant Sum	.57	.52	.54
Constant Sum Scale	.56	.51	.46
Revealed Satis.	.61	.83	--[3]
Hybrid	.55	.44	.50

** All correlations significant at p=.01
1 Coefficients do not differ statistically from revealed; p>.05
2 Coefficients differ from revealed at p<.01
3 Too many attributes for calculating revealed coefficients

methods across the secondary attributes (Table 7-5). A high correlation at only the secondary level for the preference regression does not necessarily favor this technique over the others.

Differences in predictive ability at the secondary level are not as important as differences at the primary or tertiary levels. Primary level values are used by marketing for strategic positioning issues. Tertiary values are used by the technical staffs to operationalize the concept into a physical product. Secondary attributes affect new product development only as means to get to the tertiary level.

The secondary level preference correlation may also appear higher than it actually is. Because attribute performance ratings were only obtained in the preference regression survey form, this analysis is only a measure of within-sample predictive ability for the preference methods, while for all other methods it is a measure of cross-sample external validity. One would therefore expect higher correlations with the preference regression results calculated within the same sample used to infer validity.

The very high correlation between stated satisfaction and the calculated preference index at the secondary levels may also be due in part to an overfitted model. Of the 22 preference coefficients used in the calculated preference index, only five differ significantly from zero. When the regression model is run using just these five independent variables, the R^2 for the equation is .59, 16% lower than for the regression using all 22 variables. One could expect an adjusted correlation coefficient to about .7 for the correlation between self-stated satisfaction and satisfaction index calculated from the five-parameter regression model.

H.2. **Performance on Internal Validity Measures**

Methods for determining attribute importance levels were compared across four internal validity measures: variability in the ratings, convergence among the techniques at each level of the hierarchy, stability of each method across the levels of the hierarchy, and the stability of the results across subpopulations of the cases.

Variability Across Attribute Ratings

Average importance values for food transporters can be found in Appendix 7.2. Table 7-6 summarizes the characteristics of these values. The average characteristics of the importance values for the self-stated and anchored methods are more desirable than those for the other methods. Self-stated and anchored values are higher and less variable for the upper levels of the hierarchy than for the lower levels. Attribute values for these methods are also distributed across a broad range in each of the levels of the hierarchy, with the ranges

Table 7-6. Variability and Range of Importance Means by Method

IMPORTANCE MEASURE	Self-Stated	Anchored	Constant Sum Cascaded	Constant Sum Scaled	Satisfaction	Satisfaction/Anchored (Hybrid)
ACROSS ALL ATTRIBUTES IN THE HIERARCHY						
Range	1-9	1-9	1-9	1-9	1-9	1-9
Average	5.4	4.0	2.5	1.6	2.9	2.1
σ	1.9	1.8	1.4	1.0	1.8	1.7
CoV	.3	.4	.6	.6	.6	.8
ACROSS THE PRIMARY ATTRIBUTES						
Range	4-8	3-9	3-9	2-3	1-6	1-2
Average	6.9	7.4	6.0	2.3	3.3	1.2
σ	1.4	1.8	1.8	.5	1.5	.3
CoV	.2	.2	.3	.2	.4	.3
ACROSS THE SECONDARY ATTRIBUTES						
Range	3-9	2-9	1-4	1-2	1-9	1-9
Average	6.8	5.6	2.6	1.4	2.8	3.0
σ	1.7	2.0	1.2	.2	1.9	2.7
CoV	.3	.4	.5	.2	.7	.9
ACROSS THE TERTIARY ATTRIBUTES						
Range	1-9	1-7	1-7	1-9	-	1-8
Average	5.3	3.7	2.4	1.6	-	2.0
σ	1.9	1.5	1.3	1.1	-	1.6
CoV	.4	.4	.5	.6	-	.8

for the upper levels of the hierarchy skewed slightly higher than the ranges of the lower level of the hierarchy.

Each of the other four methods has one or more unsavory characteristics associated with it. The tertiary attributes of the constant sum scaled method are on average more important than the secondaries. For the hybrid technique, primary attributes are on average less important than either the secondary or tertiary ones. The range for the attribute means on at least one level of the hierarchy is low (<3) for the constant sum, constant sum scaled, and hybrid methods. Only three of the revealed satisfaction primary values and five secondary values differ significantly from zero. This effectively reduces the number of attributes available to the designers.

Convergent Validity Within Hierarchy Level

At the primary and tertiary levels of the hierarchy, the correlations between predicted and stated satisfaction were equal across all importance methods. Yet correlations between the importance values obtained using some of the methods are low or nonexistent (Table 7-7). I would therefore expect the products generated from operationalizing the tertiary level importance values of some of the methods to differ substantially in their physical and performance characteristics. The strategic marketing positions selected for products would also vary by the importance method employed.

If the findings mean that there are multiple products (or strategic positions) which satisfy the same set of customers equally well and different importance methods produce different satisfactory products (or positions) then the choice of importance measuring technique may well be unimportant in terms of developing a product with high customer satisfaction. Can several different physical products really all satisfy the same set of customers equally well? If that was the case, would not one product which combined the

Table 7-7. Convergent Validity Across Importance Methods

PEARSON CORRELATION COEFFICIENTS FOR IMPORTANCE MEANS BY HIERARCHY LEVEL

IMPORTANCE MEASURE	Self-Stated	Anchored	Constant Sum Cascaded	Constant Sum Scaled	Satisfaction	Hybrid
ACROSS THE PRIMARY ATTRIBUTES						
Self-Stated	-					
Anchored	$.90^{*}$	-				
CS: Cascaded	$.71^{+}$	.49	-			
CS: Scaled	$.71^{+}$	.49	1.00	-		
Revealed	.04	.02	-.05	-.05	-	
Hybrid	.04	.02	-.05	-.05	1.00	-
ACROSS THE SECONDARY ATTRIBUTES						
Self-Stated	-					
Anchored	$.41^{+}$	-				
CS: Cascaded	.08	$.44^{+}$	-			
CS: Scaled	.24	$.68^{**}$	$.82^{**}$	-		
Revealed	-.02	-.09	.16	-.04	-	
Hybrid	.04	$.41^{+}$	-.24	.10	-.13	-
ACROSS THE TERTIARY ATTRIBUTES						
Self-Stated	-					
Anchored	$.54^{**}$	-				
CS: Cascade	$.45^{**}$	$.53^{**}$	-			
CS: Scaled	$.17^{*}$	$.39^{**}$	$.47^{**}$	-		
Hybrid	.12	$.28^{**}$	.06	-.04	-	-

$^{+}$ Correlation significant at $p < .05$
* Correlation significant at $p < .01$
** Correlation significant at $p < .001$

features of the others be preferred over any of them?

The straightforward result of the analysis is that even though the predicted level of theoretical satisfaction is identical, most methods would produce different products and a company cannot just randomly choose among the methods. The anchored and self-stated methods produce very similar importance values, with constant sum values somewhat similar to these two. The product designs resulting from the self-stated or anchored method should not differ greatly. However, preference regression importance values are uncorrelated with any other method. The product position, and any product generated by cascading primary level preference regression values to the tertiary level in a hybrid method should produce a product vastly different from any other importance measuring technique. It is probably a safer strategy to choose an importance determining method with results at least somewhat similar to the results produced by other methods.

Stability Across Hierarchy Levels

The only correlations between importance values of the same branch of the hierarchy but across different hierarchy levels that exhibit any statistical significance are for the importance techniques which explicitly cascade upper level importances down to the lower levels of the hierarchy (anchored, constant sum and constant sum scaled). When attributes are presented to respondents in a random order, the values of the self-stated importances and ratings that lead to revealed satisfaction measures are independent of membership in particular upper level groups. While the average self-stated importance of attributes in lower levels of the hierarchy are less (Table 7-6) than those positioned higher in the hierarchy, the average importance of lower groups of attributes do not vary by the importance of the upper level attributes. Therefore, if a product developer believes that more detailed attributes exist only as pieces of upper level attributes, as the QFD process claims, then they should probably choose a process which explicitly cascades the relative importance of the upper level attributes down to the lower levels of the hierarchy.

Stability Across Sub-Populations

Using either the self-stated or anchored methods produces more stable results across random samples and more differentiated results across expected segments. The self-stated and anchored methods outperformed all others in maintaining the means of importance values across randomly-selected subsamples of the cases (Table 7-8). The anchored method for determining attribute importance did not perform quite as well as the self-stated method because the means for one attribute differed significantly ($p <.05$) across the two samples.

Table 7-8. Stability of Results Across Random Subsamples

PRIMARY LEVEL OF REQUIREMENTS

IMPORTANCE METHOD	Importance Correlation Across Attributes ρ (p)	# of Attribute Means that Differ
Self-Stated	.97 (.001)	0
Anchored	.90 (.003)	1
Constant Sum	.37 (.20)	0
Revealed	-.53 (.11)	0*

* The calculated regression coefficient for a dummy variable for sample # did not differ significantly from 0.

While both the anchored and self-stated methods came up with differences that seem "reasonable" between the average importance values of some primary attributes for male and female respondents, these differences are statistically significant only for the self-stated method (Table 7-9). The self-stated method indicates that the attractive and good looking nature of the container and its ease of transport are significantly more important to female than to male respondents (F test, p <.05). The trends on these two primary attributes for the anchored method were in the same direction but not statistically significant. A dummy variable for sex did not enter into the preference regression equation.

Table 7-9. Ability of Methods to Identify Differences Across Segments

PRIMARY LEVEL OF REQUIREMENTS

IMPORTANCE METHOD	Importance Correlation Across Attributes ρ (p)	# of Attribute Means that Differ
Self-Stated	.87 (.005)	2
Anchored	.85 (.007)	0
Constant Sum	.77 (.02)	0
Revealed	-.39 (.20)	0*

* The calculated regression coefficient for a dummy variable for sex did not differ significantly from 0.

H.3. Performance on Other Methods Issues

The self-stated technique seems to be favored over the other techniques across most of the "other" methods issues because it is simple and straightforward. However, past theory and research on assigning importance values favors the revealed and anchored methods, especially when the importance of upper levels of the hierarchy are cascaded down to lower levels. Results with the self-stated method have demonstrated problems in the past with respondent ability to significantly differentiate between important and unimportant attributes, although that did not seem to be a problem here.

Cost to Implement

Cost factors favor the revealed and self-stated techniques over the others. From a cost viewpoint, these methods are all inherently vastly more expensive than more traditional field research methods which only use 25 to 30 attributes. Some economies might be obtained with the revealed method because competitive information about perceptual positions of products is obtained from the same data for importance values. If the revealed technique by itself could provide importance values for all 230 attributes, including those at the tertiary levels, it would be the least costly technique. However, since it only provides importance values for the upper level(s) of the hierarchy, some other method must also be used to obtain importance values at the lower level.

The main differences in cost between these methods, all of which require separately gathering importance and positioning data, will therefore arise from differences in overall and usable survey rates of return. Surveys that did not require respondents to write in numbers had an overall return rate more than 25% greater than those requiring respondents to write in numbers. While the statistical significance between the averages evaporated when the number of incomplete surveys was accounted for in the analysis, the trend was in the same direction; more survey are returned in usable form when respondents do not have to write numbers down (Table 7-2).

Because the overall response rate was so low in this study, I would not expect this large a percent difference in the averages in a study with a higher overall response rate, for example where incentives were provided and/or potential respondents were prescreened for agreement to comply. However, even with a small magnitude in the percent difference in average rates, the cost factor would continue to favor the self-stated and revealed methods over anchored and constant sum.

Performance Across Respondent Issues

Response rates are probably also one measure of how easy to fill out the respondents perceive the surveys. From response data, the self-stated and revealed questionnaires are easier. From the responses to the research in the "reactions" section of the questionnaire, obtaining importance values for many attributes is tedious and boring for respondents, regardless of which method is used.

Analyzing the "compliance" achieved by survey type is another indirect measure of how easy respondents found the questionnaire. By "compliance" I mean how well the respondents have complied with the request to provide answers to all questions on the survey. Compliance is measured as the average proportion of the attribute response section of the questionnaire filled out by respondents and the strength of the pattern of response. In measures of compliance the self-stated and revealed techniques clearly outperformed the others, while constant sum exhibited severe problems (Table 7-10).

Table 7-10. Relationship Between Attribute Group Size and Numbers of Blank Attributes

IMPORTANCE METHOD	Revealed/ Self-Stated	Anch-ored	Constant Sum
Attributes/person left blank	0.7	34.1	110.1
% of total (230)	0.0%	14.8%	47.9%
Regression Coeff: # of Blanks /# attributes in group	-	.17**	.74**
R^2: Variation explained	-	.57**	.95**

** p <.001

The level of response showed a distinct pattern; more attributes were left blank in larger groups of attributes than in smaller ones. When the number of attributes respondents left blank was regressed on the total number of attributes in the group, the regression coefficients differed significantly from zero and a large proportion of the variance in the data was explained, especially for the constant sum method, where affect of attribute group size is very large. Respondents fill out just under 75% of the attributes in a group. Since the largest group in the survey consisted of 19 items, respondents using the constant sum form filled in only five of those items with a value other than zero. Respondents seem to have a very difficult time distributing points across a large number of attributes. Their solution seems to be to pick the top three to five attributes and distribute the total number of points across those items, then either leave the rest blank or assign them values of zero.

The anchored method does not seem to present nearly the problem with compliance that the constant sum method does. The effect of group size is 25% of the affect for the constant sum method. Anchored method respondents filled in about 16 out of 19 items for the largest group.

One clue suggests respondent compliance for the anchored method may be as good as for the revealed and self-stated methods. The relative proportion of anchored method attributes assigned the lowest possible value does not differ materially from the number of self-stated or revealed attributes assigned the lowest possible rating. However, respondents have assigned almost half the constant sum attributes a "0," the lowest possible rating for that method, indicating that the problems with compliance are significant compared to the other methods.

From all this analysis I conclude that the size of a group of attributes materially affects the number of attributes within the group that respondents will assign non-zero values. The size of the affect for the constant sum method suggests that there is a limit (possibly somewhere around five) in the numbers of attributes respondents should be asked to make tradeoffs between. Because the number of lowest possible values assigned to anchored attributes is the same as for the self-stated and revealed methods, the group size affect may not be a problem with using this method in determining attribute importance.

Comparative Ease of Analysis

The last issue for comparison is how easy each method is from the research analyst's point of view. The self-stated is clearly the easiest. The analyst merely extracts averages by attribute across the cases and arranges the numbers by level in the hierarchy and/or primary group. Anchored and constant sum methods require a bit more work from the analyst because new variables must be calculated based on the importance values of upper levels of the hierarchy. Once that is done the analysis is just as straightforward as for the self-stated method. Revealed and hybrid methods are the most difficult because coefficients frequently do not differ from zero and the importance of only the upper levels of the hierarchy can be determined using revealed methods. The analyst must look at the regression equations and determine which of the coefficients should remain as they are and which must be changed to zero. Much more judgment must be employed by the analyst using the revealed method to assign importances to attributes.

I. Closing Remarks on the Important Attributes of a Food Transporter

Table 7-11 lists the primary attributes and their anchored method importance values. Using the values calculated by the anchored method, the most importance primary attribute is that the device "works well as a container," followed closely by "convenience," "easily movable," "carries many kinds of things," and "right size." Somewhat less important is the container's ability to "maintain food temperatures," while the container's "attractiveness" is by far the least important aspect of a food transporter. This suggests that for a food transporting container, design emphasis should be placed on attaining breadth and flexibility in the ways the container can be used through creatively combining pieces of the five most important primary attributes.

Table 7-11. . Average Importance Values for Primary Attributes: Anchored Method

PRIMARY ATTRIBUTE	Average Importance*
Works Well as a Container	84.3
Convenient	81.3
Easily Movable	76.0
Carries Many Kinds of Things	74.0
Right Size	71.9
Maintains Food Temperatures	61.3
Attractive, Good Looking Container	27.5

* 100 is maximum rating

CHAPTER 8. CONCLUSIONS ACROSS THE RESEARCH

A. Overall Implications of the Research

This research indicates that how a management process is implemented in companies may be more important to the improvements it brings than the specific context in which it is implemented. If, as a corporate manager, I want to change the processes used for developing products, I not only have to provide the freedom to experiment with different processes, I have to instill in the people using the new processes a real desire to use them, and to use them in a way that will have an opportunity to affect one or more changes in the product or the process.

This research also suggests that managing the team's communication processes is vital. Other researchers have already shown that communication level is positively correlated with project success. This research demonstrates that different product development processes might affect levels as well as the efficiency of communication paths. Changing particular aspects of the process for developing new products may allow differential alterations in communications paths and levels. Once specific relationships are understood better than currently, some parts of the process could be modified to improve one or more aspects of communication, while not affecting other portions of the network which already perform satisfactorily.

The information conveyed through the communications networks to the technical staffs, and the credibility of that information, determines the characteristics of the product developed. QFD uses rather crude team-based techniques for determining attribute importance values, but uses a fairly efficient mechanism to disperse the results among all team members. However, even though crude, the values generated have great credibility to the team because the team developed the numbers in concert.

The marketing methods refined and tested in this thesis provide a means for generating importance values based on inputs from customers. Using the methods may impact product outcomes positively. These marketing methods are techniques that can be performed by the team (perhaps with some help), but they are more time consuming and require more effort and marketing expertise than the traditional QFD team-based methods.

Product development teams may feel that applying the marketing methods developed in this thesis are beyond their abilities and balk at using them. One solution to this problem that managements who want to introduce some rigor into the market research aspects of QFD may use is to implement the market methods and obtain the values using a group other than the product development team (ie market research). However, the field research demonstrated that success with using a process correlated with high levels of buy-in by all persons involved with it. Therefore, I expect a major problem will arise from the credibility of the values generated using these market research methods unless the team drives their implementation.

From the teams I have observed, the technical staffs are usually just so happy to get any amount of detailed information about the needs of the customers and agreement among the team and its managers on the relative importance of the various needs, that they care (at least in the short run) very little whether those are the "right" numbers, so long as everyone agrees what values to design into the product. I am afraid that the methods tested here are more rigorous but less useful to the teams than the methods currently employed for assigning importance values.

As a researcher interested in producing improvements in the new product development processes used in industry my next task is to disseminate these findings, with all their limitations, to the research sites and obtain their reactions.

B. Limitations of the Study

All three research initiatives are limited in their generalizability by sample size. The field research and communications study also used a convenience sample instead of a random sample.

The field research divided the original 35 projects into 72 project context characteristics cells, then overlayed on that typology an implementation construct with over 300 possibilities between the six variables. While some conclusions from the research could still be drawn across some of the variables, the problem was clearly overspecified compared with the number of cases for examination. With this small a sample, the research most likely picked up only the largest determinants of success and failure. The sample size is small enough that the study could very well have missed identifying other determinants whose affects are large, but where sufficient cases for comparison were lacking.

Because the field research sample was a convenience sample with access obtained wherever I could gain corporate or project entry, the results may also be biased in some way. Given that the sample contains a number of cases demonstrating implementation success as well as a number of different kinds of failure, it does not appear that companies only allowed access to the cases that were performance stars. Even so, the non-random manner of project selection may have introduced some more subtle bias. With another sample variables other than the two predominant implementation variables found having high impact on outcomes in this sample may be shown to have an equally large impact on the success of applying this process to new product development projects. A different convenience sample would most assuredly have changed the proportion of projects by outcome. A much larger sample of QFD projects would need to be canvassed before any definitive statement could be made about the proportion of time that QFD projects succeed and fail.

The communications study is a single case study. It demonstrates that the measurement method is usable and shows that in this one case where communications were measured during the parts specification phase for one pair of matched component type projects, the pattern and amount of communication seem to differ in interesting ways between the two projects. However, to try to generalize the findings beyond this one phase of product development is probably risky. This research has been useful for generating the hypotheses to investigate across many more projects in the future.

The sample sizes in the attribute importance determining section of the market methods studies are adequate for statistically based differentiation, but smaller than I would like, and the survey return rate is very low. The low return rate could be attributable to a lack of familiarity or use with the product investigated. Perhaps food transporting devices are less widely used by graduate students than originally thought. However, the lack of prescreening and incentive may have produced a very demographically biased sample for whom the data were analyzed. If I were interested in the absolute levels of these importance values (ie, if I were a manufacturer of coolers or picnic baskets), I would use the values from these data only with great reluctance. However, the interest in the importance values in this research was only for cross-method comparisons. For these purposes (and probably only for these purposes), the data gathered in this research are probably adequate.

C. Future Research

C.1. Expanding the Field Research

The field research can both be expanded and extended. Conclusions from the results of the research can be extended and solidified by going back to the projects in the study and gathering data for different measures of project success as they become available. For instance, specific measures of quality (defect rates, mean time between failure), customer satisfaction, overall sales and share, and time to full manufacturability. For many of the projects in the study, these data were not yet available. These measures would provide a market-based substantiation of QFD's utility to go along with the company-based measure used predominantly in this study.

The field research can be expanded along two dimensions: more cases investigating projects using QFD and an extension of the study to gather data similar to the QFD data across different types of product development projects. More QFD cases will move toward filling in holes in context and implementation variable typologies and trying to identify additional variables that may discriminate between project success and failure. Looking at the results for different product development processes begins to assemble the data needed for determining which characteristics of new product development processes are critical for success.

C.2. Extending the Communication Study

I am extremely interested in determining whether the communications results obtained in this study are one-case anomalies, or represent endemic differences between different product development process aspects. My long term goal is to be able to relate changes in various aspects of the product development process to changes in communications patterns and levels, then in turn correlate the communications differences to project and product success and failure.

Over the next three to five years I would like to extend the communication research begun in this thesis across the phases of new product development. The hypotheses generated in this research need to be tested by gathering data from additional cases - enough to give statistical significance to any conclusions. The communications data also needs to be linked to measures of success for project outcomes. These might include levels of quality, customer satisfaction, and ease of ramp-up in manufacturing.

As indicated in Chapter 3, I will try to set up communications investigations in industrial firms (especially the firm hosting the study in this research), and in two sites associated with the University of Chicago. Each year 60 second year MBA students at Chicago elect to take a six month product development laboratory in which they develop new products and their business plans for corporate sponsors. While these are student subjects, this laboratory environment seems like a perfect place to try to manipulate some of the implementation variables identified in this study and look at the affects on product development.

The second research environment associated with the University is ARCH, the commercialization arm of Argonne National Research Laboratory (the University is the contract manager for Argonne). My goal is to set up ongoing communications studies with each new commercialization project as they start up. Discussions have already begun with the President of ARCH, who seems inclined to allow this research to take place.

C.3. Marketing Methods Providing Information to Technical Development Staffs

This thesis identified more market research related questions than it answered. The questions of most interest to me relate to attribute generation and hierarchy construction.

The attributes required by the technical staffs differ from the attributes required by marketing. This research identified one technique for identifying a large number of attributes. It is not clear that these attributes most efficiently address all the needs of the technical staffs. It would be interesting to ascertain exactly what kind of information technical staffs need (do some market research on the information needs of technical staffs). One extension of this research might therefore address the question of what an attribute is and what a "full set" of attributes and their structure are.

The relationship between managerially- and customer-based hierarchies appears to differ depending on the product investigated. Are there classes of products for which managers can produce hierarchies as useful as going to the field for customer input, or were the results in chapter six case-specific? This can be investigated by repeating the hierarchy development tasks across additional products and categories and comparing the results with those already obtained.

A full field test of the methods for obtaining importance values is already underway with an industrial sponsor. I expect this test to eliminate the sample size and return rate problems associated with the data gathered for this thesis.

C.4. Final Statement

This field does not lack for research opportunities. The research in this thesis just scratches the surface of four or five different research programs that can be carried on in the future. I think I can look forward to a long career of investigating how new product development can be improved.

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FUNCTIONALLY INTEGRATING NEW PRODUCT DEVELOPMENT

APPENDICES

APPENDIX 2.1. PROJECT SPECIFIC CHARACTERISTICS BY PROJECT (Including Success Factors)

COMPANY	PROJECT #	INHERENT COMPLEXITY	PROJECT TYPE	DEPENDENCE	# CUSTOMERS	AMOUNT OF CHANGE
DURABLE A	1	SS	P	D	2	MC
	2	SS	P	D	2	NG
	3	*CS*	*P*	*I*	*1*	*CS*
DURABLE B	**1**	**C**	**P**	**D**	**2**	**NG**
GOODS A	1	C	P	I	1	MC
	2	C	P	I	1	MC
GOODS B	1	C	P	I	1	IN
	2	C	P	I	1	IN
	3	**CS**	**P**	**D**	**2**	**NG**
	4	**SS**	**SE**	**D**	**2**	**NG**
	5	C	P	I	1	MC
PARTS A	**1**	**C**	**SE**	**D**	**2**	**MC**
PARTS B	*1*	*C*	*P*	*D*	*2*	*IN*
	2	*C*	*P*	*D*	*2*	*IN*
PARTS C	1	C	P	I	1	CS
	2	C	P	D	2	CS
	3	C	P	D	2	CS
HITECH A	**1**	**SS**	**SE**	**I**	**3**	**MC**
	2	**SS**	**SE**	**I**	**3**	**MC**
	3	CS	S/W	D	2	CS
	4	CS	P	I	2	CS
	5	SS	S/W	D	2	CS
	6	CS	P	I	2	CS
	7	CS	P	I	2	CS
	8	SS	SE	I	3	MC
	9	*SS*	*SE*	*D*	*3*	*CS*
	10	SS	S/W	D	2	MC
	11	SS	S/W	D	1	CS
	12	SS	P	D	2	CS
HITECH B	*1*	*C*	*P*	*D*	*2*	*CS*
	2	*SS*	*S/W*	*D*	*3*	*CS*
	3	*CS*	*S/W*	*D*	*3*	*CS*
	4	*SS*	*S/W*	*D*	*3*	*CS*
	5	SS	S/W	D	2	CS
	6	**C**	**P**	**D**	**2**	**NG**

LEGENDS:

Fonts:	Projects:	Project Type:	How Much Change:
Tactical Success	CS Complex Syst.	P Product	IN Incremental
Complete Failure	SS Subsystem	SE Service	MC Major Change
Mixed Results	C Component	S/W Software	NG Next Generate
			CS Clean Sheet

APPENDIX 2.2. IMPLEMENTATION AND MANAGEMENT CHARACTERISTICS BY PROJECT

		QFD Implementation			Project Management		
COMPANY	PROJECT #	Who Pushes QFD	Buy-in Level	Goals	Attitude to QFD	Functions	Team Familiarity
DURABLE A	1	T	M	A	E	3	L
	2	N	L	P	FC	2	L
	3	N	M	P	FC	3	M
DURABLE B	1	B	H	A	FC	2	M
GOODS A	1	T	L	P	FC	4	L
	2	T	M	P	FC	3	L
GOODS B	1	B	H	P	FC	4	H
	2	B	H	A	FC	4	H
	3	N	H	A	FC	4	L
	4	N	H	P	FC	1	M
	5	B	M	P	FC	4	M
PARTS A	1	N	H	A	FC	3	M
PARTS B	1	T	L	P	FC	3	L
	2	T	L	P	FC	3	L
PARTS C	1	T	L	P	FC	4	L
	2	T	M	P	FC	3	M
	3	T	H	A	FC	3	L
HITECH A	1	B	H	A	E	2	M
	2	B	H	A	E	2	M
	3	N	M	P	E	3	L
	4	N	L	P	E	3	H
	5	N	L	P	E	2	L
	6	N	L	P	E	3	L
	7	N	L	P	E	3	M
	8	T	L	A	E	2	L
	9	N	M	A	E	3	L
	10	N	M	A	E	3	L
	11	N	M	P	E	4	M
	12	N	L	P	E	4	L
HITECH B	1	N	M	A	FC	3	L
	2	N	L	P	FC	2	M
	3	N	M	P	FC	4	M
	4	B	M	A	FC	1	M
	5	B	L	A	E	2	M
	6	B	H	A	FC	4	L

LEGENDS:

Pushes:
T: Top-Down
B: Bottom-Up
N: Neutral 3rd Party

Buy-in & Team:
H: High
M: Moderate
L: Low

Goals:
P: Process
A: Affect Change

Attitude:
E: Expense
FC: Fixed Cost

Functions:
1: 1 out of 4
2: 2 out of 4
3: 3 out of 4
4: 4 out of 4

APPENDIX 2.3. STRATEGIC BENEFITS* BY PROJECT

		Process Improvements												Long Term Corp					
PROJECT		Improve Info				Rational Decision					Ear- ly	Good Team				Value			
COMPANY	#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
DURABLE A	1						1							1					1
	2																		0
	3		1	1	1										1				4
DURABLE B	1				1			1						1				1	4
GOODS A	1																		0
	2																		0
GOODS B	1									1	1						1	1	4
	2										1						1		2
	3							1							1		1	1	4
	4							1			1						1		3
	5										1								1
PARTS A	1																	1	1
PARTS B	1													1					1
	2														1				1
PARTS C	1	1				1													2
	2				1				1										2
	3									1		1			1	1	1		5
HITECH A	1					1											1		2
	2					1					1						1		3
	3										1						1		2
	4			1						1	1		1			1			5
	5		1																1
	6										1								1
	7																		0
	8																		0
	9		1						1	1	1	1							5
	10																		0
	11							1			1							1	3
	12				1			1			1		1						4
HITECH B	1	1	1						1										3
	2										1	1			1		1	1	5
	3	1	1		1		1						1						5
	4										1	1			1			1	4
	5															1	1		2
	6		1					1					1		1				4
TOTALS		3	6	2	5	3	2	5	4	4	13	5	4	4	7	3	9	7	

(CONTINUED ON NEXT PAGE)

APPENDIX 2.3 (CONTINUED)

CODE NUMBER	STRATEGIC BENEFIT
IMPROVES INFORMATION FLOW	
1	Improve Market Input
2	More Knowledge About the Customer
3	More Knowledge About Competitors
4	Information is Moved from Source to User
HELPS MAKE DECISIONS RATIONALLY	
5	Melds Design to Needs
6	Shows Interrelationships
7	Structures Thinking
8	More Complete Consideration of Problem
9	Set Priorities
SOLIDIFY DESIGN EARLY	
11	Avoid Late Project Blindsides
TEAM ISSUES	
10	Build a Common Vision; Get Project Buy-in
12	Build a Better Team; Morale
LONG TERM BENEFITS FOR THE COMPANY	
13	Forges Better Cross-Functional Relationships
14	Captures Knowledge
NON-SPECIFIC INDICATIONS OF VALUE	
15	"Liked QFD;" Though it was Valuable
16	Would/Did Use it Again
17	Produced an Unexpected Change in the Product/ Process

APPENDIX 2.4 VARIABLES NOT DIFFERENTIATING BETWEEN SUCCESS AND FAILURE

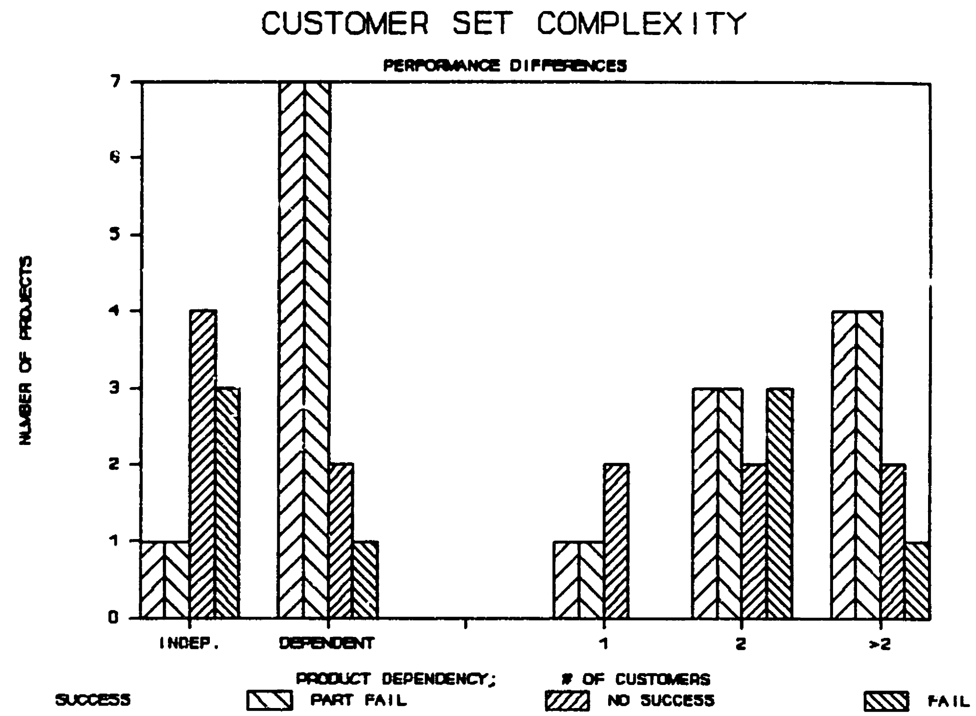

Figure A2.1 Variation Between Success Type and Customer Complexity

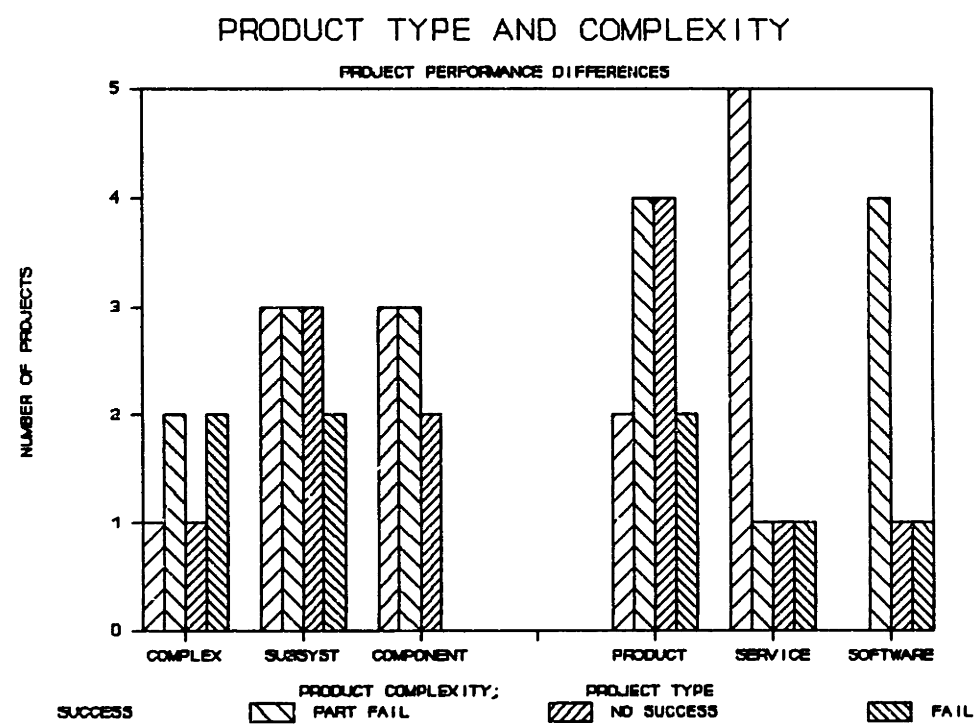

Figure A2.2 Variations Between Success Type and Project Complexity

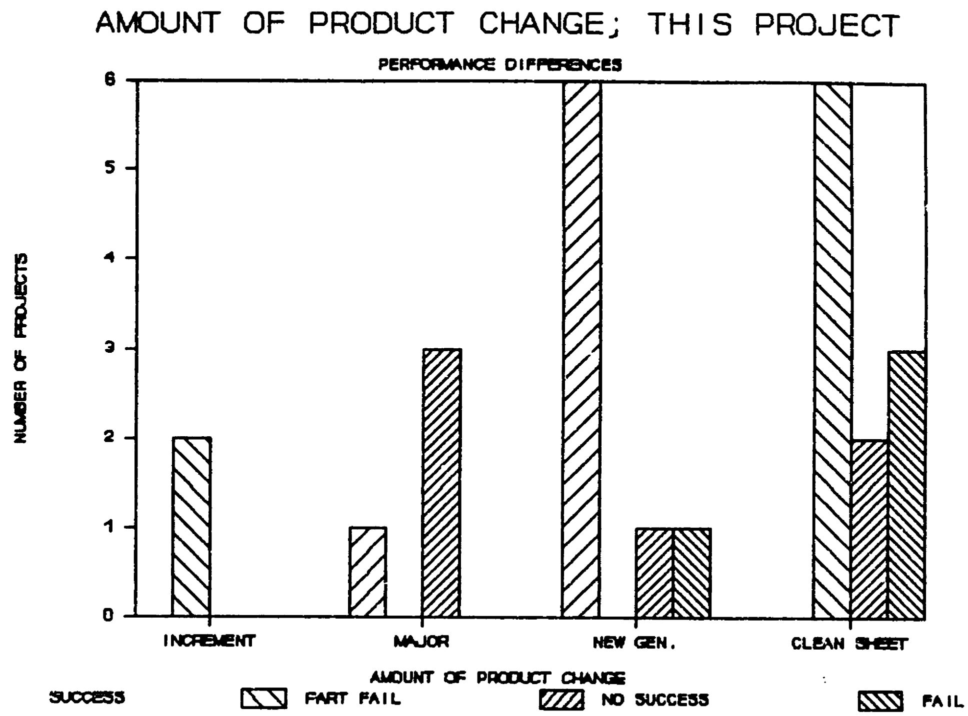

Figure A2.3 Variation in Success Type by Amount of Project Change

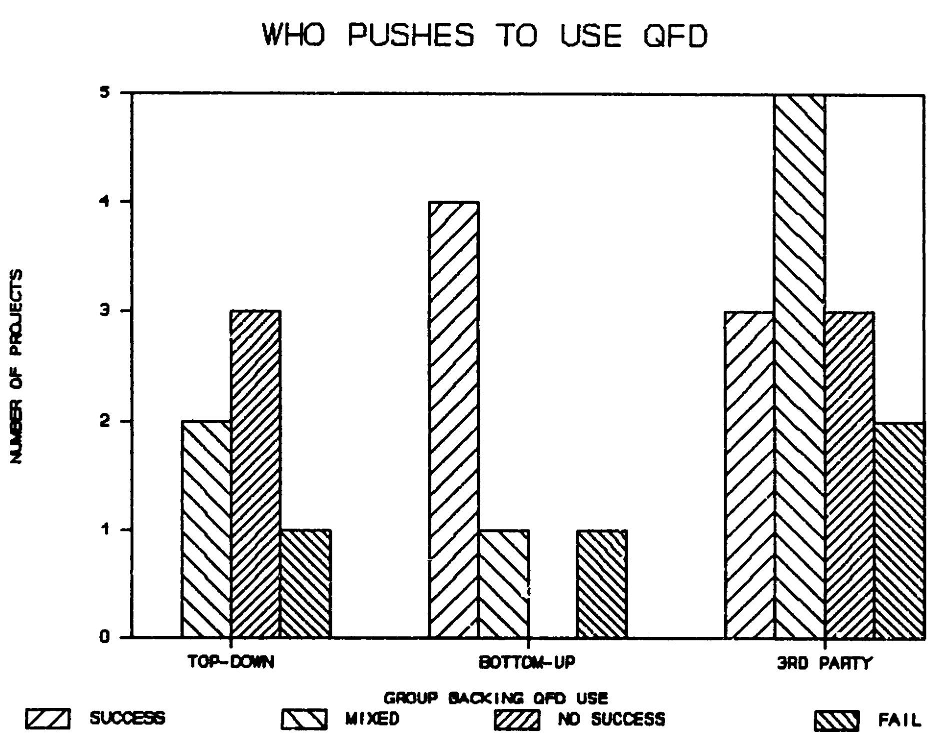

Figure A2.4 Variation in Success Type by Primary QFD Proponent

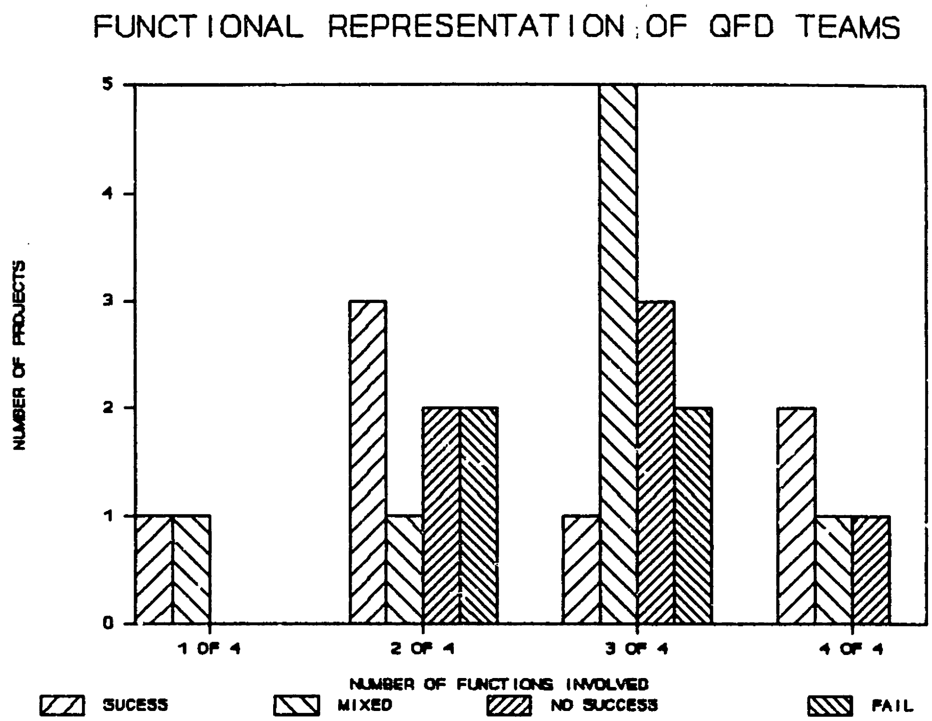

Figure A2.5 Variation in Success Type by Number of Functions on Teams

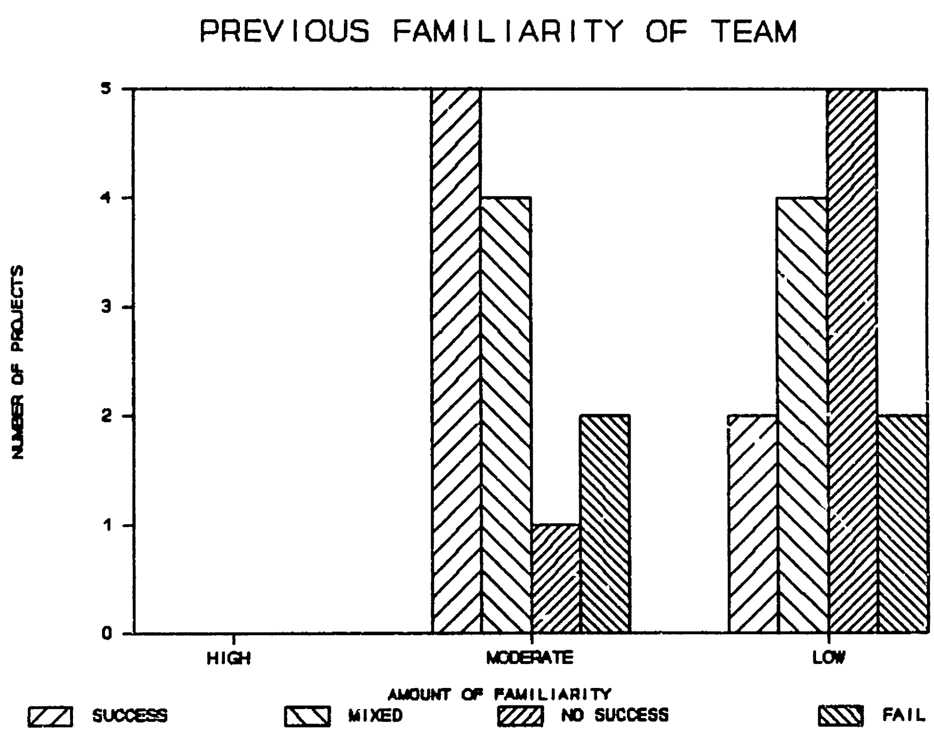

Figure A2.6 Variation in Success Type by Team Familiarity

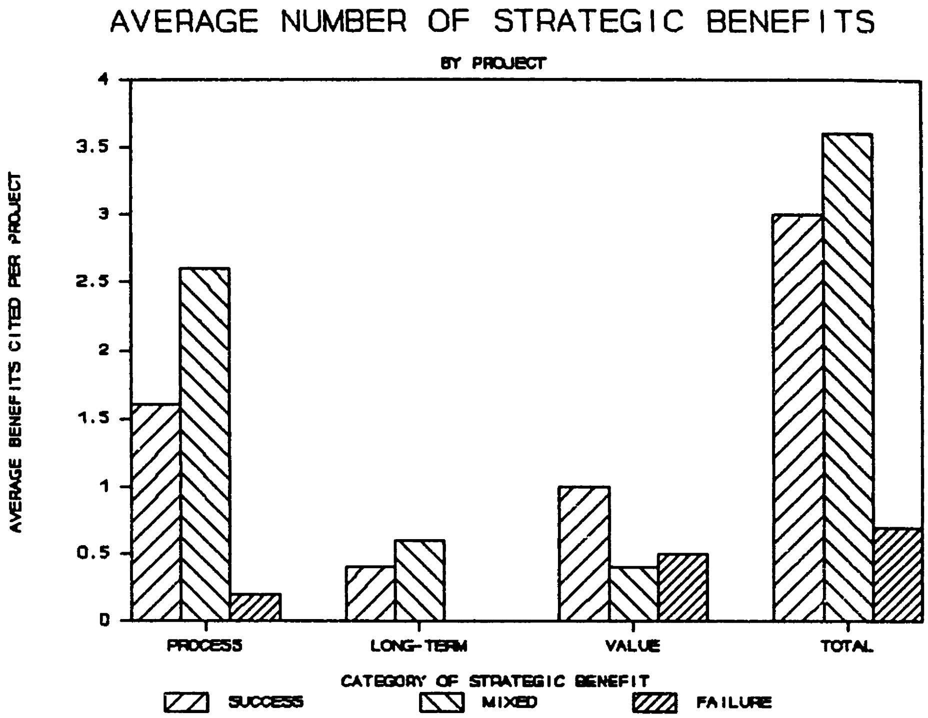

Figure A2.7 Variation in Number of Strategic Benefits by Success Type

APPENDIX 3.1. SAMPLE COMMUNICATION SURVEY FORM

PROJECT X: COMMUNICATION

FILL OUT THIS SHEET AT THE END OF THE DAY Mon

NAME: JOE DONK DATE TO BE FILLED OUT: OCT 3

Actual date: OCT-3 Time sheet was filled out: ______

Please indicate how many times you talked with each person listed on this sheet today about the door check hinge project, then place an X in the columns corresponding to each topic you talked about with each person. When you have filled out this form, please slide it into the envelope provided and drop it into the mail. Thank you for your time. Abbie Griffin

TOPICS DISCUSSED

	# Conversations Today	Cost/Pricing	Product Features	Competitor Product Info	Design Capabilities	Manufacturing Capabilities	Competitors' Strategies	Market Segments/Sizes	Customer Needs - Expressed	Customer Needs - Unstated	Product Use by Customer	Relationship to Business Strategy	Administrative/Logistical
Sam Spade Engineer													
Joe Donk Design													
Jane Doe Facilitator													
Ima Nerd Supervisor													
Ura Worker Design Superv.													
Arthur Conan Doyle Project Leader													
Frank Lee Bought Acct. Mgr.													
Jim Bob Design Engineer	1			X									
Remington Steele Purchasing	1									X			
Stevie Wonder Manufacturing													
Finance	1		X	X									
Mrkting/Mkt Research													
Planning													
Supplier Manufacturing													
Vehicle Office													
Other													

THANKS! ABBIE

APPENDIX 3.1. RESPONDENT INSTRUCTIONS FOR COMMUNICATION SURVEY

INSTRUCTIONS FOR FILLING OUT THE COMMUNICATION QUESTIONNAIRE

On one day of each week during the study someone will place on your desk a copy of the communications questionnaire. The day will change with the week to obtain a random sample of all the days of the week, without your having to fill out the questionnaire every day.

At the end of that day, just before you leave, please take 5 minutes to think back over who you talked to during the day about the particular design project I'm investigating.

For your convenience, I've listed all the people who are routinely involved in the project. For each person listed, please note how many times you talked with them during that day, and that day only, about this project. Please count each face-to-face conversation, telephone call, and meeting, and place the total in the first column of the sheet. Then think about the topics of conversation you covered with that individual that pertained to this project, and only this project. You probably covered topics not relating to this project, but I am only interested in the discussion(s) that occurred about this project. Please indicate with check marks or X's all of the listed topics you covered with that individual during the day.

Also listed are some other functions that you might talk to people in occasionally. When you have talked to someone other than those specifically listed, please fill in their names on the list and follow the same procedure as you did for the people already on the list.

Attached to each sheet will be a stamped envelope addressed to me. Please put the completed sheet in the envelope, seal it, and drop it in the most convenient mailbox.

If you have any questions, please feel free to contact me at:

Abbie Griffin
Sloan School
E52-513, MIT
Cambridge, MA 02139

Phone: (617) 253-0288

Many thanks for your help and cooperation!

APPENDIX 3.1. (Continued)

EXPLANATION OF INFORMATION CATEGORIES

Number of Conversations Today: Please write in the number of conversations you held with each of the persons listed on this sheet. Meetings count for 1 conversation, even though you may not have talked directly with that person during the meeting, or you may have talked extensively to them during the meeting.

DESIGN ISSUES

Cost/Pricing: Any issue to do with the cost of any part of the product, the final cost of the product, or prices to Ford from the supplier.

Product Features: Discussion of any specification or physical aspect of this product. Setting specs, or changing specs for any reason. Talking about or relating any test results for the product being designed.

Competitor Product Information: Any discussion concerning the physical aspects of competitive products. Features, test results, serviceability, durability.

Design Capabilities: Any discussion of how this product might be enhanced by our creative technical abilities, or limited due to technical design problems.

Manufacturing Capabilities: Volume limits, time to production. Any limitations posed on our design or commercialization due to manufacturing constraints. Any improvement or changes in our manufacturing capabilities.

MARKET INFORMATION

Competitors's Strategies: What our competitor's intend to do with their physical products. Where their products are being used. Why their products differ from ours. What we expect our competitor's to be doing.

Market Segments/Sizes: Differing needs of different car lines. Size of different segments.

CUSTOMER NEEDS

Customer Needs - Expressed: What our customers explicitly tell us they want this product to do. Customers may include the manufacturing organization, car owners, field service (repair) people. May include some government requirements.

Customer Needs - Unstated: Things we think our customers want, although they have never explicitly told us. May include safety issues.

Product Use by Customers: Any discussion of all the different ways customers do or might actually use or misuse the products.

BUSINESS PLANNING INFORMATION

Relationship to Business Strategy: Any discussion of how this product fits in with our overall business strategy, for example, may include discussions of drives to improve manufacturing or design quality.

Administrative/ Logistical: Any discussion for setting up meetings, arranging any logistics.

APPENDIX 3.2 CALCULATING RESPONDENT RELIABILITY

Respondent Reliability = R^i = the proportion of the opportunities for responding that respondent "i's" responses correctly matched the responses given by the other person in each possible communication pair across the members of the project team.

$$R^i = \frac{\Sigma_{d=1}^{15} t_d - \Sigma_{d=1}^{15} U_d}{\Sigma_{d=1}^{15} t_d}$$

where: d is the response day; a total of 15 response days were used in the study

t_d is the number of members on the team on any given response day

U_d is the number of Unreliable answers respondent "i" provided on response day d. An answer is unreliable if $C_{ij} \neq C_{ji}$ and either C_{ij} or $C_{ji} = 0$.

C_{ij} is the number of conversations respondent "i" reported having with respondent "j," who is one of the other t-1 members of respondent "i's" project team

Respondent reliability ranged from a low of .871 to a high of .994. The average reliability across all the respondents of the two teams is .947.

APPENDIX 3.3 DAILY INTRA-PROJECT CONVERSATIONS PER COMMUNICATION LINK FOR THE BASIC UNITS OF ANALYSIS - INTRA-PROJECT COMMUNICATION

Non-QFD TEAM

		DESIGN		MANUFACT.		FIELD		PLANNING	
		OEM	Supplier	OEM	Supplier	OEM	Supplier	OEM	Supplier
DESIGN	OEM	.04*							
	Supplier	.23	.00						
MANUFACTURING	OEM	.04	-	.10					
	Supplier	.03	.02	.00	.00				
FIELD	OEM	X	-	X	-	X			
	Supplier	.05	.10	.06	.03	X	.00		
PLANNING	OEM	.14	-	.01	-	X	-	.00	
	Supplier	.03	.67**	.01	.05	.10	.17*	.10	.00

QFD TEAM

		DESIGN		MANUFACT.		FIELD		PLANNING	
		OEM	Supplier	OEM	Supplier	OEM	Supplier	OEM	Supplier
DESIGN	OEM	.69*							
	Supplier	.71	.00						
MANUFACTURING	OEM	.06	-	.00					
	Supplier	.04	.00	.00	X				
FIELD	OEM	X	-	X	-	X			
	Supplier	.03	.28	.11	X	X	.00		
PLANNING	OEM	.40	-	.03	-	X	-	.10	
	Supplier	.23	X	X	X	.03	X	.00	X

** ANOVA Test Statistic: p<.001
* ANOVA Test Statistic: p<.01
+ ANOVA Test Statistic: p<.05
X comparisons not possible: no team members to communicate

APPENDIX 5.1. ATTRIBUTE GATHERING INTERVIEW GUIDE

INTRODUCTION

Hello, I'm Abbie Griffin. I'm going to be talking with you today about how you transport food when you prepare it in the home, but eat it somewhere else. I work for a market research company who has been asked to do a study to determine how people move food from one place to another.

I'll ask you first about the most recent time you prepared food in your home and ate it outside the home and then go on and inquire about some other specific kinds of situations.

There are no right or wrong answers to any of the questions I am going to ask you. I am trying to understand as much as possible about what's important to you about moving food from one place to another. At times, I will try to get you to talk in more detail about some specific aspects of the situations, using questions like why? and asking you to go into some aspect of the situation in more detail.

SCENARIO 1: MOST RECENT USE.

Could you please tell me about the most recent time your household prepared food in your home or apartment for more than one person, then took it out of your home and ate it elsewhere?

When was it you last did this? How frequently do you do this?

What kind of a meal did you prepare for what time of day?

Did you take hot food, cold food, or a mixture of both with you?

What did you put it into to carry it? What did it look like, how big was it?

What else did you put in with the food? Why? Where did you put these items?

Describe to me in detail what happened when it was time to get ready to eat the food. And tell me, please, about the event itself. What occurred?

How did you keep the hot food hot and the cold food cold? Were you happy with the temperature of the food when you ate it? Why/not? What would have been better for you?

Did you forget to take something that you wanted later? What was it? Why do you think your forgot it? How will you remember it next time?

What would you take with you in this situation, if only you could? What was it that stopped you from taking this item?

What things did you take with you other than food? Where did you put them?

Why did you carry the food and service implements this way?

What did you like about this carrying arrangement?

What worked well in the way you carried the food?

What didn't you like about this carrying arrangement? Why?

What didn't work well? What could have been done better?

What would you do differently next time in this same situation? Why?

SCENARIO 2: THE CAR TRIP.

Have you ever taken a long trip in the car where you packed food for you or you and your family to take with you?

SCENARIO 3: THE TRIP TO THE BEACH.

Have you ever packed food to take with you to a beach?

SCENARIO 4: FOOTBALL OR BASEBALL GAME.

Have you ever packed food to take with you to eat before or during a football, baseball, or softball game?

SCENARIO 5: THE ROMANTIC PICNIC.

Have you ever packed food to take with you to share intimately with a friend?

SCENARIO 6: THE WINTER EXPERIENCE.

Have you ever packed food to be eaten outside in the cold weather?

SCENARIO 7: THE BIKE TRIP

Have you ever packed food to be eaten on a bicycle day trip?

SCENARIOS 8: THE BOAT OR CANOE TRIP

Have you ever packed food to be taken with you on a boating or canoe trip?

APPENDIX 5.2. CODING INSTRUCTIONS FOR INDENTIFYING ATTRIBUTES

TO: MOT's
FROM: AJ Griffin
SUBJECT: Instructions for Coding the Transcripts from the Qualitative Interviews
DATE: September 22, 1988

OBJECTIVE OF THIS TASK: To compile a list of all the customer requirements uncovered in the qualitative interviews.

WHAT AND WHEN YOU WILL NEED TO TURN IN: By noon on Friday, October 7, 1988, you will need to turn in the computer floppy containing the full set of customer requirements to me. You may either put the floppy in my hanging folder in the lobby of E52, or deliver it to my office, E53-420. I also want the transcripts returned to me either in my office or during class the next Wednesday (Monday's a holiday).

THE PRODUCT: A food container/carrier suitable for holding the food for an average family (in the US that's about 4 people) for a day.

SO WHAT'S A CUSTOMER REQUIREMENT?

Customer requirements differ from product features. Customer requirements are problems that customers would like to have solved. These problems include things like:

- I want it to be easy to carry
- It must keep my food cool from when we leave the house to when we eat
- It keeps some of the food dry
- The temperature is the same throughout the cooler.

In QFD words, Customer Requirements are often called the Voice of the Customer. It is called this because those requirements are written down in the words that the customer actually uses. They are written in the "voice" the customer would use, not in the voice the engineer or manager might use.

Product features are the physical ways that problems are solved. Product features are things like handles, plastic exteriors, foam insulation and drains. These are the options that a product designer can use to solve the problems or address the customer needs that are expressed by the people who are interviewed.

When a customer says they want handles on a food carrier, he is telling you that this is his solution to a problem that he has. The question is, what is the problem? Getting at the problems is a bit like playing "Jeopardy." The customer talks in features (solutions); he is familiar with features, they are easy to talk about and over periods of use, he has discovered which features solve most of his problems. Getting the customer to talk in terms of problems or needs is much more difficult. However, it is very important to make the customer talk about needs if you are trying to design the product of tomorrow, not the product of today. Working with today's features, you can probably produce a dominant design, for the market as it stands today. What you cannot do with today's features is design a product that provides tomorrow's capabilities. Since technology will probably change the features you have at your disposal tomorrow, you can best figure out which ones of those to include (or how to try to push the direction the technology moves between now and tomorrow) if you really understand what it is the customer is using the product to do for him, and what he's really like to have the product do for him, if only it could.

SO WHAT ARE WE SUPPOSED TO DO?

In this part of the product development cycle, we are interested in identifying the customer requirements for the type of food carrier indicated above; one suitable for holding a day's worth of food for about 4 people. We will extract the customer requirements from the interviews that were done last week. Those interviews are being transcribed into hard copy. We will use the hard copy to come up with the Voice of the Customer.

Each team will be provided with a low density 5.25" floppy which contains a Lotus 123 template, as well as one copy of all of the interviews. The tasks which must be completed over the next week are

- identify all the customer attributes in all the interviews
- gather them into a full list
- weed out duplicates
- put them into the Lotus template and hand the final version in to me

<u>Identify Customer Attributes</u>: Each of the interviews must be read through and all the customer requirements in it identified or highlighted in some way. There are a number of ways to do this, among which are:

- highlight each attribute with a highlighting pen
- transcribe each attribute directly into the spreadsheet.

Reading and highlighting a transcript takes between 20 and 30 minutes, generally. You may split this task up however you want. That is, each team member may read 4 interviews, or some team members may want to read and highlight more transcripts and do less work on some later aspect of the process.

<u>Gather the Attributes into a List and Eliminate Duplicates</u>: Once all the transcripts have been highlighted, or each team member reading transcripts has entered the attributes they have identified into spreadsheets, the lists must be joined together. Some attributes will be mentioned in virtually all the interviews. Other attributes will be mentioned by only 1 or 2 people. The objective of this part of the task is to make sure you have put together a list of all the attributes, but at the same time make sure you have eliminated all the duplications across the various interviews. How you organize this task depends on how your group did the identification task. It will probably take a meeting of the people who did the attribute identifying to get everything in and eliminate all the duplicates.

<u>Put the Attributes onto a Template</u>: The last step is to hand the list of attributes, in the customer's wording, in to me. My task will be to look across the lists the 4 groups hand in and eliminate the duplicates across the groups. I have only the weekend to do this task, so I ask you to please make sure you get your lists in on time.

APPENDIX 5.3. CUSTOMER ATTRIBUTE LIST

1 accomodates leakproof storage containers
2 access to all food without unpacking
3 adapts to what I'm taking
4 accomodates tall glasses
5 adjust size of hot and cold sections
6 add additional coolant quickly
7 attractive, good looking container
8 adjustable in size
9 bumping into the container doesn't hurt
10 big enough to carry food for four people
11 can be attached to vehicles
12 can add coolant without repacking food
13 can be put inside a back pack
14 can be packed quickly
15 can carry container in front of me
16 can carry container at my side
17 can carry container like a shoulder bag
18 can carry container in hand or over shoulder
19 can carry container without using my hands
20 can carry container on my back
21 can find things easily
22 can close container with one hand
23 can move container without carrying it
24 can get in and out quickly
25 can sit on the container
26 can pick my container out in a crowd
27 can use a packaged coolant
28 can store container in kitchen
29 can use dry ice as a coolant
30 can use container for more than 4 years
31 can use ice cubes as coolant
32 can use during a football game
33 can warm drinks up
34 can use the container as a table
35 carries 12-24 drink cans
36 can't lose any container pieces
37 carries tupperware efficiently
38 carries at least 6 drink cans
39 carryable by one person for 15 minutes
40 carryable by a 7-year old
41 carrying mechanisms are rigid
42 carryable with one hand
43 comfortable in my hand
44 carrying mechanisms don't break

111 even temperature kept throughout each compart
112 elegant design
113 excess water drains out qickly
114 everything fits in one container
115 fits into almost any space
116 fits in a car trunk
117 fits on the floor of a car's back seat
118 fits on a car's front seat
119 flexible design
120 flexible construction
121 good price for the performance
122 food is balanced for carrying
123 has a workspace to prepare food
124 hands don't get cold looking for items
125 hides beer at prohibited area
126 has external storage areas
127 ice storage space
128 holds an umbrella
129 keeps bottles from touching one another
130 inexpensive over the long run
131 keeps different things at different temperatu
132 keeps cold air in when open
133 keeps food cold all day
134 keeps food cold
135 keeps food from tasting different
136 keeps food from getting soggy
137 keeps food warm for 2 or 3 hours
138 keeps food off the ground
139 keeps odors in; contains smells
140 keeps hot stuff where kids can't get it
141 lasts over 10 years
142 keeps warm food warm
143 lets me carry a tablecloth
144 leak-proof section for non-food items (keys,
145 lets me carry bread
146 lets me carry a thermos
147 lets me carry chips & crackers
148 lets me carry cans
149 lets me carry fruit
150 lets me carry drinks
151 lets me carry ice cream home from the store
152 lets me carry glass items
153 lets me carry non-food items
154 lets me carry ice for drinks

APPENDIX 5.3. CUSTOMER ATTRIBUTE LIST (Continued)

45 compresses for storage
46 comfortable to carry
47 container closes easily
48 container can be carried several ways
49 container doesn't break when dropped
50 container does not sweat
51 container doesn't leak
52 container doesn't dent
53 container doesn't snag on things
54 container doesn't slip around
55 container folds up
56 container expands
57 container has place to set drinks
58 container has no sharp edges
59 container is durable
60 container is compact
61 container is organized, neat
62 container is not easily punctured
63 container is stackable
64 container is rugged
65 container is waterproof
66 container is very well insulated
67 container keeps sand out
68 container keeps hot liquids from leaking
69 container molds to leg when carried
70 container keeps some items dry
71 container needs no preparation before use
72 container needs no maintenance
73 container protects things
74. container opens easily
75 container stays clean looking
76 container serves multiple purposes
77 contains a cooling mechanism
78 container stores compactly
79 contemporary design
80 contains a food heating capability
81 convenient to carry
82 convenient
83 coolant is not in the way
84 cool air stays inside container
85 cooling material doesn't soak food
86 coolant is not messy
87 cooling material takes up a minimum of space
88 cooling material is cheap

155 lets me carry plates
156 lets me carry paper goods (plates, cups, napk
157 lets me carry rice balls
158 lets me carry real silverware
159 lets me carry salt/pepper
160 lets me carry salads
161 lets me carry wine bottles
162 lets me carry sandwiches
163 lid locks open
164 lid can't be lost
165 lid remains attached to cooler when open
166 lid is leak-proof
167 lid stays closed when container falls over
168 lid locks shut
169 made of non-toxic materials
170 lightweight
171 means for carrying doesn't interfere with loa
172 matching utensils/cups/etc.
173 minimal external space taken up
174 means of carrying moves out of way
175 minimum room taken by insulation
176 minimum effort to move container
177 natural looking
178 multiple entries into container
179 not clumsy to carry
180 no loose ice inside container
181 one or two persons can carry
182 objects don't rattle around
183 prevent food from being crushed
184 option to get into one section at a time
185 prevent liquid from spilling
186 prevent food from spoiling
187 protect fragile foods
188 prevent mess inside
189 reasonably priced
190 protection for glass/breakables
191 resistant to dry ice temperatures
192 remove things without disturbing remainder
193 right size
194 reusable coolant
195 see everything at once
196 right size for sitting on
197 self-contained; glasses, cups, plates, utensi
198 segregates warm food from cold food

89 cools foods fast
90 cools effectively
91 doesn't let me forget items
92 does not bang into you when carried
93 don't have to refreeze coolant every night
94 doesn't squeak when it rubs
95 drain mechanism doesn't clog
96 drain cap/plug can't get lost
97 easily movable
98 drain out water without tilting container
99 easy for children to use
100 easy access with one hand
101 easy to clean
102 easy to carry
103 easy to drain out excess water
104 easy to dispose of
105 easy to handle in the car
106 easy to get things out
107 easy to tell what's in the container
108 easy to store container
109 efficient use of space
110 easy to use in a car

199 separates food from coolant
200 separate wet items from dry
201 shock proof
202 shape doesn't waste space
203 stable shelf/work area
204 size adjusts to the amount of food
205 structurally rigid
206 store other things in container when not in u
207 temperature is controllable
208 suitable for year-round use
209 useful for romantic picnics
210 two persons can carry the container together
211 useful on a car trip
212 useful on a boat
213 uses a convenient cooling mechanism
214 useful on bike ride
215 utensils stored separately
216 uses something other than ice to cool
217 won't flip over during transport
218 waterproof
219 can get a good grip on container
220 won't slide during transport

APPENDIX 5.4. DATA MATRIX: ATTRIBUTES IDENTIFIED BY RESPONDENTS

	Respondent																													
ATTRIBUT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
lets me carry drinks	1	0	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0
keeps food cold all day	1	1	0	1	1	1	1	1	0	1	0	1	1	0	1	1	0	1	1	1	1	1	1	1	0	0	0	1	1	0
keeps food cold	1	0	1	1	1	1	1	0	0	0	1	1	0	1	1	1	0	1	1	1	1	0	1	1	1	0	1	1	0	1
lets me carry fruit	1	1	0	1	1	1	0	0	0	0	1	1	1	0	0	0	1	1	0	1	1	1	1	0	1	1	1	1	1	1
CONTAINER SEPARATES THINGS	1	0	1	0	0	1	1	0	0	0	0	1	0	1	0	1	0	1	1	0	1	1	1	1	0	0	1	1	0	1
prevent food from being crushed	1	1	1	1	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	1	1	1	1	1	0	0	1
lightweight	1	0	1	1	0	1	1	0	0	0	0	0	1	1	1	1	0	0	1	0	1	0	1	0	1	1	0	1	0	0
keeps warm food warm	0	1	0	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	1	1
CONTAINER DOESN'T LEAK	1	0	1	0	1	0	1	0	0	0	1	1	1	0	0	0	0	0	0	1	1	0	1	1	0	0	1	0	1	0
lets me carry cheese	1	1	0	1	0	1	0	0	0	1	0	1	0	0	1	0	0	0	1	1	1	0	1	1	0	0	0	0	0	1
easy to carry	1	1	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	1	1	1	1	0	1	1	0	0	1
lets me carry a thermos	1	1	0	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0	1	0	0	1	1	1	1	1	0	1	0	0
container is very well insulated	0	1	0	1	0	0	0	0	1	0	0	0	1	1	0	0	1	0	1	1	1	1	1	0	1	0	0	1	0	0
REASONABLY PRICED	0	1	0	1	1	0	1	0	0	0	1	0	1	0	0	0	0	1	1	0	1	0	1	0	1	1	0	0	0	0
lets me carry chips & crackers	0	1	0	0	1	1	0	1	0	1	1	1	0	0	1	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0
lets me carry sandwiches	1	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	1	1	0	1	0	1	1	0	1	0	1	0	0
easy to dispose of	0	0	1	0	0	0	0	0	1	0	1	0	1	1	0	0	1	0	1	0	1	0	0	1	1	1	0	1	0	0
CONVENIENT	0	0	0	0	0	1	0	1	1	0	1	1	0	1	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	1
CONTAINER IS ORGANIZED, NEAT	1	1	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	1
prevent food from spoiling	0	0	1	0	1	0	1	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	1	0	0	1	0	1	0
container keeps some items dry	1	0	0	0	0	1	1	0	0	1	1	0	1	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	1	0
fits on the floor of a car's back se	0	0	0	0	1	0	1	0	1	1	1	0	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0
cooling material doesn't soak food	0	0	0	1	0	1	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	1	1	0
can carry container without using my	1	1	0	1	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0
lets me carry bread	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	1	1	1	0	0	1	0	0	1
ATTRACTIVE, GOOD LOOKING CONTAINER	0	0	0	0	1	0	0	0	0	1	0	0	1	1	1	0	1	0	1	0	0	0	1	0	0	0	0	1	0	0
contuiner opens easily	0	0	0	0	1	0	1	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	1	0
container is compact	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	1	0	0
size adjusts to the amount of food	1	0	0	0	0	1	1	1	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0
carrying mechanisms don't break	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0	0	1	0	1	0	0	0	0
separate wet items from dry	1	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0	0
CONTAINER IS DURABLE	0	1	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	0
EVERYTHING FITS IN ONE CONTAINER	0	0	0	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
prevent mess inside	1	1	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0
useful on a car trip	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	1	0	0	0	0	1	1	1	0	1	0	0	0	0
keeps different things at different	0	0	0	0	0	1	0	0	0	1	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1
not clumsy to carry	1	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1
lets me carry rice balls	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	1	1	0	1	0
can find things easily	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
keeps food from getting soggy	0	1	0	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1
WORKS WELL AS A CONTAINER	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	1	0	0
EASY TO DRAIN OUT EXCESS WATER	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0
USES A CONVENIENT COOLING MECHANISM	0	0	0	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
accomodates leakproof storage contai	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	0
self-contained: glasses, cups, plate	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	1	0	1	0	1	0	0	0	0	0	0	1

APPENDIX 5.4. (Continued)

ATTRIBUT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
minimal external space taken up	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	1	0	0	0	1	0	0
food is balanced for carrying	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0	1	1	0	0
lets me carry paper goods (plates, c	1	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0
fits in a car trunk	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	1	0	1	0
lets me carry cans	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	1	1
coolant lasts a long time	0	0	0	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0
lets me carry wine bottles	1	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
lid is leak-proof	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0
no loose ice inside container	0	1	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1
protection for glass/breakables	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0
MAINTAINS FOOD TEMPERATURES	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
RIGHT SIZE	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	1	0	0
CONTAINER SERVES MULTIPLE PURPOSES	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
shape doesn't waste space	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
lets me carry ice for drinks	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0
objects don't rattle around	1	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
won't slide during transport	0	0	0	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
container can be carried several way	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0
lets me get at frequently used stuff	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
container doesn't break when dropped	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
can use the container as a table	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
can sit on the container	0	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
structurally rigid	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
container is waterproof	0	0	0	1	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
lets me carry salads	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	1	0	0	0	0
waterproof	0	0	0	1	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
flexible construction	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0
coolant is not messy	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0
contqiner closes easily	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0
EFFICIENT USE OF SPACE	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LETS ME CARRY FOOD ITEMS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	1	0	0	0	0	0	0
good price for the performance	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	1	0	0
lid stays closed when container fell	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
can carry container at my side	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
easy to get things out	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
lid locks shut	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
utensils stored seperately	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
useful on a boat	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
separates food from coolant	0	0	0	1	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
prevent liquid from spilling	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
contains a cooling mechanism	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
access to all food without unpacking	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
carryable with one hand	1	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
can carry container like a shoulder	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0
contains a food heating capability	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0

APPENDIX 5.4. (Continued)

ATTRIBUT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
container is rugged	0	1	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
does not bang into you when carried	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
easy for children to use	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
lets me carry glass items	0	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
can carry container on my back	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0
CONVENIENT TO CARRY	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0
EASY TO USE	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0
LETS ME CARRY NON-FOOD ITEMS	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
CONTAINER PROTECTS THINGS	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
LID WORKS WELL	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
minimum room taken by insulation	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
contemporary design	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
compresses for storage	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
can use container for more than 4 ye	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
keeps food warm for 2 or 3 hours	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
container doesn't dent	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
segregates warm food from cold food	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
uses something other than ice to coo	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
keeps food from tasting different	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
store other things in container when	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
flexible design	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0
easy to clean	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
lets me carry a tablecloth	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
container is stackable	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
keeps cold air in when open	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
can get a good grip on container	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
lid remains attached to cooler when	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
can get in and out quickly	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0
can use ice cubes as coolant	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
can be packed quickly	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
remove things without disturbing rem	0	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can close container with one hand	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
won't flip over during transport	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
container stays clean looking	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1
container keeps sand out	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
doesn't let me forget items	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
EASILY MOVABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0
CARRIES MANY KINDS OF THINGS	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EASY TO TRANSPORT	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
container doesn't slip around	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
easy to tell what's in the container	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
can store container in kitchen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0
cools effectively	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can use a packaged coolant	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0
useful at the beach	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

APPENDIX 5.4. (Continued)

ATTRIBUT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
option to get into one section at a	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
can be attached to vehicles	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
container keeps hot liquids from lea	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
easy to handle in the car	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
comfortable to carry	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
drain cap/plug can't get lost	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
don't have to refreeze coolant every	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
easy access with one hand	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
multiple entries into container	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
container has place to set drinks	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
keeps bottles from touching one anot	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
container is not easily punctured	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
carryable by one person for 15 minut	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
right size for sitting on	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
fits on a car's front seat	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
cooling material takes up a minimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
useful for camping	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0
container stores compactly	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
cool air stays inside container	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
cooling material is cheap	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SUITABLE FOR YEAR-ROUND USE	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPERATURE IS CONTROLLABLE	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
USEFUL FOR TRAVELING	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
container expands	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
easy to store container	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
container does not sweat	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can carry container in front of me	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
uses an available cooling mechanism	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
one or two persons can carry	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
lets me carry salt/pepper	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can use dry ice as a coolant	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
adjust size of hot and cold sections	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
natural looking	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
bumping into the container doesn't h	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
has a workspace to prepare food	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
container doesn't snag on things	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
lets me carry real silverware	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
even temperature kept throughout eac	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
can't lose any container pieces	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can use during a football game	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
means of carrying moves out of way	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
big enough to carry food for four pe	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
carries 12-24 drink cans	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
lasts over 10 years	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
carries at least 6 drink cans	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX 5.4. (Continued)

ATTRIBUT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
shock proof	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lid locks open	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can add coolant witho"t repacking fo	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
drain out water without tilting cont	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
comfortable in my hand	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
protect fragile foods	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
useful for romantic picnics	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
carrying mechanisms are rigid	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
adapts to what I'm taking	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
excess water drains out qickly	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
two persons can carry the container	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
lets me carry ice cream home from th	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
container has no sharp edges	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
keeps odors in; contains smells	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
accomodates tall glasses	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
container folds up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
container molds to leg when carried	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
reusable coolant	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
ELEGANT DESIGN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
CONTAINER DOESN'T CAUSE PROBLEMS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
ice storage space	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
stable shelf/work area	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
adjustable in size	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
see everything at once	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
holds an umbrella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
keeps hot stuff where kids can't get	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
fits into almost any space	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
keeps food off the ground	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can carry container in hand or over	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
drain mechanism doesn't clog	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
container needs no maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
hands don't get cold looking for ite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
add additional coolant quickly	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
has external storage areas	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
carries tupperware efficiently	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
container needs no preparation befor	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
easy to use in a car	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lets me carry plates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can warm drinks up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
leak-proof section for non-food item	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
doesn't squeak when it rubs	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
resistant to dry ice temperatures	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can move container without carrying	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can pick my container out in a crowd	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
coolant is not in the way	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX 5.4. (Continued)

ATTRIBUT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
cools foods fast	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can be put inside a back pack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
hides beer at prohibited area	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
minimum effort to move container	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
useful on bike ride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
carryable by a 7-year old	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
lid can't be lost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
means for carrying doesn't interfere	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
made of non-toxic materials	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
inexpensive over the long run	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
matching utensils/cups/etc.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

APPENDIX 5.5. DATA MATRIX: IMPORTANT ATTRIBUTES IDENTIFIED BY RESPONDENTS

Respondent

ATTRIBUTE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	**	18	19	20	21	22	23	24	25	26	27	28	29	30
lets me carry drinks	1	0	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0
lets me carry fruit	1	1	0	1	1	1	0	0	0	0	1	1	1	0	0	0	1	1	0	1	1	1	1	0	1	1	1	1	1	1
CONTAINER SEPARATES THINGS	1	0	1	0	0	1	1	0	0	0	0	1	0	1	0	1	0	1	1	0	1	1	1	1	0	0	1	1	0	1
prevent food from being crushed	1	1	1	1	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	1	1	1	1	1	0	0	1
lightweight	1	0	1	1	0	1	1	0	0	0	0	0	1	1	1	1	0	0	1	0	1	0	1	0	1	1	0	1	0	0
CONTAINER DOESN'T LEAK	1	0	1	0	1	0	1	0	0	0	1	1	1	0	0	0	0	0	0	1	1	0	1	1	0	0	1	0	1	0
easy to carry	1	1	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	1	1	1	1	0	1	1	0	0	1
lets me carry a thermos	1	1	0	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0	1	0	0	1	1	1	1	1	0	1	0	0
lets me carry chips & crackers	0	1	0	0	1	1	0	1	0	1	1	1	0	0	1	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0
lets me carry sandwiches	1	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	1	1	0	1	0	1	1	0	1	0	1	0	0
easy to dispose of	0	0	1	0	0	0	0	0	1	0	1	0	1	1	0	0	1	0	1	0	1	0	0	1	1	1	0	1	0	0
CONVENIENT	0	0	0	0	0	1	0	1	1	0	1	1	0	1	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	1
CONTAINER IS ORGANIZED, NEAT	1	1	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	1
prevent food from spoiling	0	0	1	0	1	0	1	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	1	0	0	1	0	1	0
container keeps some items dry	1	0	0	0	0	1	1	0	0	1	1	0	1	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	1	0
fits on the floor of a car's back se	0	0	0	0	1	0	1	0	1	1	1	0	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0
cooling material doesn't soak food	0	0	0	1	0	1	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	1	1	0
can carry container without using my	1	1	0	1	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0
lets me carry bread	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	1	1	1	0	0	1	0	0	1
ATTRACTIVE, GOOD LOOKING CONTAINER	0	0	0	0	1	0	0	0	0	1	0	0	1	1	1	0	1	0	1	0	0	0	1	0	0	0	0	1	0	0
container opens easily	0	0	0	0	1	0	1	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	1	0
container is compact	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	1	0	0
size adjusts to the amount of food	1	0	0	0	0	1	1	1	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0
carrying mechanisms don't break	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0	0	1	0	1	0	0	0	0
separate wet items from dry	1	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0	0
EVERYTHING FITS IN ONE CONTAINER	0	0	0	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
prevent mess inside	1	1	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0
useful on a car trip	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	1	0	0	0	0	1	1	1	0	1	0	0	0	0
not clumsy to carry	1	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1
can find things easily	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
keeps food from getting soggy	0	1	0	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1
WORKS WELL AS A CONTAINER	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	1	0	0
EASY TO DRAIN OUT EXCESS WATER	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0
USES A CONVENIENT COOLING MECHANISM	0	0	0	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
accomodates leakproof storage contai	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	0
minimal external space taken up	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	1	0	0	0	1	0	0
food is balanced for carrying	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0	1	1	0	0
fits in a car trunk	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	1	0	1	0
lets me carry cans	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	1	1
lid is leak-proof	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0
protection for glass/breakables	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0
MAINTAINS FOOD TEMPERATURES	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
RIGHT SIZE	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	1	0	0
CONTAINER SERVES MULTIPLE PURPOSES	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
shape doesn't waste space	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
lets me carry ice for drinks	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0

ATTRIBUTE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	**	18	19	20	21	22	23	24	25	26	27	28	29	30
objects don't rattle around	1	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
won't slide during transport	0	0	0	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
container can be carried several way	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0
can use the container as a table	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
can sit on the container	0	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
container is waterproof	0	0	0	1	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
lets me carry salads	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	1	0	0	0	0
waterproof	0	0	0	1	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
flexible construction	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0
coolant is not messy	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0
container closes easily	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0
EFFICIENT USE OF SPACE	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LETS ME CARRY FOOD ITEMS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	1	0	0	0	0	0	0
lid stays closed when container fell	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
can carry container at my side	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
easy to get things out	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
lid locks shut	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
prevent liquid from spilling	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
access to all food without unpacking	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
carryable with one hand	1	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
can carry container like a shoulder	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0
does not bang into you when carried	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
can carry container on my back	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0
CONVENIENT TO CARRY	0	0	0	1	0	0	0	0	C	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0
EASY TO USE	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0
LETS ME CARRY NON-FOOD ITEMS	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
CONTAINER PROTECTS THINGS	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
LID WORKS WELL	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
minimum room taken by insulation	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
compresses for storage	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
keeps food from tasting different	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
store other things in container when	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
flexible design	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0
easy to clean	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
container is stackable	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
can get a good grip on container	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
lid remains attached to cooler when	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
can get in and out quickly	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0
can use ice cubes as coolant	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
can be packed quickly	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
remove things without disturbing rem	0	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can close container with one hand	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
won't flip over during transport	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
container keeps sand out	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
EASILY MOVABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0
CARRIES MANY KINDS OF THINGS	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ATTRIBUTE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		**18	19	20	21	22	23	24	25	26	27	28	29	30
EASY TO TRANSPORT	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
container doesn't slip around	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
easy to tell what's in the container	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
can store container in kitchen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0
can use a packaged coolant	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0
container keeps hot liquids from lea	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
easy to handle in the car	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
comfortable to carry	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
drain cap/plug can't get lost	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
easy access with one hand	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
container has place to set drinks	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
carryable by one person for 15 minut	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
right size for sitting on	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
fits on a car's front seat	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
cooling material takes up a minimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
container stores compactly	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
cooling material is cheap	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SUITABLE FOR YEAR-ROUND USE	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
USEFUL FOR TRAVELING	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
easy to store container	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
container does not sweat	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can carry container in front of me	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
one or two persons can carry	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
can use dry ice as a coolant	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
has a workspace to prepare food	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can't lose any container pieces	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
means of carry'ng moves out of way	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
big enough arry food for four pe	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
carries at least 6 drink cans	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lid locks open	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can add coolant without repacking fo	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
drain out water without tilting cont	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
comfortable in my hand	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
protect fragile foods	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
useful for romantic picnics	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
carrying mechanisms are rigid	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
adapts to what I'm taking	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
excess water drains out qickly	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
two persons can carry the container	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
container folds up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
reusable coolant	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
stable shelf/work area	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
adjustable in size	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
fits into almost any space	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
keeps food off the ground	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can carry container in hand or over	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX 5.5. (Continued)

ATTRIBUTE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	**	18	19	20	21	22	23	24	25	26	27	28	29	30
drain mechanism doesn't clog	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
add additional coolant quickly	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
has external storage areas	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
carries tupperware efficiently	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
container needs no preparation befor	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
easy to use in a car	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
leak-proof section for non-food item	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
coolant is not in the way	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
can be put inside a back pack	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
minimum effort to move container	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
lid can't be lost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
means for carrying doesn't interfere	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

APPENDIX 6.1. AFFINITY HIERARCHY OF CUSTOMER ATTRIBUTES

CUSTOMER ATTRIBUTES
PICNIC BASKETS

LEVEL	ATT NUM	
1	221	CONTAINER UTILITY
2	76	container serves multiple purposes
3	25	can sit on the container
3	34	can use the container as a table
3	57	container has place to set drinks
3	123	has a workspace to prepare food
3	138	keeps food off the ground
3	203	stable shelf/work area
3	206	store other things in container when not in use
2	208	suitable for year-round use
3	11	can be attached to vehicles
3	32	can use during a football game
3	110	easy to use in a car
3	209	useful on romantic picnics
3	212	useful on a boat
3	211	useful on a car trip
3	214	useful on bike ride

APPENDIX 6.1. (Continued)

1	82	**CONVENIENT**
2	222	access to the container
3	223	container closes
4	47	container closes easily
4	168	lid locks shut
4	167	lid stays closed when container falls over
3	224	container opens
4	74	container opens easily
4	163	lid locks open
4	165	lid remains attached to cooler when open
4	178	multiple entries into container
3	225	container seals
4	67	container keeps sand out
4	139	keeps odors in; contains smells
2	61	container is organized, neat
3	91	doesn't let me forget items
4	33	can't lose any container pieces
4	96	drain cap/plug can't get lost
4	164	lid can't be lost
3	106	easy to get things out
4	2	access to all food without unpacking
4	14	can be packed quickly
4	22	can close container with one hand
4	24	can get in and out quickly
4	100	easy access with one hand
4	99	easy for children to use
4	105	easy to handle in the car
4	184	option to get into one section at a time
4	192	remove things without disturbing remainder
3	226	find things fast
4	21	can find things easily
4	107	easy to tell what's in the container
4	124	hands don't get cold looking for items
4	195	see everything at once
3	119	flexible design, configuration changes
4	4	accomodates tall glasses
4	5	adjust size of hot and cold sections
4	37	carries tupperware efficiently
4	109	efficient use of space
4	122	food is balanced for carrying
3	188	prevent mess inside
4	140	keeps hot stuff where kids can't get it
5	1	accomodates leakproof storage container
5	126	has external storage areas
5	135	keeps food from tasting different
5	199	separates food from coolant
5	215	utensils stored separately
4	200	separate wet items from dry
5	68	container keeps hot liquids from leakin

APPENDIX 6.1. (Continued)

5	70	container keeps some items dry
5	136	keeps food from getting soggy
5	185	prevent liquid from spilling
4	182	objects don't rattle around
5	129	keeps bottles from touching one another
2	97	easily movable
3	23	can move container without carrying it
3	48	container can be carried several ways
4	19	can carry container without using my hands
5	18	can carry container in hand or over sho
5	17	can carry container like a shoulder bag
5	20	can carry container on my back
4	42	carryable with one hand
5	16	can carry container at my side
4	227	carryable with two hands
5	15	can carry container in front of me
5	181	one or two persons can carry
5	210	two persons can carry the container tog
3	102	easy to carry
4	9	bumping into the container doesn't hurt
4	219	can get a good grip on container
4	40	carryable by a 7-year old
4	39	carryable by one person for 15 minutes
4	43	comfortable in my hand
4	46	comfortable to carry
4	53	container doesn't snag on things
4	58	container has no sharp edges
4	81	convenient to carry
4	92	does not bang into you when carried
4	170	lightweight
4	171	means for carrying doesn't interfere with lo
4	174	means of carrying moves out of way
4	176	minimum effort to move container
4	179	not clumsy to carry
4	217	won't flip over during transport
2	228	easy to keep between uses
3	63	container is stackable
3	72	container needs no maintenance
3	71	container needs no preparation before use
3	101	easy to clean
3	104	easy to dispose of
3	108	easy to store container
2	114	everything fits in one container
3	229	carries food items
4	230	lets me carry cooled dry food items
5	145	lets me carry bread
5	157	lets me carry rice balls
5	160	lets me carry salads
5	162	lets me carry sandwiches

5	149	lets me carry fruit
4	231	lets me carry frozen foods
5	151	lets me carry ice cream home from the s
4	232	lets me carry non-perishable items
5	147	lets me carry chips & crackers
5	159	lets me carry salt/pepper
3	233	external container dimensions
4	8	adjustable in size
5	45	compresses for storage
5	56	container expands
5	78	container stores compactly
5	55	container folds up
5	3	adapts to what I'm taking
5	204	size adjusts to the amount of food
4	115	fits into almost any space
5	13	can be put inside a back pack
5	28	can store container in kitchen
5	116	fits in a car trunk
5	118	fits on a car's front seat
5	117	fits on the floor of a car's back seat
4	173	minimal external space taken up
5	60	container is compact
5	175	minimum room taken by insulation
5	202	shape doesn't waste space
4	193	right size
5	10	big enough to carry food for four peopl
5	38	carries at least 6 drink cans
5	35	carries 12-24 drink cans
5	196	right size for sitting on
3	234	lets me carry liquids
4	125	hides beer at prohibited area
4	148	lets me carry cans
4	150	lets me carry drinks
4	154	lets me carry ice for drinks
4	161	lets me carry wine bottles
3	153	lets me carry non-food items
4	235	lets me carry tableware
5	143	lets me carry a tablecloth
5	152	lets me carry glass items
5	156	lets me carry paper goods (plates, cups
5	155	lets me carry plates
5	158	lets me carry real silverware
5	197	self-contained; glasses, cups, plates,
4	236	holds miscellaneous items
5	128	holds an umbrella
5	144	leak-proof section for non-food items (
5	146	lets me carry a thermos

APPENDIX 6.1. (Continued)

1	237	PHYSICAL CHARACTERISTICS
2	7	attractive, good looking container
3	238	appearance is pleasing
4	75	container stays clean looking
4	172	matching utensils/cups/etc.
3	239	style
4	26	can pick my container out in a crowd
4	79	contemporary design
4	112	elegant design
4	177	natural looking
2	51	container doesn't leak
3	166	lid is leak-proof
2	59	container is durable
3	30	can use container for more than 4 years
3	141	lasts over 10 years
2	64	container is rugged
3	41	carrying mechanisms are rigid
3	49	container doesn't break when dropped
3	44	carrying mechanisms don't break
3	52	container doesn't dent
3	62	container is not easily punctured
3	191	resistant to dry ice temperatures
3	210	shock proof
3	205	structurally rigid
2	240	container movement
3	54	container doesn't slip around
3	94	doesn't squeak when it rubs
3	220	won't slide during transport
2	103	easy to drain out excess water
3	95	drain mechanism doesn't clog
3	98	drain out water without tilting container
3	113	excess water drains out qickly
2	120	flexible construction, moldable
3	69	container molds to leg when carried
2	169	made of non-toxic materials
2	73	container protects things
3	183	prevent food from being crushed
3	187	protect fragile foods
3	190	protection for glass/breakables
2	218	waterproof
3	65	container is waterproof

APPENDIX 6.1. (Continued)

1	241	CONTAINER PRICE
2	88	cooling material is cheap
2	121	good price for the performance
2	130	inexpensive over the long run
2	189	reasonably priced

1	242	THERMAL CHARACTERISTICS
2	77	contains a cooling mechanism
3	243	types of coolant
4	27	can use a packaged coolant
4	29	can use dry ice as a coolant
4	31	can use ice cubes as coolant
4	127	ice storage space
4	194	reusable coolant
4	216	uses something other than ice to cool
3	213	uses a convenient cooling mechanism
4	86	coolant is not messy
5	85	cooling material doesn't soak food
5	180	no loose ice inside container
4	90	cools effectively
5	83	coolant is not in the way
5	87	cooling material takes up a minimum of
5	93	don't have to refreeze coolant every ni
4	244	quickly work with coolant
5	6	add additional coolant quickly
5	12	can add coolant without repacking food
2	245	maintains desired temperature
3	50	container does not sweat
3	66	container is very well insulated
3	132	keeps cold air in when open
3	134	keeps food cold
3	133	keeps food cold all day
3	137	keeps food warm for 2 or 3 hours
3	142	keeps warm food warm
3	186	prevent food from spoiling
2	246	maintains multiple temperatures
3	131	keeps different things at different temperatures
3	198	segregates warm food from cold food
2	247	temperature is regulated
3	33	can warm drinks up
3	80	contains a food heating capability
3	84	cool air stays inside container
3	89	cools foods fast
3	111	even temperature kept throughout each compartment
3	207	temperature is controllable

APPENDIX 6.2. CUSTOMER SORT TASK PRESCREENING PROTOCOL

Have you transported food for 3 or 4 people from one place to another for eating later in the day in the last 12 months?

IF NO: Thank you very much for your time. (Terminate interview)

IF YES: Has anyone interviewed you recently about what is important to you when you are transporting food from one place to another?

IF YES: Thank you very much for your time. (Terminate interview)

IF NO: Would you be willing to take 20 minutes of your time to help us understand how people talk about things which transport food from one place to another?

IF NO: Thank you very much for your time. (Terminate interview)

IF YES: Could you please tell me your age? ______
What do you normally use to transport food from one place to another?

Make __________

Brand __________

Approximate Size __________

Administer sorting task. Go to next sheet of instructions.

RESPONDENT INFORMATION SHEET

Age: __________

Sex: __________

Marital Status: __________

Number of Children: __________

Frequency you transport food: __________ per week

__________ per month

__________ per year

APPENDIX 6.2. CUSTOMR SORT TASK INSTRUCTIONS TO RESPONDENTS

We've asked you today to help us understand more about how people talk about transporting food from one place to another. We'd like you to tell us about some of the words the people use to describe moving food from one place to another.

Here's how we'd like to do this interview. We have collected a number of words and phrases from other people who have transported food from one place to another and put them on these cards (show example). We would like you to go through the stack of cards and sort them into piles.

You decide which card goes into which pile. You also decide how many piles to make.

The way to decide whether a card goes into a pile or not is to ask yourself whether the word on the card "fits with" or "is similar to" the words on the other cards already in the pile.

What do we mean by "fits with" or "is similar to"? Each of the words or phrases has something to do with the container that food might be moved from one place to another in, or how food might be transported from one place to another. For example, if the words described aspects of apples, the words "tastes kind of sweet" and "is crunchy" might go together because they have to do with eating, whereas the words "has vitamins" and "has fiber" might go together because they have to do with nutrition.

Because you decide which word goes with which, there is no such thing as a right or wrong answer. All we're interested in is your opinion. The piles, however, should not be divided into those statements you agree with those you disagree with.

How many piles should you make? Again, that's up to you. As you're going along, you may find that you want to split up a pile...that's fine. Or, you might want to put two piles together...that's okay too.

Once you're satisfied with the groups the cards are sorted into, please go through each pile and pick out the best representative of each pile. By "best" we mean the word that best describes the pile as a whole. Please put that card on the top of its pile.

As you go through the cards, if you have any questions, be sure to ask. When you get all the cards sorted, please leave them in piles and let me know so we can record your sorting.

To summarize, you form piles of cards that fit with or go with the other cards in the pile. When you have divided the cards into the piles you want, pick the best example from each pile and put it on the top of each pile.

APPENDIX 6.2. CUSTOMER SORT TASK DATA CODING SHEET

Pile #	Top Card	REMAINING CARDS										
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												

APPENDIX 6.3. AGGREGATE SIMILARITY MATRIX

The aggregate data matrix is too large to fit all onto one page. The next 16 pages present the matrix in bolcks corresponding to the schedule below:

Block # for the pages of the matrix:

Attribute #'s	1-40	41-92	93-144	145-195	197-220
1-46	1	6	-	-	-
47-94	2	7	-	-	-
95-142	3	8	11	-	-
143-190	4	9	12	14	-
191-200	5	10	13	15	16

APPENDIX 6.3. (Continued)

BLOCK 1

CUSTOMER ATTRIBUTES: FOOD CONTAINERS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1 accomodates leakproof storage containers																																								
2 access to all food without unpacking	7																																							
3 adapts to what I'm taking	6	7																																						
4 accomodates tall glasses	14	5	9																																					
5 adjust size of hot and cold sections	8	8	18	10																																				
6 add additional coolant quickly	6	12	2	0	1																																			
7 attractive, good looking container	0	0	5	1	1	0																																		
8 adjustable in size	0	4	51	9	18	1	2																																	
9 bumping into the container doesn't h	5	4	5	1	0	2	6	4																																
10 big enough to carry food for four pe	8	4	21	17	17	0	1	25	2																															
11 can be attached to vehicles	1	2	7	1	1	0	0	12	7	7																														
12 can add coolant without repacking fo	5	15	2	6	5	59	1	1	2	0	0																													
13 can be put inside a back pack	2	2	10	2	5	0	0	17	7	16	22	0																												
14 can be packed quickly	4	51	7	4	5	14	4	4	4	2	2	14	2																											
15 can carry container in front of me	2	1	1	0	0	0	0	5	12	2	17	0	16	1																										
16 can carry container at my side	2	1	1	0	0	0	0	5	15	5	17	0	18	1	56																									
17 can carry container like a shoulder	0	0	2	1	0	0	1	5	12	5	16	0	15	0	52	52																								
18 can carry container in hand or over	1	1	1	0	0	1	0	5	12	4	16	0	17	0	55	56	53																							
19 can carry container without using my	1	5	1	0	1	1	0	5	12	2	17	1	16	2	53	53	51	51																						
20 can carry container on my back	1	1	1	0	0	0	1	5	12	5	17	0	17	1	56	58	52	54	54																					
21 can find things easily	5	45	8	4	8	12	1	6	2	4	5	14	5	56	1	1	1	1	4	1																				
22 can close container with one hand	4	10	5	0	0	5	0	5	4	5	5	5	4	19	7	7	5	6	6	7	15																			
23 can move container without carrying	1	2	5	1	0	1	2	5	12	2	19	0	15	2	46	46	46	44	50	46	5	6																		
24 can get in and out quickly	4	41	6	5	7	11	0	5	5	2	5	15	2	59	1	2	0	1	4	1	45	20	2																	
25 can sit on the container	5	1	7	5	4	0	5	4	7	6	7	1	6	2	2	5	2	2	2	2	5	5	2	1																
26 can pick my container out in a crowd	2	2	4	1	5	1	26	6	2	7	7	2	12	6	10	10	7	8	9	10	2	2	9	2	5															
27 can use a packaged coolant	5	0	0	4	5	55	2	0	0	1	1	54	1	0	1	1	1	1	1	1	0	1	1	0	0	0														
28 can store container in kitchen	0	1	15	5	7	1	0	20	2	20	12	2	18	5	1	2	1	2	1	2	2	5	2	2	6	6	1													
29 can use dry ice as a coolant	5	1	0	4	5	51	0	0	0	0	0	55	0	1	0	0	0	0	0	0	1	0	0	1	0	0	51	2												
30 can use container for more than 4 ye	2	1	5	1	1	0	2	1	15	2	1	0	1	2	0	0	0	0	0	0	2	2	1	2	7	1	0	2	0											
31 can use ice cubes as coolant	6	2	1	4	5	50	0	0	0	0	0	51	1	2	0	0	0	0	0	0	2	1	0	2	1	0	50	1	51	0										
32 can use during a football game	4	5	6	5	1	5	5	4	4	7	9	5	8	7	1	1	1	1	1	1	5	5	1	4	8	6	1	8	2	2	1									
33 can ware drinks up	4	0	0	1	15	6	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	10	0	9	2								
34 can use the container as a table	1	5	[illegible]	8	7	0	4	4	4	6	4	2	4	5	1	2	2	1	2	1	5	5	2	4	47	4	0	5	0	4	1	8	0							
35 carries 12-24 drink cans	14	2	14	50	10	1	0	11	0	27	5	0	9	1	1	2	1	2	1	2	2	0	1	2	4	4	1	7	0	1	0	9	4	6						
36 can't lose any container pieces	8	6	2	2	5	5	4	2	10	4	4	2	1	7	1	2	1	1	1	1	5	9	5	6	15	4	0	4	0	11	0	4	0	7	7					
37 carries tupperware efficiently	18	12	8	24	10	1	0	5	1	11	4	1	1	7	2	2	1	1	5	2	10	2	5	7	6	1	0	5	0	1	0	5	1	8	21	4				
38 carries at least 6 drink cans	14	2	11	51	11	1	0	12	0	27	0	0	5	1	0	1	0	1	0	1	1	0	0	2	4	4	0	7	0	1	0	7	4	7	51	2	20			
39 carryable by one person for 15 minut	1	1	1	0	0	0	1	5	12	2	16	0	14	1	50	50	47	46	51	51	1	6	42	1	2	7	1	1	0	0	0	1	0	1	1	1	2	0		
40 carryable by a 7-year old	0	2	1	0	0	1	0	2	15	2	9	0	7	2	55	54	54	55	55	54	1	5	50	2	2	1	0	2	0	10	0	1	0	1	0	0	1	0	56	
41 carrying mechanisms are rigid	0	0	1	0	0	0	0	2	18	4	14	0	8	0	26	26	27	25	27	25	0	9	22	0	9	2	1	2	0	8	0	5	0	6	0	8	2	0	27	25
42 carryable with one hand	0	0	1	0	0	0	1	5	12	5	16	0	15	0	52	54	52	54	50	55	0	7	41	0	2	6	2	2	0	0	0	1	0	1	[illegible]	1	1	2	49	54
43 comfortable in my hand	0	1	1	0	0	1	2	2	14	5	14	0	15	1	45	44	48	46	46	45	1	6	40	1	2	6	2	1	0	0	0	1	0	1	1	1	1	0	45	54
44 carrying mechanisms don't break	5	0	0	5	0	0	1	2	21	2	9	0	7	0	15	16	16	15	16	17	0	1	15	0	6	2	0	2	0	20	0	1	0	5	0	8	1	0	18	16
45 compresses for storage	0	2	20	5	11	1	2	29	5	17	9	1	16	2	1	1	1	1	2	1	5	2	2	2	5	2	1	58	1	5	1	6	0	5	7	2	4	6	1	1
46 comfortable to carry	0	0	1	0	0	0	0	2	12	5	15	0	14	0	50	49	51	50	47	49	0	7	41	0	5	5	2	1	0	1	0	1	0	1	1	2	1	0	45	55

APPENDIX 6.3. (Continued) BLOCK 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
47 container closes easily	6	12	2	0	1	7	1	2	5	2	5	4	4	21	5	5	2	3	4	5	15	48	4	22	5	5	1	5	0	2	1	2	0	2	0	12	2	0	5	2
48 container can be carried several way	1	1	2	0	0	0	2	5	11	5	16	0	15	1	53	55	50	51	51	56	1	8	40	1	5	8	1	5	0	0	0	1	0	5	7	1	2	1	49	52
49 container doesn't break when dropped	1	2	2	1	2	1	4	2	22	5	4	0	5	2	2	2	2	2	5	2	2	5	5	2	10	5	0	5	0	56	1	5	0	7	0	15	1	0	2	11
50 container does not sweat	5	4	2	1	5	4	4	5	6	5	5	4	2	5	1	1	1	1	1	1	5	5	2	5	2	10	2	5	2	8	2	6	2	4	0	8	4	2	1	5
51 container doesn't leak	22	5	2	1	1	5	1	5	6	2	5	5	5	5	2	2	5	2	2	2	5	2	5	4	2	2	5	2	5	6	7	1	5	1	0	4	1	0	2	2
52 container doesn't dent	0	2	5	1	2	0	7	4	18	4	5	0	2	6	1	1	2	1	1	1	2	5	5	2	7	9	0	4	0	54	0	4	0	4	0	12	1	1	1	9
53 container doesn't snag on things	2	5	5	2	4	2	7	4	25	4	6	2	5	5	9	8	10	8	10	8	5	2	9	5	5	5	1	5	1	8	2	6	0	5	2	10	5	2	8	11
54 container doesn't slip around	5	5	4	0	4	2	7	7	14	4	25	5	10	8	20	20	19	19	22	21	5	8	21	6	5	10	1	5	0	4	1	4	0	5	0	8	4	1	19	12
55 container folds up	1	5	18	2	7	0	2	27	5	15	15	0	18	4	7	7	7	7	8	7	4	7	8	2	6	5	1	24	0	4	0	4	0	4	5	5	5	2	7	4
56 container expands	1	4	51	7	20	1	2	47	4	27	7	1	17	5	1	1	1	1	1	1	6	2	1	5	6	5	0	15	0	5	0	6	0	5	10	5	5	11	1	1
57 container has place to set drinks	5	6	7	14	11	2	5	5	2	11	5	2	5	5	0	0	0	0	0	0	4	2	0	5	50	2	0	6	0	4	1	7	5	57	14	6	12	16	0	0
58 container has no sharp edges	0	5	5	1	2	1	17	5	26	5	8	2	5	6	5	5	6	5	5	5	5	5	5	4	5	8	0	5	0	5	0	5	0	5	0	10	1	1	5	7
59 container is durable	2	1	5	0	1	0	5	1	20	2	2	0	2	5	0	1	0	0	0	1	1	5	0	2	10	1	0	4	0	42	0	4	0	6	0	16	1	0	1	8
60 container is compact	0	5	17	4	11	1	2	27	6	25	11	1	24	2	5	7	6	6	6	6	5	4	7	2	10	9	1	25	0	5	0	6	0	10	9	7	5	9	5	5
61 container is organized, neat	4	28	9	5	8	7	5	6	4	5	5	9	4	22	0	0	0	0	0	0	50	5	0	25	5	1	0	5	1	5	5	7	0	5	4	4	15	2	0	2
62 container is not easily punctured	1	2	4	1	2	0	6	4	20	5	2	0	1	6	0	0	0	0	0	1	2	4	1	5	7	5	0	4	0	57	0	1	0	5	1	15	1	5	1	5
63 container is stackable	0	1	15	2	4	1	5	18	4	12	12	1	15	4	6	7	7	6	7	8	2	4	8	1	11	5	1	52	0	5	0	6	0	9	4	7	1	2	8	2
64 container is rugged	0	1	2	2	4	0	9	4	12	5	5	1	2	5	1	1	1	1	2	1	2	2	2	2	7	4	0	5	0	28	0	2	0	8	1	10	5	4	1	9
65 container is waterproof	17	2	5	1	5	2	4	5	4	6	2	1	2	4	1	1	2	1	1	1	2	2	2	2	5	5	5	4	2	6	5	1	5	5	0	4	2	1	1	5
66 container is very well insulated	5	1	0	1	10	10	5	1	2	1	0	10	1	5	0	0	0	0	0	0	1	1	0	1	1	5	15	1	14	2	15	1	21	1	0	4	0	1	0	0
67 container keeps sand out	9	1	2	1	5	2	4	5	4	4	4	2	5	4	5	5	2	5	2	2	1	5	2	4	7	7	0	5	0	2	2	5	2	7	1	7	5	7	2	1
68 container keeps hot liquids from lea	21	0	0	2	5	5	0	1	5	1	2	2	5	0	2	2	2	2	2	2	0	0	2	1	2	0	1	1	1	1	2	1	15	0	7	1	1	2	2	2
69 container molds to leg when carried	0	2	4	1	1	1	0	8	15	4	15	0	15	2	45	45	46	41	44	45	1	7	56	1	5	5	0	5	0	1	0	5	1	5	1	2	4	5	44	51
70 container keeps some items dry	11	6	4	5	4	1	0	1	1	2	0	2	1	5	0	0	1	0	0	0	5	0	1	5	1	0	1	0	1	0	2	1	8	2	5	2	6	5	0	0
71 container needs no preparation befor	2	16	7	5	4	9	1	5	4	2	9	9	5	24	2	2	1	2	5	5	15	11	5	16	4	5	2	4	2	5	5	5	0	2	1	9	5	0	5	1
72 container needs no maintenance	0	5	1	1	0	4	4	5	14	2	2	2	2	8	0	0	1	1	1	0	7	8	4	5	4	1	1	6	0	26	1	5	0	2	0	17	1	0	0	7
73 container protects things	2	5	5	6	4	0	4	2	5	2	2	1	2	5	1	1	0	1	0	0	5	1	1	4	7	2	0	1	1	10	2	1	5	8	1	9	6	1	0	1
74 container opens easily	7	14	4	0	1	9	0	5	5	1	5	6	2	25	4	4	5	4	5	4	17	45	5	24	5	5	1	5	1	5	2	4	1	2	0	11	2	0	4	2
75 container stays clean looking	1	2	5	1	1	1	28	5	6	1	0	2	1	6	0	0	1	0	0	0	1	5	2	2	0	17	1	5	1	7	2	5	0	0	0	2	0	1	0	1
76 container serves multiple purposes	1	4	15	10	7	0	4	9	1	8	4	1	5	4	1	1	2	1	2	1	6	1	2	5	31	4	0	6	0	2	1	11	0	56	10	5	7	9	1	1
77 contains a cooling mechanism	2	0	0	5	7	26	0	0	0	0	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41	0	42	0	39	2	15	0	0	1	0	0	0	0
78 container stores compactly	1	7	16	5	6	0	1	20	4	15	10	4	15	5	1	2	1	1	1	1	7	2	2	7	8	4	0	40	1	4	0	6	0	8	6	7	4	4	1	2
79 contemporary design	0	0	5	1	5	0	52	5	6	5	1	0	0	4	0	0	0	0	0	0	1	0	1	0	2	28	0	5	0	5	0	5	0	5	0	4	1	2	0	0
80 contains a food heating capability	2	1	1	1	14	6	1	0	0	1	0	5	0	0	0	0	0	0	0	0	0	0	0	0	1	1	9	0	11	2	12	1	49	1	0	2	0	0	0	0
81 convenient to carry	1	1	0	1	1	0	0	2	11	4	15	0	15	1	50	50	51	50	52	50	0	5	40	1	2	4	2	1	0	0	0	2	0	1	7	2	2	1	48	55
82 convenient	2	17	9	5	4	10	5	8	7	5	4	8	6	25	4	5	5	4	6	4	20	14	4	21	7	6	1	6	0	8	1	5	0	6	7	8	2	5	5	5
83 coolant is not in the way	5	9	2	4	5	55	2	1	1	2	0	58	1	9	0	0	0	1	1	0	7	2	1	8	0	5	58	2	57	0	36	1	5	1	0	2	1	1	0	1
84 cool air stays inside container	4	0	0	4	7	17	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	1	0	0	29	1	51	0	28	5	22	0	1	1	1	1	0	0
85 cooling material doesn't soak food	6	4	0	5	5	22	0	0	0	1	0	21	1	2	0	0	0	0	0	0	5	1	0	5	0	0	52	1	51	1	55	1	5	1	1	1	4	1	0	0
86 coolant is not messy	4	4	1	5	5	28	1	1	0	0	1	50	0	5	1	1	1	1	1	1	5	2	1	5	0	1	59	1	58	0	58	1	5	1	0	1	2	0	1	1
87 cooling material takes up a minimum	2	2	2	5	6	52	2	4	1	4	1	55	2	5	0	0	0	0	0	0	1	1	1	1	0	2	42	4	40	0	39	1	7	0	0	1	0	1	0	0
88 cooling material is cheap	1	0	0	5	2	21	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	0	50	7	51	0	4	0	0	1	0	0	0	2
89 cools foods fast	5	2	1	4	11	15	1	0	0	1	0	18	0	1	0	0	0	0	0	0	1	0	0	1	1	2	26	0	27	1	26	2	21	1	0	5	0	0	0	0
90 cools effectively	4	1	0	5	7	17	0	0	0	0	0	21	1	1	0	0	0	0	0	0	1	1	0	1	0	0	50	0	50	1	52	1	21	0	0	1	0	0	0	0
91 doesn't let me forget items	2	25	9	5	5	4	4	2	2	4	2	5	2	17	1	1	1	2	2	1	24	6	5	24	6	4	0	2	1	4	1	5	0	8	7	9	9	2	1	5
92 does not bang into you when carried	0	1	1	1	0	1	1	5	14	5	11	1	15	0	42	42	45	40	45	42	1	5	58	1	5	4	0	2	1	0	0	2	0	4	1	4	1	1	41	52
93 don't have to refreeze coolant every	5	2	0	7	5	55	0	0	1	0	0	57	0	2	0	0	0	1	1	0	2	0	1	2	0	2	47	1	44	0	42	1	9	1	0	1	0	0	0	1
94 doesn't squeak when it rubs	2	5	2	2	1	2	7	5	17	5	7	5	4	4	8	8	8	8	8	8	2	7	9	5	7	7	2	5	1	9	1	7	0	7	1	11	5	2	8	8

APPENDIX 6.3. (Continued) BLOCK 3

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
95 drain mechanism doesn't clog	4	6	2	0	1	5	0	2	2	1	1	3	5	6	0	1	1	0	1	1	5	5	1	5	3	1	5	3	3	6	5	2	0	2	0	6	1	0	1	0
96 drain cap/plug can't get lost	2	7	1	0	2	5	4	1	6	1	2	3	5	6	1	2	2	2	4	5	6	6	5	6	2	1	1	3	1	5	3	1	0	2	0	21	2	0	4	1
97 easily movable	0	1	3	0	2	1	2	4	10	4	15	0	12	1	58	57	40	40	41	57	1	5	58	1	4	7	1	2	0	2	0	2	0	2	1	5	0	0	58	29
98 drain out water without tilting cont	4	8	5	0	2	7	0	2	5	1	1	5	5	8	0	1	1	1	5	1	9	5	2	9	2	1	2	2	2	1	4	2	0	2	0	5	1	0	1	1
99 easy for children to use	2	15	6	2	4	6	4	4	4	4	5	5	4	17	7	7	5	7	7	7	17	14	6	17	2	9	0	2	1	1	1	5	0	5	5	6	2	2	7	14
100 easy access with one hand	4	25	5	2	2	9	1	4	6	0	9	7	6	22	16	16	13	16	15	15	21	25	15	28	0	5	1	0	1	2	2	1	0	2	2	5	4	1	15	10
101 easy to clean	1	10	5	1	1	10	7	4	7	2	1	6	4	14	0	1	5	1	2	1	11	8	5	11	2	5	1	5	2	7	3	4	0	5	0	7	1	0	1	2
102 easy to carry	0	1	1	0	0	1	2	5	11	5	14	1	16	1	47	47	48	48	50	48	1	4	40	1	5	4	2	1	0	1	0	1	0	2	1	2	1	0	48	52
103 easy to drain out excess water	4	8	2	0	1	7	0	2	5	1	1	4	5	9	1	2	2	2	5	2	8	7	5	8	2	1	5	4	5	2	5	2	0	1	0	6	1	0	2	2
104 easy to dispose of	2	8	5	1	2	7	6	5	9	5	5	5	4	15	2	2	1	5	2	1	8	9	2	11	5	6	0	3	0	7	0	7	0	5	0	7	2	0	1	5
105 easy to handle in the car	5	7	4	2	5	5	0	9	7	6	26	4	15	10	9	9	8	9	10	9	9	9	11	10	5	8	0	7	0	1	0	9	0	5	4	4	5	5	10	8
106 easy to get things out	4	44	6	5	5	15	2	4	4	5	2	14	2	35	0	0	0	1	2	0	59	12	1	59	1	2	0	1	1	2	2	4	0	5	2	7	6	2	0	5
107 easy to tell what's in the container	4	59	10	5	5	10	2	4	4	5	4	14	5	35	2	2	1	2	4	5	48	14	5	59	2	2	0	4	1	5	2	5	0	5	2	5	8	1	5	2
108 easy to store container	0	5	15	1	5	5	0	16	2	14	10	5	18	6	5	4	4	4	5	4	4	5	6	4	6	6	1	45	2	5	1	7	0	5	4	4	1	2	4	4
109 efficient use of space	5	12	18	4	16	5	2	22	5	22	8	6	17	10	1	1	1	1	2	1	12	5	1	9	6	6	0	19	0	5	0	6	0	5	8	4	11	6	1	1
110 easy to use in a car	4	5	6	5	5	5	0	11	5	8	51	2	19	5	7	7	6	7	8	7	6	6	7	7	6	11	0	12	0	1	0	14	0	4	6	4	5	4	8	5
111 even temperature kept throughout eac	5	0	0	1	17	7	0	0	0	0	1	6	0	1	0	0	0	0	0	0	2	0	1	0	1	1	10	0	10	1	11	2	54	0	2	1	5	2	0	0
112 elegant design	2	7	2	1	5	0	50	1	4	5	0	0	1	4	1	1	0	1	0	0	0	0	1	1	1	29	0	1	0	5	0	5	0	2	1	5	1	2	0	0
113 excess water drains out qickly	5	8	5	0	1	7	0	5	5	1	1	4	5	9	0	1	2	1	2	1	8	7	5	8	1	1	5	5	5	1	5	2	0	1	0	4	1	0	1	1
114 everything fits in one container	10	17	17	19	17	5	0	16	1	22	7	4	7	11	2	2	1	1	2	2	17	5	2	12	2	5	1	12	1	2	0	4	0	4	17	5	17	15	2	0
115 fits into almost any space	0	2	12	5	8	1	2	21	5	19	16	1	25	2	5	5	3	5	4	5	6	5	4	5	6	4	1	54	1	2	1	9	0	7	7	5	4	8	5	2
116 fits in a car trunk	2	5	9	2	5	0	0	17	4	14	54	0	26	2	5	5	4	4	5	5	3	4	7	5	6	8	0	17	0	2	0	9	0	5	7	2	2	4	6	5
117 fits on the floor of a car's back se	1	2	8	2	2	0	1	15	5	15	55	0	23	2	6	6	5	5	6	6	4	4	8	4	6	8	0	16	0	2	0	9	0	5	6	2	2	4	7	4
118 fits on a car's front seat	1	2	8	2	2	0	0	17	5	15	56	0	26	2	6	6	5	5	6	6	5	4	7	5	6	10	0	19	0	2	0	9	0	5	6	2	2	4	7	5
119 flexible design	2	5	18	1	9	1	19	21	6	8	5	1	9	4	1	1	1	1	1	1	5	2	2	2	8	11	0	8	0	5	1	3	0	7	4	7	2	5	1	1
120 flexible construction	2	5	25	5	15	1	9	26	10	15	6	1	8	2	1	1	1	1	1	1	3	5	2	2	7	4	1	11	0	8	1	4	0	6	5	11	5	6	1	5
121 good price for the performance	1	0	1	1	0	0	0	0	1	1	0	0	0	1	8	0	0	0	0	0	0	2	0	1	0	0	1	0	0	12	0	1	0	0	1	1	0	1	0	5
122 food is balanced for carrying	1	15	4	4	7	1	5	2	5	4	9	2	10	6	26	25	27	24	26	25	7	5	18	8	5	5	1	1	0	2	0	2	1	5	4	5	10	4	24	19
123 has a workspace to prepare food	2	6	7	8	7	1	5	4	5	6	5	1	5	4	0	1	1	0	1	0	7	2	1	5	41	2	0	4	0	5	1	7	1	47	5	9	9	5	0	0
124 hands don't get cold looking for ite	4	25	4	5	5	15	1	5	5	1	1	17	1	25	1	1	1	2	2	1	22	8	2	24	2	5	8	2	9	5	9	5	5	1	1	5	4	1	1	5
125 hides beer at prohibited area	7	8	8	19	11	0	0	7	1	12	2	2	5	8	0	0	0	0	0	0	8	2	0	8	9	4	0	4	0	1	2	9	1	15	10	5	15	21	0	1
126 has external storage areas	6	11	15	14	14	1	2	14	5	16	5	2	7	7	0	1	0	0	1	0	10	4	0	9	11	5	0	5	0	5	0	4	0	15	10	7	14	9	1	0
127 ice storage space	5	5	2	13	15	17	2	4	0	7	0	19	1	5	0	0	0	0	0	0	5	1	0	4	4	2	24	2	25	0	28	5	6	5	9	1	13	8	0	0
128 holds an umbrella	9	4	9	28	7	0	2	4	4	9	2	0	2	4	0	1	0	0	0	0	5	1	0	4	17	1	0	2	0	4	0	6	0	18	22	8	15	19	0	0
129 keeps bottles from touching one anot	4	11	6	14	10	2	2	2	0	5	0	5	2	8	0	0	0	0	0	0	8	0	0	9	4	1	0	0	1	2	1	2	2	6	12	4	16	12	0	0
130 inexpensive over the long run	1	0	1	1	0	0	0	0	2	1	0	0	0	1	0	0	0	0	0	0	0	2	0	1	0	0	1	0	0	14	0	1	0	0	1	1	0	1	0	5
131 keeps different things at different	2	0	5	0	20	6	1	1	0	1	0	5	1	0	0	0	1	0	0	0	0	0	1	1	1	2	10	0	10	1	11	1	51	1	0	2	0	0	0	0
132 keeps cold air in when open	5	1	1	5	8	15	1	0	1	1	0	15	1	0	0	0	0	0	0	0	0	2	1	1	1	2	25	0	25	1	25	5	19	0	1	5	5	1	0	0
133 keeps food cold all day	5	1	1	4	8	14	0	0	1	0	0	15	0	0	0	0	0	0	0	0	0	0	0	1	1	0	22	0	22	0	21	5	25	1	2	1	1	2	0	0
134 keeps food cold	5	1	1	5	9	9	1	0	0	1	0	10	0	0	0	0	0	0	0	0	0	0	0	1	1	1	18	0	19	1	18	2	25	1	0	2	0	0	0	0
135 keeps food from tasting different	5	4	5	0	10	5	1	0	1	5	0	5	5	1	0	0	0	0	0	0	1	0	0	1	5	5	4	0	5	2	4	2	11	2	1	4	1	1	0	0
136 keeps food from getting soggy	8	5	2	2	7	2	1	0	0	5	0	5	0	1	0	0	0	0	0	0	5	0	0	2	2	1	5	0	5	1	5	1	9	5	0	5	6	0	0	0
137 keeps food warm for 2 or 3 hours	5	1	1	1	14	4	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	0	1	1	0	8	0	8	1	9	2	45	0	2	2	1	2	0	0
138 keeps food off the ground	5	4	2	5	5	0	2	4	2	5	5	0	5	5	1	1	1	1	1	1	4	2	1	5	12	5	0	4	0	1	1	9	5	12	5	5	6	6	1	1
139 keeps odors in; contains smells	9	6	5	2	7	1	2	1	5	5	2	1	2	5	1	1	0	0	1	1	5	5	1	2	5	4	2	1	1	2	2	1	6	4	2	8	4	1	1	0
140 keeps hot stuff where kids can't get	5	12	4	2	11	4	1	5	5	1	1	8	0	10	1	1	1	1	2	1	14	5	0	15	1	5	5	0	5	1	4	1	16	5	5	4	5	5	1	5
141 lasts over 10 years	2	1	5	1	1	0	2	1	14	2	1	0	1	2	0	0	0	0	0	0	2	2	0	2	5	1	0	2	0	55	0	1	0	4	1	7	1	1	0	11
142 keeps warm food warm	2	1	1	1	15	4	1	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	0	1	2	1	8	0	8	1	10	1	41	1	0	5	0	0	0	0

APPENDIX 6.3. (Continued) BLOCK 4

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
143 lets me carry a tablecloth	14	5	8	52	8	0	0	6	1	11	4	0	4	5	1	1	1	1	1	1	5	2	0	5	5	1	1	2	0	2	0	6	2	8	25	5	24	22	1	1
144 leak-proof section for non-food items	16	5	5	7	5	1	2	2	5	5	1	2	5	2	0	0	0	0	0	0	5	1	0	5	5	1	1	1	1	5	2	1	1	4	4	5	7	4	0	0
145 lets me carry bread	12	5	7	24	8	2	0	5	0	15	1	1	1	1	0	0	1	1	0	0	1	0	0	1	5	0	1	1	1	1	1	6	4	5	51	1	17	29	0	0
146 lets me carry a thermos	12	0	5	51	4	5	0	4	0	6	2	2	2	0	5	5	5	5	5	5	0	0	2	0	5	2	2	0	2	1	2	5	8	4	25	1	22	21	5	2
147 lets me carry chips & crackers	12	4	8	25	9	1	0	5	0	15	1	0	1	2	0	0	1	1	0	0	2	0	0	2	5	0	0	1	0	1	0	5	5	6	52	1	18	50	0	0
148 lets me carry cans	15	4	9	51	9	2	0	6	0	17	1	1	1	2	0	0	1	1	0	0	2	0	0	2	4	0	1	1	1	1	1	6	5	7	40	1	20	59	0	0
149 lets me carry fruit	12	4	7	25	10	1	0	5	0	15	1	0	1	2	0	0	1	1	0	0	2	0	0	2	2	0	0	1	0	1	0	5	5	5	51	1	18	29	0	0
150 lets me carry drinks	12	2	6	28	7	5	0	5	0	14	1	2	1	1	0	0	0	0	0	0	1	0	0	1	4	0	2	1	2	1	2	7	6	6	58	1	18	56	0	0
151 lets me carry ice cream home from th	10	2	4	20	7	6	0	5	0	12	1	6	1	0	0	0	1	1	0	0	1	0	0	1	2	0	6	1	7	1	7	6	7	5	25	1	11	24	0	0
152 lets me carry glass items	11	5	7	59	7	1	0	4	2	10	2	0	2	4	0	0	0	0	0	0	5	1	0	5	5	0	0	2	0	5	0	5	2	8	22	2	21	20	0	0
153 lets me carry non-food items	15	5	8	51	8	1	0	6	1	10	5	2	4	5	1	1	1	1	2	1	5	1	0	5	4	1	1	5	2	2	1	6	2	7	24	2	22	21	2	0
154 lets me carry ice for drinks	12	1	4	19	8	10	0	2	0	9	1	10	0	0	1	1	2	2	1	1	0	0	1	0	2	0	15	0	15	1	15	4	9	2	21	1	15	20	1	1
155 lets me carry plates	14	5	9	53	8	0	0	6	1	10	2	0	5	4	0	0	1	0	0	0	5	1	1	5	4	0	0	2	0	2	0	7	2	7	25	5	24	22	0	0
156 lets me carry paper goods (plates, c	14	4	9	54	8	0	0	5	1	10	2	1	5	4	0	0	0	0	1	0	4	1	0	4	4	0	0	5	1	5	0	6	2	7	25	2	24	22	1	0
157 lets me carry rice balls	12	5	8	25	10	1	0	5	0	15	1	0	1	1	0	0	1	1	0	0	2	0	0	1	5	0	0	1	0	1	0	5	5	5	52	1	17	50	0	0
158 lets me carry real silverware	15	5	8	55	8	0	0	5	1	10	2	1	4	4	0	0	0	0	0	0	5	1	0	5	4	0	0	5	1	2	0	6	2	7	25	2	24	22	0	0
159 lets me carry salt/pepper	11	5	10	51	8	1	0	5	0	12	1	0	1	2	0	0	0	0	0	0	2	0	0	2	5	0	0	1	0	1	0	5	5	6	55	1	19	50	0	0
160 lets me carry salads	12	5	6	24	9	2	0	5	0	15	1	1	1	1	0	0	1	1	0	0	1	0	0	1	2	0	1	1	1	1	1	6	4	4	50	1	17	28	0	0
161 lets me carry wine bottles	11	2	7	56	9	2	0	7	0	12	2	1	1	2	1	1	1	1	1	1	2	0	0	2	5	1	1	1	1	1	1	5	4	6	54	1	21	52	1	0
162 lets me carry sandwiches	10	5	6	25	6	2	0	5	0	15	2	1	1	1	1	1	2	2	1	1	1	0	1	1	5	0	1	1	1	1	1	6	5	5	50	1	17	28	1	1
163 lid locks open	5	7	2	0	2	5	5	1	5	2	5	5	1	9	1	1	1	1	1	1	7	50	2	12	6	4	0	5	0	4	0	4	0	4	0	22	1	0	1	0
164 lid can't be lost	7	5	2	0	2	4	4	1	4	2	5	5	2	6	1	1	1	1	1	1	4	22	2	6	6	4	1	4	1	4	2	1	0	4	0	50	2	0	1	1
165 lid remains attached to cooler when	5	5	2	0	5	4	5	1	4	2	5	5	1	6	1	1	1	1	1	1	5	25	2	7	5	4	1	5	1	4	1	2	0	5	0	29	2	0	1	0
166 lid is leak-proof	16	5	1	1	2	5	2	2	1	0	1	2	1	5	1	1	5	1	1	1	4	16	5	5	1	5	1	0	1	2	4	0	1	5	0	8	1	0	1	0
167 lid stays closed when container fall	4	6	1	0	1	5	2	1	5	1	4	5	2	7	1	1	1	1	1	1	6	25	2	8	4	5	0	2	0	4	1	1	0	5	0	18	1	0	1	1
168 lid locks shut	6	7	2	1	5	5	2	1	5	2	5	5	2	9	1	1	1	1	1	1	7	29	2	11	4	5	1	2	0	5	1	1	0	2	1	20	2	1	1	0
169 made of non-toxic materials	0	5	2	5	5	5	14	5	18	5	2	4	2	8	0	0	1	0	0	0	5	4	2	5	5	7	1	5	2	9	1	5	1	5	0	10	5	1	0	4
170 lightweight	0	1	2	1	5	1	4	8	15	10	10	1	15	4	51	52	52	55	50	52	1	7	26	1	4	8	1	4	0	5	1	2	0	1	4	4	2	5	51	26
171 means for carrying doesn't interfere	2	9	5	0	2	5	2	4	8	5	18	6	10	9	28	29	28	26	52	50	9	10	28	10	4	6	2	2	1	2	1	1	0	5	1	9	5	0	51	18
172 matching utensils/cups/etc.	5	5	6	17	5	2	12	2	1	5	2	1	4	5	0	0	0	0	0	0	6	1	0	5	6	15	1	2	1	5	1	5	1	9	7	5	14	7	0	0
173 minimal external space taken up	1	5	15	6	10	1	4	25	5	25	12	1	24	4	5	5	4	5	3	5	4	4	6	1	6	8	0	28	0	5	0	6	0	5	9	2	5	7	5	2
174 means of carrying moves out of way	2	7	5	0	2	6	2	5	15	4	19	4	10	8	54	56	54	54	58	57	7	9	56	7	4	10	0	5	1	2	1	1	0	4	1	8	4	1	56	24
175 minimum room taken by insulation	1	1	9	5	11	12	4	11	2	18	5	15	9	5	0	1	0	1	0	1	0	0	1	0	5	6	16	9	15	4	15	4	8	5	4	2	1	6	0	0
176 minimum effort to move container	0	2	2	0	0	1	0	5	11	5	15	0	11	1	58	40	41	41	42	40	2	4	40	1	5	5	1	2	0	1	0	0	0	1	1	1	1	1	59	51
177 natural looking	0	0	2	0	5	0	48	1	4	2	0	1	0	4	0	0	0	0	1	0	2	1	1	1	2	29	0	2	0	2	0	5	0	5	0	5	0	1	0	0
178 multiple entries into container	5	50	8	7	8	7	0	7	2	8	2	9	6	20	0	1	0	0	1	0	28	15	0	50	2	1	0	2	0	2	1	5	1	5	4	5	6	6	0	0
179 not clumsy to carry	0	2	0	0	0	1	5	2	15	2	15	0	15	1	45	46	45	45	46	47	1	5	57	1	2	5	1	1	0	0	1	5	0	1	0	1	1	0	45	52
180 no loose ice inside container	5	5	0	6	4	25	2	1	1	1	0	22	1	7	0	0	0	1	1	0	5	1	1	5	1	5	31	5	32	0	52	1	5	1	0	2	4	1	0	2
181 one or two persons can carry	1	1	1	0	0	0	1	5	12	5	17	0	15	1	52	53	47	50	50	54	1	7	41	1	2	8	2	2	0	0	0	1	0	1	2	1	2	1	54	54
182 objects don't rattle around	5	9	7	9	10	1	2	5	2	5	5	5	4	5	1	1	2	1	1	1	7	2	5	6	5	5	0	2	0	2	1	5	1	8	5	10	12	4	1	1
183 prevent food from being crushed	6	4	1	8	6	0	0	1	5	2	1	1	2	4	1	1	1	1	1	1	2	1	2	5	5	0	0	0	0	7	1	5	2	6	5	8	9	6	1	1
184 option to get into one section at a	6	28	7	5	11	8	1	6	2	6	2	12	5	22	0	1	0	0	1	0	29	14	1	29	2	5	0	2	1	2	2	4	2	4	5	9	6	2	0	0
185 prevent liquid from spilling	18	7	1	7	6	1	0	0	2	2	1	1	0	5	1	1	0	0	1	1	5	2	1	4	1	2	1	1	2	1	2	1	4	5	4	4	10	4	1	0
186 prevent food from spoiling	6	5	2	5	6	6	2	1	2	5	0	8	0	1	0	0	0	0	0	1	2	0	0	2	2	1	10	0	10	2	10	5	15	5	2	5	1	5	1	0
187 protect fragile foods	7	6	2	10	7	1	0	1	5	5	1	2	0	4	0	0	0	0	0	0	5	1	1	5	4	1	1	2	1	4	2	4	5	6	7	7	14	8	0	0
188 prevent mess inside	7	16	5	6	8	6	1	5	4	2	2	7	4	12	0	0	0	0	0	0	15	4	0	11	2	2	2	2	2	2	4	5	2	4	2	6	9	1	0	0
189 reasonably priced	1	0	1	1	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	11	0	1	0	0	1	1	0	1	0	5
190 protection for glass/breakables	4	6	2	21	4	1	0	1	5	5	1	1	1	6	0	0	0	0	0	0	4	1	0	5	5	0	0	1	0	5	1	5	1	8	6	4	15	7	0	1

APPENDIX 6.3. (Continued) BLOCK 5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
191 resistant to dry ice temperatures	2	0	1	5	4	19	1	1	2	5	2	19	1	0	1	1	1	1	1	1	0	2	1	0	4	1	50	5	52	11	50	0	9	2	0	5	0	0	1	1
192 remove things without disturbing res	4	57	5	2	7	10	1	4	2	5	1	11	4	28	0	0	0	1	1	0	58	10	1	52	1	1	1	1	1	5	2	5	1	5	1	6	8	1	0	1
193 right size	0	2	24	4	11	1	5	20	5	51	12	1	21	6	5	4	4	5	5	4	4	5	5	5	6	11	1	21	0	5	0	8	0	4	17	5	5	9	2	1
194 reusable coolant	5	1	0	5	4	51	0	0	0	0	1	50	0	0	0	0	0	0	0	0	1	0	0	1	0	0	48	1	48	5	45	1	8	0	0	0	0	0	0	2
195 see everything at once	5	56	6	5	6	9	1	5	2	5	2	11	5	27	0	0	0	1	2	0	45	9	1	55	5	2	0	2	1	5	2	5	0	4	2	5	7	1	0	2
196 right size for sitting on	1	1	10	5	11	0	5	11	4	17	6	1	9	2	1	2	1	2	1	2	2	5	2	2	41	6	0	12	0	5	1	8	0	56	6	8	6	8	1	1
197 self-contained; glasses, cups, plate	7	5	8	25	6	1	1	4	2	7	2	2	5	5	0	0	0	0	0	0	6	2	0	4	5	1	0	1	1	1	0	6	2	8	15	6	20	14	0	0
198 segregates warm food from cold food	6	6	1	5	26	2	1	2	0	2	0	5	1	5	0	0	0	0	0	0	5	0	1	4	1	2	5	0	5	0	7	1	18	2	4	2	7	4	0	0
199 separates food from coolant	5	9	0	8	9	15	1	1	0	1	0	22	0	5	0	0	0	0	0	0	7	1	0	7	1	1	18	1	17	0	18	1	4	5	2	5	9	2	0	0
200 separate wet items from dry	10	10	2	7	9	0	1	1	0	2	0	5	0	5	0	0	0	0	0	0	7	0	1	6	1	1	1	0	1	0	2	5	4	4	5	4	14	5	0	0
201 shock proof	1	1	2	2	2	1	5	5	18	5	4	0	5	2	2	2	2	2	2	2	1	4	4	1	8	4	0	5	0	27	0	1	0	6	0	12	2	0	2	5
202 shape doesn't waste space	0	4	16	4	11	0	4	27	2	22	9	0	21	4	2	2	2	2	2	2	4	1	5	2	4	10	0	25	0	5	0	5	0	5	7	1	5	6	2	1
203 stable shelf/work area	1	6	7	7	7	1	5	5	5	7	5	1	5	5	0	0	1	0	0	0	7	2	1	5	55	4	0	7	0	7	1	7	0	41	5	7	10	7	0	2
204 size adjusts to the amount of food	1	7	51	9	23	0	2	44	2	25	7	0	15	6	0	0	0	0	0	0	7	2	1	6	5	4	0	14	0	4	1	4	0	6	15	4	6	12	0	0
205 structurally rigid	2	1	2	0	1	0	6	4	20	5	6	1	4	1	5	5	5	5	4	5	1	5	5	1	15	2	0	4	0	28	0	4	0	9	0	14	5	0	5	6
206 store other things in container when	5	6	10	14	7	0	0	9	5	7	7	1	2	5	2	2	1	1	2	2	5	2	2	4	19	1	0	22	1	2	1	8	0	25	7	4	11	16	2	1
207 temperature is controllable	2	1	5	1	16	9	1	2	1	2	1	8	1	2	0	0	0	0	0	0	1	1	0	1	2	1	14	1	14	5	15	5	29	2	1	5	2	1	0	0
208 suitable for year-round use	1	1	6	4	6	2	1	5	5	4	4	1	2	5	0	0	0	0	0	0	2	1	1	1	10	4	2	5	2	16	2	17	5	8	5	6	5	5	0	4
209 useful for romantic picnics	5	1	7	6	1	0	15	5	5	5	6	0	4	6	5	5	2	5	2	2	5	2	1	1	6	12	0	4	0	5	1	51	1	6	6	1	7	5	2	1
210 two persons can carry the container	1	2	1	1	0	0	1	5	15	5	16	0	15	1	49	50	45	47	48	51	1	5	40	1	2	7	2	2	0	0	0	0	0	1	2	1	2	1	50	52
211 useful on a car trip	2	5	7	5	2	1	2	8	4	4	25	1	12	2	5	5	5	5	5	5	5	1	4	2	4	5	1	9	1	1	2	27	2	5	4	1	5	2	4	2
212 useful on a boat	2	1	7	4	5	0	4	8	4	7	20	0	11	5	5	5	5	5	5	5	2	1	4	1	7	8	0	9	0	2	1	55	1	5	6	2	4	4	5	1
213 uses a convenient cooling mechanism	5	2	0	4	5	50	0	0	2	0	0	52	0	2	0	0	0	0	0	0	1	1	0	1	0	0	46	1	48	0	45	5	10	0	0	1	0	0	0	0
214 useful on bike ride	5	2	6	4	1	0	4	6	9	6	22	0	15	4	6	6	6	6	6	6	5	1	7	1	7	6	0	8	0	2	1	54	1	4	7	2	6	5	6	4
215 utensils stored separately	9	11	7	19	10	1	1	5	1	7	2	5	5	8	2	2	2	2	2	2	12	2	1	9	7	1	0	5	1	5	1	5	1	10	11	5	20	11	2	2
216 uses something other than ice to coo	4	0	2	4	5	50	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	1	0	49	1	52	0	50	2	9	1	0	0	0	0	0	0
217 won't flip over during transport	2	4	4	1	2	2	2	4	15	4	24	2	11	5	20	20	20	20	22	20	4	4	25	1	5	7	0	4	0	4	0	4	0	5	0	6	4	0	19	15
218 waterproof	15	2	2	1	1	2	4	5	4	4	2	2	2	4	1	1	2	1	1	1	4	5	2	2	5	4	5	2	2	9	4	1	1	4	0	4	1	0	1	2
219 can get a good grip on container	0	5	1	0	1	1	1	5	16	4	15	0	15	2	57	58	59	59	59	58	2	6	56	5	6	7	2	2	0	2	0	5	0	4	1	5	1	0	57	28
220 won't slide during transport	1	2	5	2	5	1	4	5	9	2	26	1	8	5	17	17	17	17	18	17	2	2	18	5	4	9	0	1	0	5	0	4	0	5	1	6	5	1	18	11

	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92
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46	27	49	51	16	1																																												
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48	25	52	45	17	1	47	5
49	19	2	2	30	5	2	2	2
50	1	1	1	4	2	1	4	1	10
51	5	2	2	5	2	2	5	2	7	18
52	16	1	1	27	2	1	5	1	48	16	8
53	8	7	10	11	6	9	3	8	15	10	5	14
54	13	19	19	10	2	18	7	20	8	15	7	10	19
55	7	7	6	2	56	6	7	7	6	5	4	6	5	11
56	5	1	1	2	50	1	1	1	3	5	2	3	5	5	27
57	0	0	0	1	6	0	2	0	4	5	2	4	6	3	4	7
58	7	5	6	4	1	5	5	6	13	15	3	15	20	17	8	2	4
59	16	1	1	27	2	0	6	1	44	8	7	59	9	5	5	2	5	9
60	5	6	5	5	25	5	5	5	9	2	2	5	7	6	24	24	4	5	8
61	1	0	0	2	5	0	6	1	2	3	5	2	4	5	3	5	6	4	5	5
62	16	1	1	29	5	0	4	1	45	12	9	47	11	9	8	4	4	14	45	5	5
63	6	8	6	6	51	5	4	8	6	4	5	6	6	9	53	16	5	5	7	21	5	6
64	12	1	1	22	4	1	2	1	58	15	8	40	16	12	6	4	7	16	54	7	1	55	9
65	6	1	1	6	2	1	2	1	9	22	55	11	7	6	5	5	5	8	6	4	1	10	5	15
66	0	0	0	0	0	1	2	0	2	17	13	4	1	5	0	0	2	4	1	0	2	5	1	5	10
67	2	2	2	1	2	2	5	2	4	15	19	7	7	8	4	5	7	5	2	3	5	4	3	6	19	14
68	2	2	2	3	2	2	2	2	2	8	55	2	2	5	3	2	2	0	2	1	3	2	3	2	25	15	18
69	25	42	43	17	7	44	4	40	6	4	5	5	15	21	12	6	5	9	5	4	3	4	7	5	2	0	4	2
70	0	0	0	0	0	0	2	0	0	7	13	1	3	2	0	0	4	0	1	0	6	0	2	1	12	8	14	22	0
71	2	2	3	5	5	1	14	3	3	5	3	6	5	9	7	4	5	4	6	5	10	6	10	5	1	1	5	0	4	0
72	9	0	1	12	5	0	9	0	24	6	4	25	7	4	5	1	5	7	26	5	5	22	6	19	5	2	5	0	5	0	19
73	5	0	0	6	1	0	2	0	10	5	8	11	15	8	4	5	7	4	8	5	9	11	4	12	5	0	12	6	1	16	5	9
74	3	5	2	0	5	2	49	4	2	5	5	4	2	8	7	3	5	4	5	5	5	5	6	5	2	3	4	1	5	0	14	8	1
75	0	0	1	0	2	0	3	0	1	5	2	4	1	5	1	0	1	8	4	1	5	5	2	5	2	4	5	0	0	1	11	17	0	5
76	1	1	1	1	7	1	2	2	3	5	1	3	6	4	6	11	22	4	2	8	6	4	8	5	4	2	6	0	2	2	2	2	7	1	2
77	0	0	0	0	0	0	1	0	0	4	4	0	0	0	0	0	1	0	0	0	0	0	1	0	3	19	3	4	0	5	1	0	1	0	1	0
78	4	1	1	1	57	1	2	1	4	1	1	4	3	5	27	19	4	2	4	21	9	5	29	4	1	1	2	0	4	1	4	4	4	2	2	10	0
79	0	0	1	0	4	0	1	1	4	5	0	7	6	5	2	3	5	16	2	2	5	5	2	8	5	5	4	0	1	0	0	4	3	0	28	3	0	2
80	0	0	0	0	0	0	0	0	1	5	5	1	1	1	1	1	1	1	1	1	0	1	0	1	3	22	5	11	0	6	0	0	5	1	0	1	18	0	1
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APPENDIX6.3. (Continued) BLOCK 9

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181	25	51	44	17	1	46	5	48	5	1	5	1	8	20	7	1	0	5	1	7	0	1	6	1	1	0	2	2	42	0	5	0	0	4	0	1	0	0	0	0	47	4	0	0	0	0	0	0	0	0	0	59
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220	15	17	15	8	0	17	5	15	5	7	2	5	15	57	7	2	5	11	2	5	2	5	4	5	5	4	5	2	18	5	4	1	6	4	4	5	0	2	4	1	15	9	5	0	1	2	7	0	2	0	6	18

APPENDIX 6.3. (Continued) BLOCK 11

	93	94	95	96	97	98	99	100	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
94	1
95	3	2
96	3	5	32
97	1	9	1	3
98	4	3	46	29	1
99	2	5	3	4	6	5
100	1	2	3	6	12	5	21
101	5	5	8	9	2	11	8	10
102	1	8	1	5	40	2	5	13	2
103	4	2	57	51	2	51	5	6	10	5
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105	2	4	2	4	16	4	13	10	6	9	4	8
106	2	5	6	6	2	8	18	28	11	1	9	8	7
107	2	3	6	7	1	8	17	20	9	2	9	10	9	51
108	2	2	5	5	4	5	5	6	7	4	4	6	10	7	6
109	1	2	3	4	2	2	3	5	4	1	2	6	7	9	13	16
110	2	5	2	4	12	4	9	7	5	7	4	7	44	4	5	15	12
111	11	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	2	0
112	0	6	1	5	1	0	3	3	5	0	0	7	0	2	1	1	5	0	0
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115	1	3	1	5	7	2	2	1	2	3	2	5	15	5	2	29	22	18	1	1	1	14
116	0	3	1	1	10	1	5	2	1	4	1	5	58	2	3	16	15	41	1	2	1	9	28
117	0	F	1	1	12	1	5	2	2	5	1	5	40	2	5	15	14	45	1	2	1	8	27	54
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APPENDIX 6.3. (Continued) BLOCK 14

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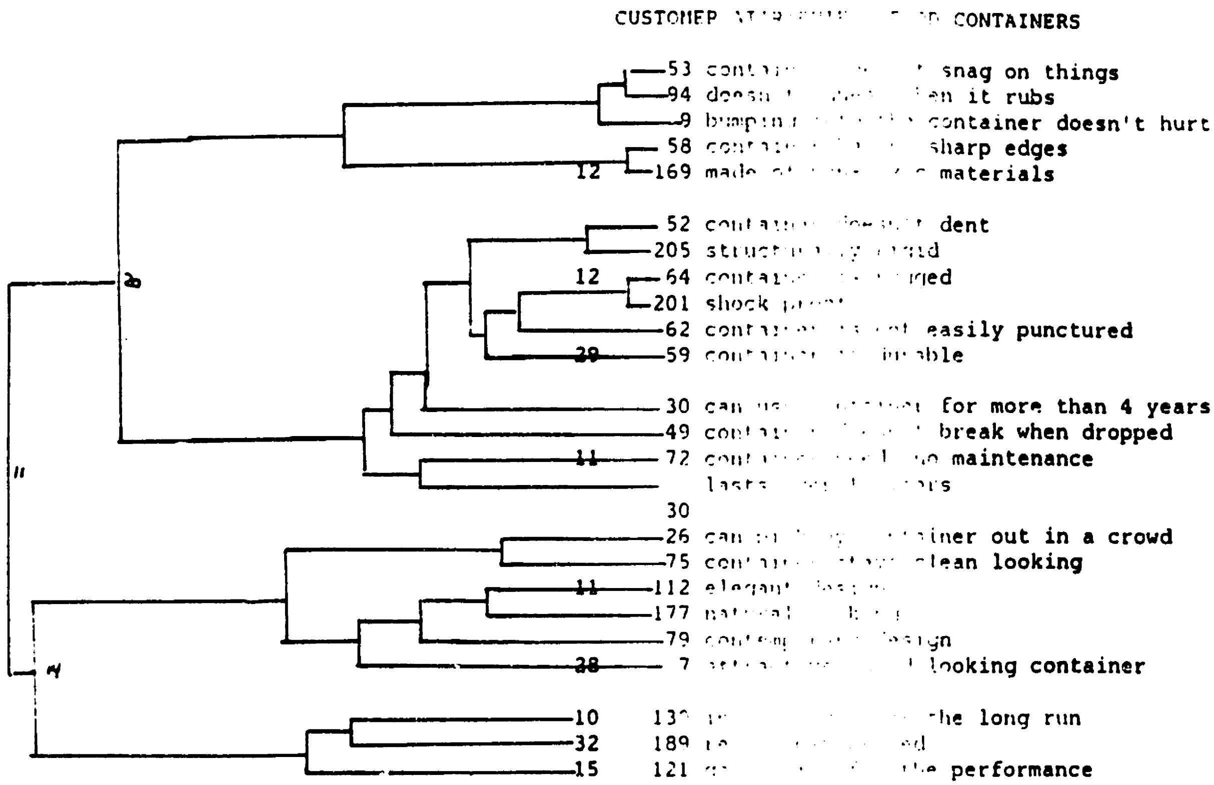
215	6	24	6	5	1	2	1	14	5	5	2	19	10	15	12	8	11	15	0	19	1	14	5	0	11	7
216	0	1	0	0	15	0	0	0	0	51	0	0	0	0	1	11	1	2	0	0	51	0	0	48	0	1
217	21	2	4	25	1	25	1	5	20	1	19	8	8	4	6	4	5	7	0	6	4	4	4	0	5	5
218	4	5	5	5	4	1	4	2	1	6	1	7	8	1	18	7	5	8	0	5	10	5	4	2	2	5
219	25	2	4	52	0	55	1	5	57	1	56	4	1	2	1	0	1	5	0	1	7	5	2	0	5	5
220	15	2	4	22	4	21	5	5	16	5	17	6	5	4	4	2	4	5	0	5	2	4	4	0	4	1

	97	98	99	200	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
192																								
193																								
194																								
195																								
196																								
197																								
198	6																							
199	6	18																						
200	11	21	27																					
201	1	5	1	5																				
202	5	5	2	1	2																			
203	7	4	4	5	4	4																		
204	7	4	3	5	3	26	4																	
205	2	1	0	1	56	3	9	4																
206	15	4	3	6	1	8	22	9	2															
207	1	25	7	5	3	1	2	4	2	1														
208	5	6	1	0	10	4	7	3	8	8	8													
209	5	1	0	2	1	6	5	4	1	8	1	20												
210	0	0	0	0	2	2	0	0	5	2	0	1	1											
211	2	1	1	2	1	6	3	6	1	6	5	16	20	3										
212	4	1	1	1	2	11	6	6	2	8	1	18	51	3	40									
213	1	C	18	1	0	0	0	0	0	1	18	4	0	1	1	0								
214	4	1	0	1	3	10	5	4	2	6	1	19	29	6	59	49	0							
215	53	12	16	17	2	5	9	7	3	15	5	3	4	2	2	4	0	5						
216	0	6	18	1	0	0	1	0	0	1	14	2	0	0	1	0	48	0	1					
217	2	1	0	1	11	5	3	2	9	1	2	4	3	19	11	8	1	12	2	0				
218	1	5	6	9	11	4	3	2	10	1	5	3	5	1	1	4	2	4	4	2	7			
219	1	0	0	0	4	5	5	1	5	2	1	2	2	56	5	3	0	7	2	1	16	5		
220	2	1	1	4	2	5	5	3	6	1	1	2	4	17	15	13	1	15	5	1	57	5	15	

APPENDIX 6.4. HORIZONTAL ICICLE PLOT OF THE AGGLOMERATION SCHEDULE

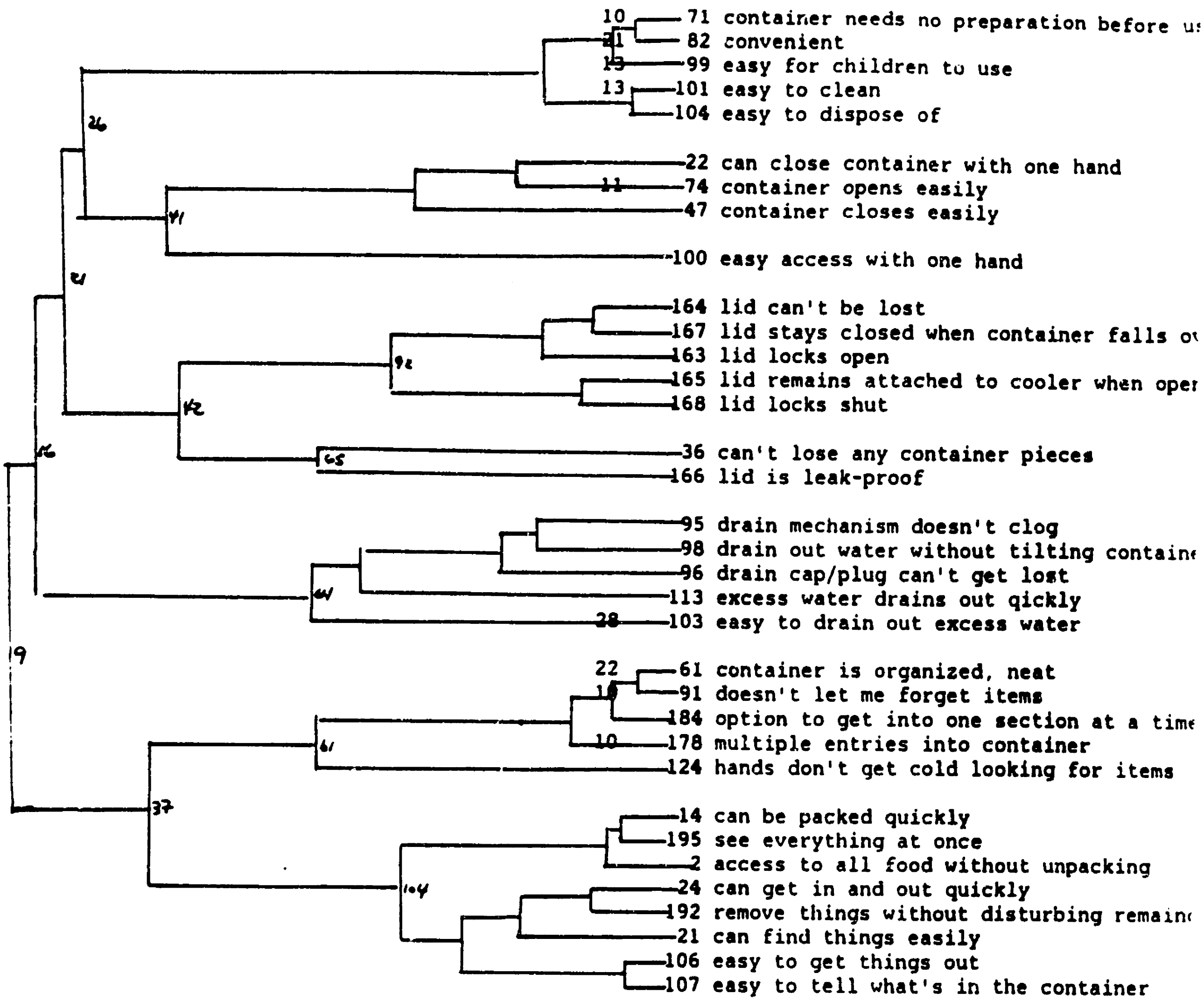
This Cluster becomes: ATTRACTIVE, GOOD LOOKING CONTAINER



Note: Small, handwritten numbers to the left indicate which generation the two clusters come together. Smaller numbers, and vertical lines further to the left indicate groups that came together later in the clustering process.

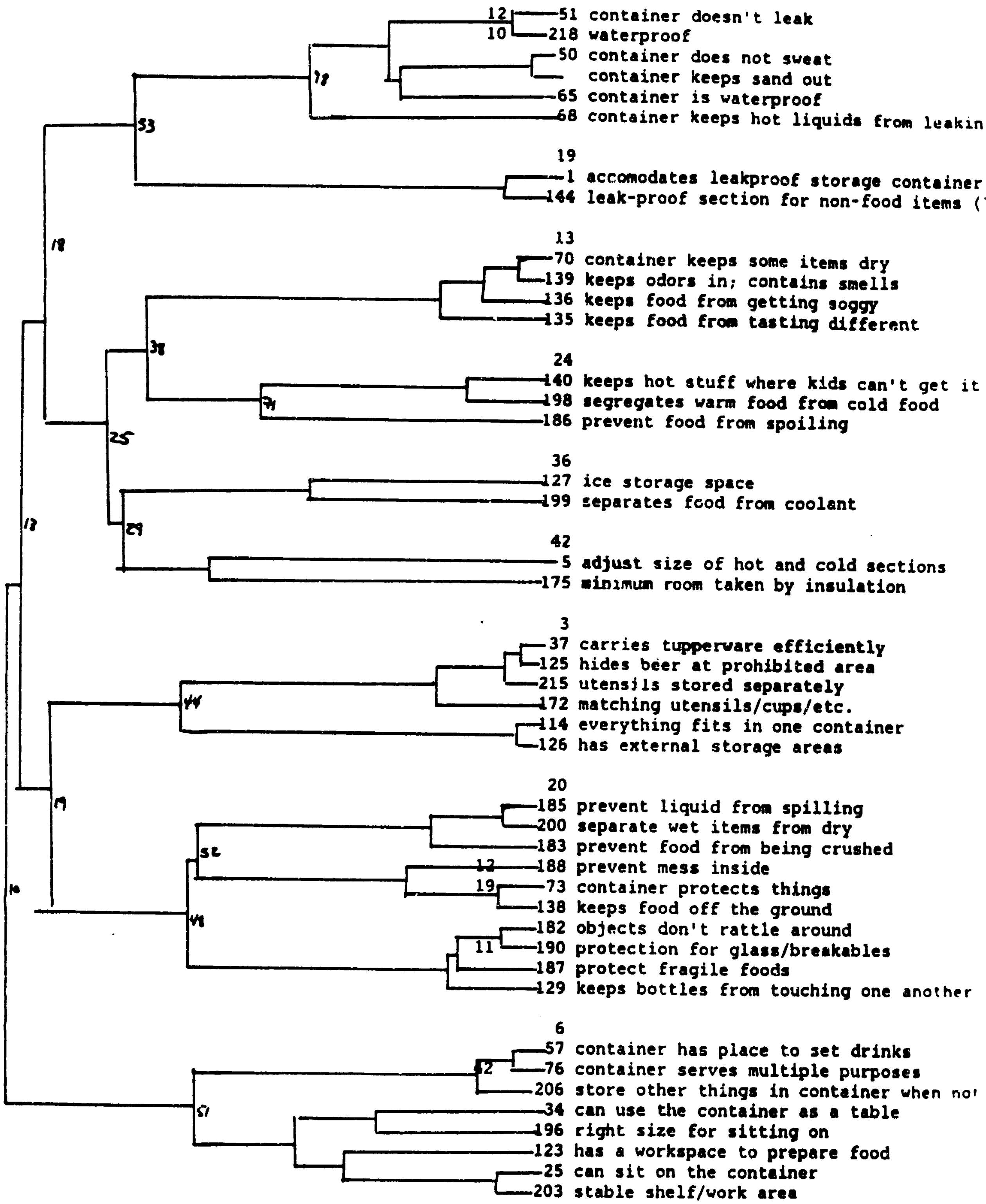
APPENDIX 6.4. (Continued)

This cluster becomes: CONVENIENT



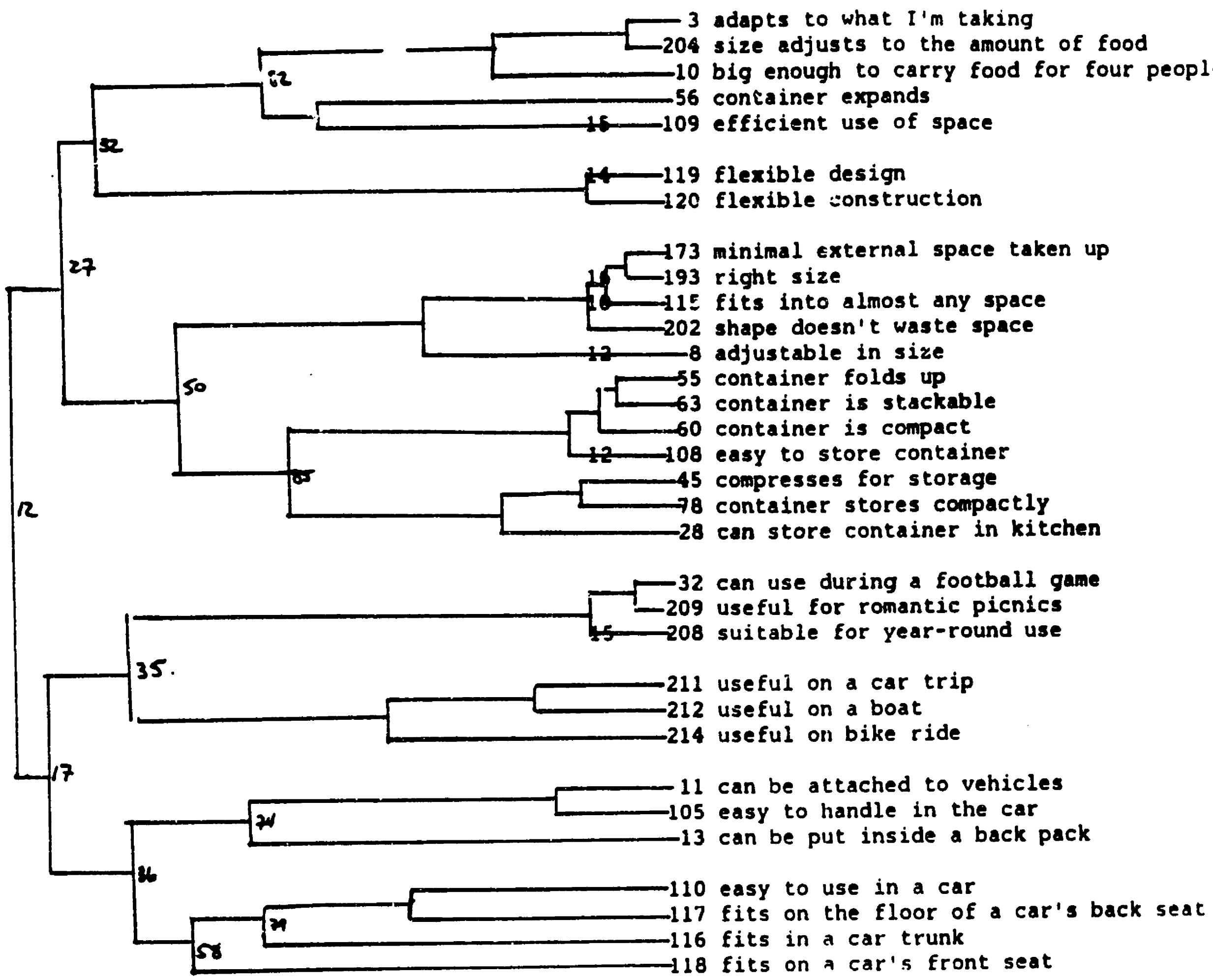
APPENDIX 6.4. (Continued)

This cluster becomes: WORKS WELL AS A CONTAINER



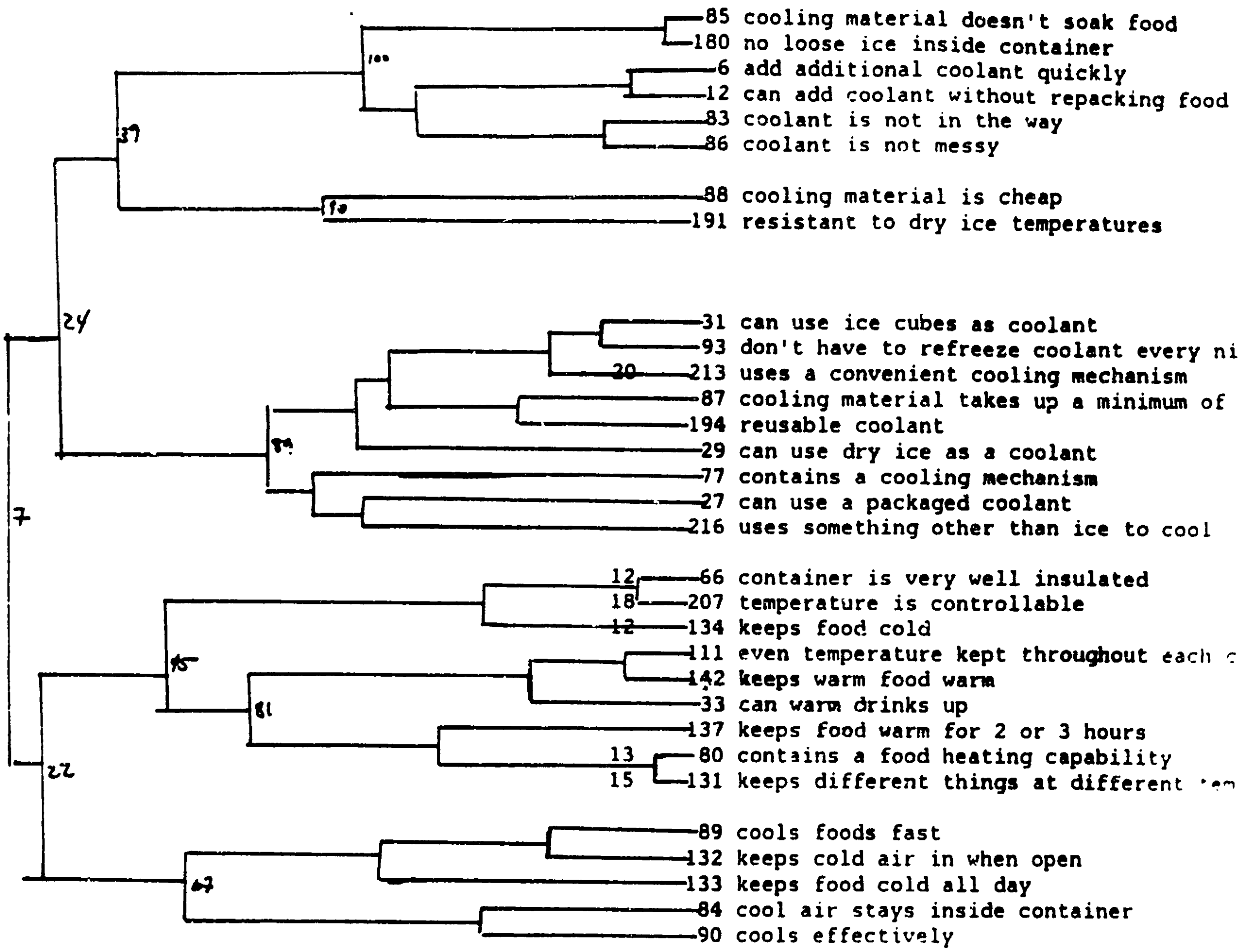
APPENDIX 6.4. (Continued)

This cluster becomes: RIGHT SIZE



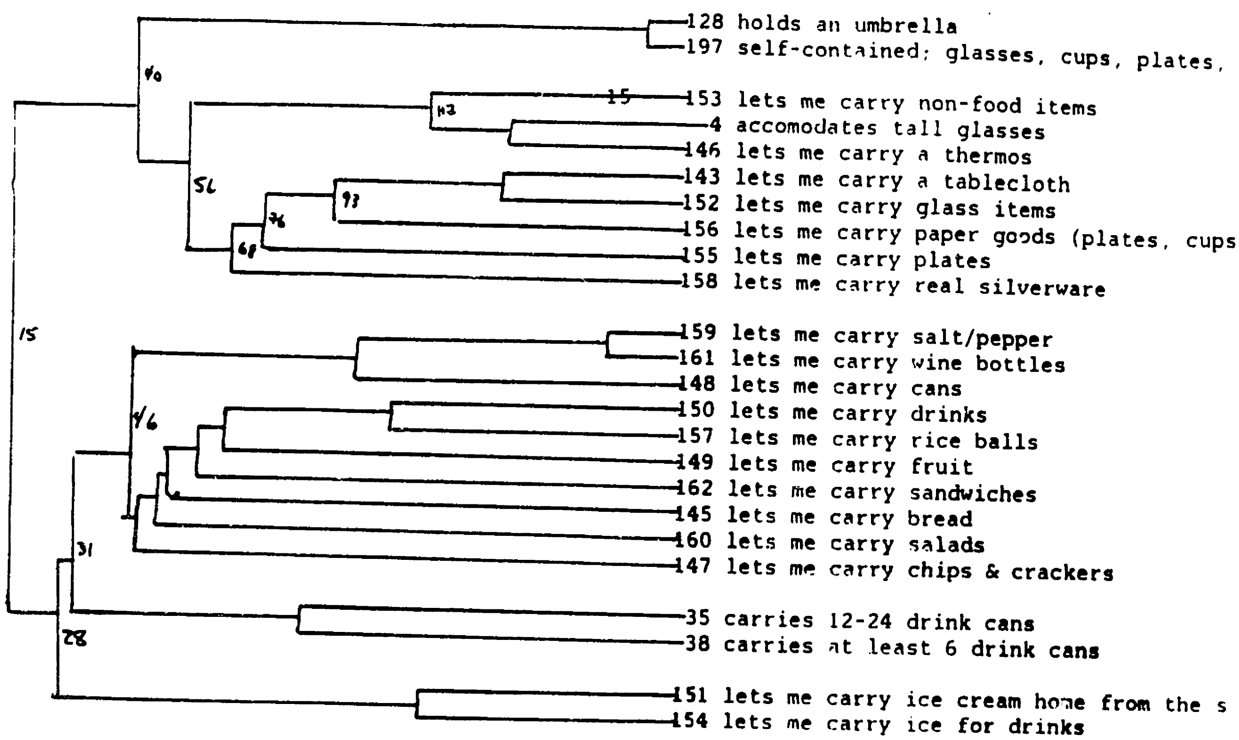
APPENDIX 6.4. (Continued)

This cluster becomes: MAINTAINS FOOD TEMPERATURES



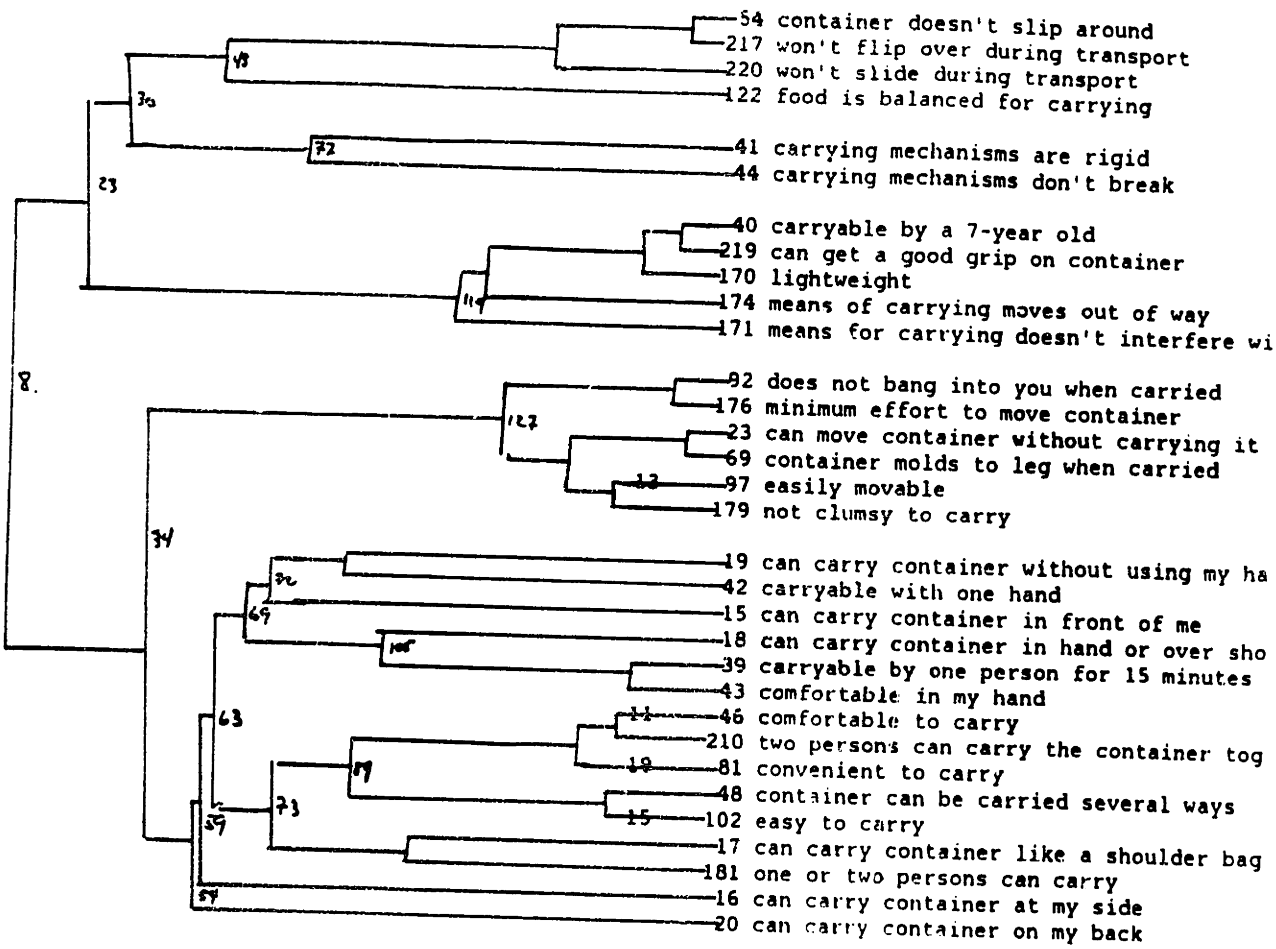
APPENDIX 6.4. (Continued)

This cluster becomes: CARRIES MANY KINDS OF THINGS



APPENDIX 6.4. (Continued)

This cluster becomes: EASILY MOVABLE



APPENDIX 6.5. CUSTOMER SORT HIERARCHY OF CUSTOMER ATTRIBUTES

LEVEL	TOP CDS		CUSTOMER ATTRIBUTES: FOOD CONTAINERS
1	28	7	ATTRACTIVE, GOOD LOOKING CONTAINER
2		221	CONTAINER DOESN'T CAUSE PROBLEMS
3	12	169	made of non-toxic materials
3		9	bumping into the container doesn't hurt
3		53	container doesn't snag on things
3		58	container has no sharp edges
3		94	doesn't squeak when it rubs
2	29	59	CONTAINER IS DURABLE
3	12	64	container is rugged
3	11	72	container needs no maintenance
3		141	lasts over 10 years
3		30	can use container for more than 4 years
3		49	container doesn't break when dropped
3		52	container doesn't dent
3		62	container is not easily punctured
3		201	shock proof
3		205	structurally rigid
2	11	112	ELEGANT DESIGN
3		26	can pick my container out in a crowd
3		75	container stays clean looking
3		79	contemporary design
3		177	natural looking
2	32	189	REASONABLY PRICED
3	15	121	good price for the performance
3	10	130	inexpensive over the long run

APPENDIX 6.5. (Continued)

1	21	82	CONVENIENT
2		228	EASY TO USE
3	13	99	easy for children to use
3	13	101	easy to clean
3	11	74	container opens easily
3	10	71	container needs no preparation before use
3		22	can close container with one hand
3		47	container closes easily
3		100	easy access with one hand
3		104	easy to dispose of
2		222	LID WORKS WELL
3		36	can't lose any container pieces
3		163	lid locks open
3		164	lid can't be lost
3		165	lid remains attached to cooler when open
3		166	lid is leak-proof
3		167	lid stays closed when container falls over
3		168	lid locks shut
2	28	103	EASY TO DRAIN OUT EXCESS WATER
3		95	drain mechanism doesn't clog
3		96	drain cap/plug can't get lost
3		98	drain out water without tilting container
3		113	excess water drains out qickly
2	22	61	CONTAINER IS ORGANIZED, NEAT
3	10	91	doesn't let me forget items
3	10	178	multiple entries into container
3		2	access to all food without unpacking
3		14	can be packed quickly
3		21	can find things easily
3		24	can get in and out quickly
3		106	easy to get things out
3		107	easy to tell what's in the container
3		124	hands don't get cold looking for items
3		184	option to get into one section at a time
3		192	remove things without disturbing remainder
3		195	see everything at once

APPENDIX 6.5. (Continued)

```
 1   3 227 WORKS WELL AS A CONTAINER
-------------------------------------------------

 2  12  51 CONTAINER DOESN'T LEAK
 3  10 218 waterproof
 3       1 accomodates leakproof storage containers
 3      50 container does not sweat
 3      65 container is waterproof
 3      67 container keeps sand out
 3      68 container keeps hot liquids from leaking
 3     144 leak-proof section for non-food items (keys, wal

 2     223 CONTAINER SEPARATES THINGS
 3       5 adjust size of hot and cold sections
 3      70 container keeps some items dry
 3     127 ice storage space
 3     135 keeps food from tasting different
 3     136 keeps food from getting soggy
 3     139 keeps odors in; contains smells
 3     140 keeps hot stuff where kids can't get it
 3     175 minimum room taken by insulation
 3     186 prevent food from spoiling
 3     198 segregates warm food from cold food
 3     199 separates food from coolant

 2  19  73 CONTAINER PROTECTS THINGS
 3  12 188 prevent mess inside
 3  11 190 protection for glass/breakables
 3     129 keeps bottles from touching one another
 3     138 keeps food off the ground
 3     182 objects don't rattle around
 3     183 prevent food from being crushed
 3     185 prevent liquid from spilling
 3     187 protect fragile foods
 3     200 separate wet items from dry

 2     114 EVERYTHING FITS IN ONE CONTAINER
 3      37 carries tupperware efficiently
 3     125 hides beer at prohibited area
 3     126 has external storage areas
 3     172 matching utensils/cups/etc.
 3     215 utensils stored separately

 2  42  76 CONTAINER SERVES MULTIPLE PURPOSES
 3      25 can sit on the container
 3      34 can use the container as a table
 3      57 container has place to set drinks
 3     123 has a workspace to prepare food
 3     196 right size for sitting on
 3     203 stable shelf/work area
 3     206 store other things in container when not in use
```

APPENDIX 6.5. (Continued)

```
 1  16 193 RIGHT SIZE
-----------------------------------------------

 2  15 109 EFFICIENT USE OF SPACE

 3  14 119 flexible design
 3  12   8 adjustable in size
 3  12 108 easy to store container
 3  10 115 fits into almost any space
 3       3 adapts to what I'm taking
 3      10 big enough to carry food for four people
 3      28 can store container in kitchen
 3      45 compresses for storage
 3      55 container folds up
 3      56 container expands
 3      60 container is compact
 3      63 container is stackable
 3      78 container stores compactly
 3     120 flexible construction
 3     173 minimal external space taken up
 3     202 shape doesn't waste space
 3     204 size adjusts to the amount of food


 2  15 208 SUITABLE FOR YEAR-ROUND USE

 3      32 can use during a football game
 3     209 useful for romantic picnics
 3     211 useful on a car trip
 3     212 useful on a boat
 3     214 useful on bike ride


 2     224 USEFUL FOR TRAVELING

 3      11 can be attached to vehicles
 3      13 can be put inside a back pack
 3     105 easy to handle in the car
 3     110 easy to use in a car
 3     116 fits in a car trunk
 3     117 fits on the floor of a car's back seat
 3     118 fits on a car's front seat
```

APPENDIX 6.5. (Continued)

1	5	229	MAINTAINS FOOD TEMPERATURES

2	20	213	USES A CONVENIENT COOLING MECHANISM
3		6	add additional coolant quickly
3		12	can add coolant without repacking food
3		27	can use a packaged coolant
3		29	can use dry ice as a coolant
3		31	can use ice cubes as coolant
3		77	contains a cooling mechanism
3		83	coolant is not in the way
3		85	cooling material doesn't soak food
3		86	coolant is not messy
3		87	cooling material takes up a minimum of space
3		88	cooling material is cheap
3		93	don't have to refreeze coolant every night
3		180	no loose ice inside container
3		191	resistant to dry ice temperatures
3		194	reusable coolant
3		216	uses something other than ice to cool

2	18	207	TEMPERATURE IS CONTROLLABLE
3	15	131	keeps different things at different temperat
3	13	80	contains a food heating capability
3	12	66	container is very well insulated
3	12	134	keeps food cold
3		33	can warm drinks up
3		84	cool air stays inside container
3		89	cools foods fast
3		90	cools effectively
3		111	even temperature kept throughout each compar
3		132	keeps cold air in when open
3		133	keeps food cold all day
3		137	keeps food warm for 2 or 3 hours
3		142	keeps warm food warm

APPENDIX 6.5. (Continued)

```
 1   6 230 CARRIES MANY KINDS OF THINGS
-------------------------------------------------

 2  15 153 LETS ME CARRY NON-FOOD ITEMS

 3       4 accomodates tall glasses
 3     128 holds an umbrella
 3     143 lets me carry a tablecloth
 3     146 lets me carry a thermos
 3     152 lets me carry glass items
 3     155 lets me carry plates
 3     156 lets me carry paper goods (plates, cups, nap
 3     158 lets me carry real silverware
 3     197 self-contained; glasses, cups, plates, utens


 2     225 LETS ME CARRY FOOD ITEMS

 3      35 carries 12-24 drink cans
 3      38 carries at least 6 drink cans
 3     145 lets me carry bread
 3     147 lets me carry chips & crackers
 3     148 lets me carry cans
 3     149 lets me carry fruit
 3     150 lets me carry drinks
 3     151 lets me carry ice cream home from the store
 3     154 lets me carry ice for drinks
 3     157 lets me carry rice balls
 3     159 lets me carry salt/pepper
 3     160 lets me carry salads
 3     161 lets me carry wine bottles
 3     162 lets me carry sandwiches
```

APPENDIX 6.5. (Continued)

```
 1  13  97 EASILY MOVABLE
------------------------------------------------

 2     226 EASY TO TRANSPORT

 3      40 carryable by a 7-year old
 3      41 carrying mechanisms are rigid
 3      44 carrying mechanisms don't break
 3      54 container doesn't slip around
 3     122 food is balanced for carrying
 3     170 lightweight
 3     171 means for carrying doesn't interfere with loadin
 3     174 means of carrying moves out of way
 3     217 won't flip over during transport
 3     219 can get a good grip on container
 3     220 won't slide during transport


 2  19  81 CONVENIENT TO CARRY

 3  15 102 easy to carry
 3  11  46 comfortable to carry
 3      15 can carry container in front of me
 3      16 can carry container at my side
 3      17 can carry container like a shoulder bag
 3      18 can carry container in hand or over shoulder
 3      19 can carry container without using my hands
 3      20 can carry container on my back
 3      23 can move container without carrying it
 3      39 carryable by one person for 15 minutes
 3      42 carryable with one hand
 3      43 comfortable in my hand
 3      48 container can be carried several ways
 3      69 container molds to leg when carried
 3      92 does not bang into you when carried
 3     176 minimum effort to move container
 3     179 not clumsy to carry
 3     181 one or two persons can carry
 3     210 two persons can carry the container together
```

APPENDIX 7.1. IMPORTANCE SURVEY COVER LETTER

E53-353
Sloan School of Management
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

John R. Hauser
Professor of Management Science

Telephone: (617) 253-2929

February 13, 1989

Dear Member of the MIT Graduate Student Community:

New products are important to us all. When corporations identify your needs, the products they design satisfy you. This survey is part of an MIT project to improve the techniques companies use to gather customer information for engineers and product designers. General Motors, Procter & Gamble, IBM, and others are interested in this technique and are experimenting with it.

Your family is being asked to be part of a study to improve these techniques. One section gathers your input on a specific product; the other section asks you to comment on the technique. Your responses to both sections are important.

The questionnaire asks for your opinions about containers that transport and carry food or drink on excursions. (We refer to this item as a food or drink carrying container or just a container.) Excursions include picnics, concerts, days at the beach, car trips, sports events, anything where you took some sort of food or drink with you to eat later in the day or on the next day. (Lunches at the office don't count.)

The information is collected at a *very detailed level* so that *your needs* can be translated directly into engineering decisions. We expect the results of this study to have a major impact on engineering practice, particularly at the engineering/marketing interface.

The questionnaire **takes 30 to 40 minutes** to complete and has been designed to be easy to answer. There are no **right or wrong answers** to the questionnaire. We are interested only in your opinions. You are **not asked** to put your name on the questionnaire, and there is no way to link your answers to you.

I hope that you or a member of your family will take the time in the next day or two to fill out this questionnaire. To ensure that your responses are included, please send the completed questionnaire via interdepartmental mail to my office, E53-417, by ***March 13, 1989.*** We have enclosed a pre-addressed mailing label for your convenience.

Your response is important. Thank you in advance for your help.

Sincerely,

Prof. John R. Hauser

APPENDIX 7.1. IMPORINACE SURVEY INTRODUCTION AND SAMPLE QUESTIONS: SELF-STATED DIRECT IMPORTANCE MEASURE

IN FILLING OUT SECTION 2, PLEASE RATE THE FOOD OR DRINK CARRYING CONTAINER YOU JUST DESCRIBED AS THE ONE YOU MOST FREQUENTLY TAKE WITH YOU.

SECTION 2. ATTRIBUTE IMPORTANCES FOR CONTAINERS INSTRUCTIONS

In this section of the questionnaire we would like to know how important each of the following attributes is to you for a container that transports food and drink. We've listed a large number of attributes becuase we're testing a method for providing engineers with very detailed market data. Please be sure to tell us how important the attributes are, <u>not</u> whether the food or drink carrying container you own has these attributes.

Circle one number for each phrase to indicate how important you consider that attribute is for food or drink carrying containers. Circle larger numbers for more important attributes and circle lower numbers for less important attributes. Remember, we are interested in how important each of the attributes is, whether or not the particular food or drink container you most frequently use is good or bad on that attribute.

1. HOW IMPORTANT IS IT THAT THE CONTAINER:	Of Little Importance		Somewhat Important		Important		Very Important		Extremely Important
Keeps bottles from touching one another	1	2	3	4	5	6	7	8	9
Lets me carry bread	1	2	3	4	5	6	7	8	9
Can sit on the container	1	2	3	4	5	6	7	8	9
Fits on the floor of a car's back seat	1	2	3	4	5	6	7	8	9

APPENDIX 7.1. IMPORTANCE SURVEY INTRODUCTION AND SAMPLE QUESTIONS: DIRECT MEASURE ANCHORED TO 100

SECTION 2. ATTRIBUTE IMPORTANCES FOR CONTAINERS
INSTRUCTIONS

In this section of the questionnaire we would like to know how important you think each of the following attributes is for a device that contains and transports food or drink. We've listed a large number of attributes because we're testing a method for providing engineers with very detailed market data. Please be sure to tell us how important you think the attributes are and not whether the food or drink carrying container you own has these attributes.

You will tell us how important each attribute is by first identifying the most important attribute in a group of attributes presented to you. Place a 100 on the line to the left of that attribute. Next, decide how important you think each of the remaining attributes is on a scale of 0 to 100, relative to the attribute already selected as most important.

Record the numbers to the left of each phrase in the list. Always give more important attributes larger numbers and give the less important attributes smaller numbers. Repeat the process for each group of attributes in the survey. Remember, we are interested in how important each of the attributes is, regardless of whether your container is good or bad on that attribute.

1. How important is each of the following characteristics to you in determining whether a container is attractive and good looking? (Most important = 100.)

    _____ container doesn't cause problems

    _____ container is durable

    _____ elegant design

    _____ reasonably priced

APPENDIX 7.1. IMPORTANCE SURVEY INTRODUCTION AND SAMPLE QUESTIONS: CONSTANT SUM TO 100 DIRECT MEASURE

IN FILLING OUT SECTION 2, PLEASE RATE THE FOOD OR DRINK CARRYING CONTAINER YOU JUST DESCRIBED AS THE ONE YOU MOST FREQUENTLY TAKE WITH YOU.

SECTION 2. ATTRIBUTE IMPORTANCE: CONTAINERS
INSTRUCTIONS

In this section of the questionnaire we would like to know how important each of the following attributes is to you for a device that contains and transports food or drink. We've listed a large number of attributes because we're testing a method for providing engineers with very detailed market data. Please be sure to tell us how important the attributes are and not whether the food or drink carrying container you own has these attributes.

You will tell us how important each attribute is to you by dividing 100 points or "chips" among a group of attributes. Within each group you can divide the 100 points any way you like, depending on how important you consider each attribute within the group.

Please record the number of points you decide to give each attribute on the line to the left of the attribute. The numbers you assign to the attributes within one group must add to 100. Always give more the important attributes larger numbers and give the less important attributes smaller numbers.

Repeat the process for each group of attributes in the survey. Remember, we are interested in how important each of the attributes is, regardless of whether your container is good or bad on that attribute.

1. How important is each of the following characteristics to you in determining that a carrying container carries many kinds of things?

____ it lets me carry non-food items

____ it lets me carry food items

APPENDIX 7.2. AVERAGE IMPORTANCE VALUES FOR FOOD TRANSPORTERS

PRIMARY ATTRIBUTES SUMMARY

VBLE	ATRIBUTE	ANCHORED	SELF-STATED	CONSTANT SUM	REVEALED PREFERENCE
P1	ATTRACTIVE, GOOD LOOKING CONTAINER	27.5	3.7	5.4	0.14
P2	CONVENIENT	81.3	7.0	16.8	0.07
P3	WORKS WELL AS A CONTAINER	84.3	7.1	13.7	0.27
P4	RIGHT SIZE	71.9	5.9	17.9	0.19
P5	MAINTAINS FOOD TEMPERATURES	61.3	6.5	23.0	0.10
P6	CARRIES MANY KINDS OF THINGS	74.0	5.6	10.4	0.10
P7	EASILY MOVABLE	76.0	6.2	14.3	-0.02

AVERAGE IMPORTANCE VALUES: SECONDARY ATTRIBUTES

ATRIBUTE	ANCHORED	SELF STATED	CONSTANT SUM	CONSTANT SUM CASCADED	REVEALED PREFER-ENCE	HYBRID
CONTAINER DOESN'T CAUSE PROBLEMS	22.0	7.2	1.2	1.6	0.43	7.5
CONTAINER IS DURABLE	23.1	7.5	1.7	2.2	0.04	8.1
ELEGANT DESIGN	14.4	3.0	1.5	2.0	0.05	4.2
REASONABLY PRICED	20.9	6.9	0.9	1.1	-0.30	6.8
EASY TO USE	78.7	6.6	8.0	10.7	-0.16	0.0
LID WORKS WELL	63.3	6.5	3.8	5.1	-0.14	0.0
EASY TO DRAIN OUT EXCESS WATER	40.4	5.8	2.5	3.3	0.16	0.0
CONTAINER IS ORGANIZED, NEAT	45.7	5.3	2.5	3.3	0.06	0.0
CONTAINER DOESN'T LEAK	73.8	7.4	4.6	7.7	-0.07	87.3
CONTAINER SEPARATES THINGS	42.6	4.0	1.1	1.9	-0.06	47.3
CONTAINER PROTECTS THINGS	63.0	5.9	3.9	6.6	0.18	76.0
EVERYTHING FITS IN ONE CONTAINER	67.7	5.3	2.6	4.4	0.11	78.3
CONTAINER SERVES MULTIPLE PURPOSES	61.5	5.0	1.4	2.3	-0.04	73.1
EFFICIENT USE OF SPACE	61.9	6.8	6.2	6.2	0.12	32.2
SUITABLE FOR YEAR-ROUND USE	54.4	6.5	3.2	3.2	-0.20	26.9
USEFUL FOR TRAVELING	67.4	7.0	7.6	7.6	0.06	33.9
USES A CONVENIENT COOLING MECHANISM	55.5	5.4	15.9	10.6	0.12	0.0
TEMPERATURE IS CONTROLLABLE	22.5	3.3	6.1	4.0	0.13	0.0
LETS ME CARRY NON-FOOD ITEMS	30.4	4.0	5.1	3.4	0.11	0.0
LETS ME CARRY FOOD ITEMS	64.7	7.0	5.3	3.5	0.26	0.0
EASY TO TRANSPORT	57.1	6.2	5.6	3.7	0.13	0.0
CONVENIENT TO CARRY	71.0	6.6	8.7	5.8	0.19	0.0

APPENDIX 7.2. TERTIARY ATTRIBUTE IMPORTANCES

AVERAGE IMPORTANCE VALUES: TERTIARY ATTRIBUTES

	CONSTANT SUM	CONSTANT SUM CASCADED	SELF STATED	ANCHORED	HYBRID
made of non-toxic materials	3.1	2.7	6.0	16.4	5.6
bumping into the container doe	1.6	1.4	5.0	17.7	5.1
container doesn't snag on thin	2.1	1.7	5.5	18.4	5.6
container has no sharp edges	2.2	2.1	5.1	18.9	5.8
doesn't squeak when it rubs	0.7	0.8	3.9	13.5	2.9
container is rugged	2.2	4.8	6.3	19.9	6.6
container needs no maintenance	1.7	2.8	6.7	18.3	5.7
lasts over 10 years	0.4	1.2	6.1	14.2	4.7
can use container for more tha	1.2	2.6	6.9	19.5	5.9
container doesn't break when d	1.8	4.0	7.6	20.8	7.3
container doesn't dent	0.9	1.5	5.7	16.4	5.3
container is not easily punctu	0.6	1.7	6.0	18.4	6.5
shock proof	0.8	1.7	5.9	13.3	4.5
structurally rigid	1.0	2.0	5.5	15.5	4.3
can pick my container out in a	3.1	2.2	3.7	7.5	1.7
container stays clean looking	2.7	2.0	5.4	13.1	3.8
contemporary design	6.7	4.5	2.6	9.4	2.4
natural looking	0.3	0.2	2.7	6.9	1.8
good price for the performance	3.4	1.3	7.1	19.0	5.8
inexpensive over the long run	3.7	1.3	7.0	19.7	6.2
container needs no preparation	10.8	86.8	5.9	66.2	0.0
easy for children to use	0.5	44.1	3.5	22.6	0.0
easy to clean	16.7	58.8	6.9	59.8	0.0
container opens easily	12.5	3.8	6.2	67.1	0.0
can close container with one h	2.9	76.4	4.7	44.5	0.0
container closes easily	14.3	48.7	6.4	63.5	0.0
easy access with one hand	2.8	20.0	5.2	53.0	0.0
easy to dispose of	1.2	74.2	2.2	26.4	0.0
can't lose any container piece	2.2	3.7	5.7	37.9	0.0
lid locks open	1.0	1.6	4.0	30.3	0.0
lid can't be lost	3.5	4.7	6.0	38.1	0.0
lid remains attached to cooler	2.2	3.2	5.5	29.8	0.0
lid is leak-proof	7.5	10.4	6.6	57.3	0.0
lid stays closed when containe	8.1	10.3	6.6	60.4	0.0
lid locks shut	4.5	5.4	5.1	50.7	0.0
drain mechanism doesn't clog	4.3	3.3	5.1	53.0	0.0
drain cap/plug can't get lost	4.9	3.9	5.8	34.4	0.0
drain out water without tiltin	5.8	3.7	4.2	30.7	0.0
excess water drains out qickly	4.8	3.7	5.5	31.8	0.0
doesn't let me forget items	1.1	2.0	2.7	8.6	0.0
option to get into one section	1.4	3.5	3.8	24.3	0.0
remove things without disturbi	1.5	3.5	4.9	31.3	0.0
see everything at once	0.4	0.8	4.1	23.2	0.0
multiple entries into containe	0.7	1.3	3.0	21.8	0.0
access to all food without unp	2.6	5.4	5.3	34.9	0.0
can be packed quickly	2.7	5.7	5.5	33.1	0.0
can find things easily	2.1	5.5	4.6	38.7	0.0
can get in and out quickly	2.4	5.5	5.5	37.4	0.0
easy to get things out	2.5	4.8	5.4	37.0	0.0
easy to tell what's in the con	1.3	2.7	3.9	33.1	0.0
hands don't get cold looking f	0.8	1.4	3.7	17.8	0.0

APPENDIX 7.2. (Continued)

AVERAGE IMPORTANCE VALUES: TERTIARY ATTRIBUTES

	CONSTANT SUM	CONSTANT SUM CASCADED	SELF STATED	ANCHORED	HYBRID
adapts to what I'm taking	3.2	6.3	5.0	40.3	19.5
big enough to carry food for f	3.5	7.3	4.7	30.6	14.0
can store container in kitchen	0.4	0.9	3.6	28.1	13.1
compresses for storage	2.3	4.9	3.5	27.9	13.6
container folds up	0.3	0.6	3.3	27.5	13.0
can use during a football game	2.0	1.1	2.8	17.6	9.4
useful for romantic picnics	5.3	3.5	3.8	24.8	12.1
useful on a car trip	7.7	4.8	6.4	47.7	23.6
useful on a boat	5.6	3.1	3.4	17.9	9.7
useful on bike ride	2.7	1.5	3.5	24.4	11.6
can be attached to vehicles	0.4	0.3	2.9	23.3	11.9
can be put inside a back pack	4.1	11.2	3.0	41.7	21.5
easy to handle in the car	10.3	16.4	6.2	49.6	24.1
easy to use in a car	15.6	12.4	6.0	50.7	25.0
fits in a car trunk	10.2	8.2	7.2	53.1	25.7
fits on the floor of a car's b	8.6	10.6	4.3	49.3	24.0
fits on a car's front seat	4.3	3.3	3.8	43.2	20.3
add additional coolant quickly	5.9	7.8	5.2	25.2	0.0
cooling material takes up a mi	10.1	12.1	5.6	39.1	0.0
cooling material is cheap	9.4	15.5	5.1	39.2	0.0
don't have to refreeze coolant	12.1	15.0	4.8	24.0	0.0
no loose ice inside container	5.1	6.1	3.5	21.8	0.0
resistant to dry ice temperatu	2.2	2.6	4.0	24.5	0.0
reusable coolant	9.9	11.7	4.7	30.9	0.0
uses something other than ice	3.1	4.0	3.2	18.4	0.0
can add coolant without repack	15.8	19.6	4.8	30.6	0.0
can use a packaged coolant	11.1	14.0	5.2	28.2	0.0
can use dry ice as a coolant	1.2	3.6	3.4	28.3	0.0
can use ice cubes as coolant	10.2	16.5	6.0	45.2	0.0
contains a cooling mechanism	5.0	6.2	4.0	13.1	0.0
coolant is not in the way	12.9	15.5	4.6	29.9	0.0
cooling material doesn't soak	11.8	15.0	7.0	44.5	0.0
coolant is not messy	6.0	8.2	6.7	41.5	0.0
keeps different things at diff	7.8	7.5	3.5	8.4	0.0
keeps cold air in when open	1.0	1.1	4.3	13.3	0.0
keeps food cold all day	7.2	7.4	7.0	20.5	0.0
keeps food warm for 2 or 3 hou	0.3	0.6	4.4	13.2	0.0
keeps warm food warm	6.8	6.7	4.7	13.0	0.0
contains a food heating capabi	0.4	0.4	2.4	7.0	0.0
container is very well insulat	11.9	13.7	7.0	20.3	0.0
keeps food cold	10.8	10.7	7.1	20.3	0.0
can warm drinks up	0.0	0.0	2.2	4.9	0.0
cool air stays inside containe	5.8	5.9	5.3	14.7	0.0
cools foods fast	1.2	1.1	4.8	10.0	0.0
cools effectively	2.7	2.6	6.4	12.5	0.0
even temperature kept througho	0.6	0.6	4.9	12.1	0.0
accomodates tall glasses	0.3	0.4	2.6	8.0	0.0
holds an umbrella	0.0	2.8	1.6	17.5	0.0
lets me carry a tablecloth	1.9	5.2	2.1	7.3	0.0
lets me carry a thermos	11.5	10.1	3.9	27.7	0.0
lets me carry glass items	0.4	1.2	4.0	9.8	0.0

APPENDIX 7.2. (Continued)

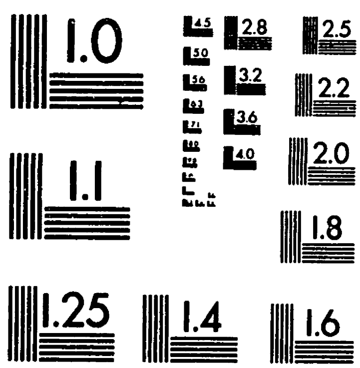
AVERAGE IMPORTANCE VALUES: TERTIARY ATTRIBUTES

	CONSTANT SUM	CONSTANT SUM CASCADED	SELF STATED	ANCHORED	HYBRID
waterproof	6.4	8.2	6.8	63.4	76.7
accomodates leakproof storage	6.1	8.0	5.2	49.1	58.6
container does not sweat	5.8	7.5	5.2	42.5	50.9
container is waterproof	11.8	17.0	7.4	60.4	74.4
container keeps sand out	6.7	8.8	5.7	49.0	53.3
container keeps hot liquids fr	3.3	5.4	4.7	52.1	63.6
leak-proof section for non-foo	3.7	4.8	5.0	34.7	36.3
adjust size of hot and cold se	0.2	0.4	3.2	16.4	18.0
segregates warm food from cold	1.5	3.1	4.0	21.2	24.7
separates food from coolant	2.1	4.4	4.8	23.2	26.4
container keeps some items dry	1.6	3.3	5.9	39.6	42.3
ice storage space	1.1	2.3	4.7	24.7	26.8
keeps food from tasting differ	0.5	1.0	6.7	27.4	29.4
keeps food from getting soggy	1.3	2.6	6.4	34.5	37.1
keeps odors in; contains smell	0.6	1.8	4.3	16.1	17.0
keeps hot stuff where kids can	0.0	0.0	2.7	6.0	7.4
minimum room taken by insulati	0.2	0.4	5.4	25.0	27.1
prevent food from spoiling	0.9	1.8	7.0	30.7	34.6
prevent mess inside	3.2	5.3	5.8	52.5	65.0
protection for glass/breakable	5.0	10.3	5.6	34.3	41.7
keeps bottles from touching on	0.3	0.5	2.8	21.4	24.8
keeps food off the ground	2.3	3.8	5.3	42.5	46.3
objects don't rattle around	3.9	6.5	4.9	28.4	34.3
prevent food from being crushe	7.0	14.3	6.1	50.7	62.7
prevent liquid from spilling	6.7	11.2	6.3	47.3	58.2
protect fragile foods	2.9	4.8	5.8	37.3	48.6
separate wet items from dry	4.9	8.5	5.0	37.9	47.1
carries tupperware efficiently	11.7	10.8	4.4	49.9	58.5
hides beer at prohibited area	3.5	3.3	2.6	17.1	20.6
has external storage areas	2.9	2.7	3.5	26.1	30.1
matching utensils/cups/etc.	1.0	0.9	2.2	5.2	7.2
utensils stored separately	1.4	1.3	2.7	9.5	11.4
can sit on the container	3.8	5.0	2.8	33.7	40.8
can use the container as a tab	3.6	4.6	3.9	32.2	42.6
container has place to set dri	0.6	0.8	3.9	33.6	40.5
has a workspace to prepare foo	1.4	1.8	3.3	25.1	34.2
right size for sitting on	1.6	2.0	3.5	31.3	38.1
stable shelf/work area	0.8	1.1	3.4	29.2	36.3
store other things in containe	1.9	2.4	3.9	37.6	41.4
flexible design	2.5	5.2	3.7	38.6	18.5
container expands	2.1	4.1	3.3	23.9	11.7
container is compact	2.8	5.7	5.3	37.6	18.5
container is stackable	1.3	2.7	4.2	29.1	13.3
container stores compactly	2.0	4.1	6.1	44.6	21.4
flexible construction	1.5	3.0	3.9	34.0	17.1
minimal external space taken u	6.8	13.8	5.5	52.5	26.5
shape doesn't waste space	15.5	31.1	5.4	53.8	26.5
size adjusts to the amount of	4.8	9.7	3.9	32.8	16.1
adjustable in size	3.4	7.0	3.5	32.9	16.0
easy to store container	5.3	10.9	5.3	45.8	21.6
fits into almost any space	1.2	2.5	4.6	39.2	18.7

APPENDIX 7.2. (Continued)

AVERAGE IMPORTANCE VALUES: TERTIARY ATTRIBUTES

	CONSTANT SUM	CONSTANT SUM CASCADED	SELF STATED	ANCHORED	HYBRID
lets me carry plates	3.0	5.3	3.0	9.7	0.0
lets me carry paper goods (pla	5.7	7.9	3.3	18.9	0.0
lets me carry real silverware	1.9	1.5	2.1	10.0	0.0
self-contained; glasses, cups,	0.9	0.6	2.0	7.9	0.0
carries 12-24 drink cans	2.7	2.8	3.8	21.0	0.0
lets me carry rice balls	0.6	0.9	1.8	10.1	0.0
lets me carry salt/pepper	0.0	2.5	3.1	14.6	0.0
lets me carry salads	2.8	5.7	4.3	30.9	0.0
lets me carry wine bottles	2.4	2.8	4.2	16.8	0.0
lets me carry sandwiches	5.1	7.2	6.2	58.8	0.0
carries at least 6 drink cans	3.6	7.4	6.0	41.9	0.0
lets me carry bread	1.9	2.3	3.4	35.5	0.0
lets me carry chips & crackers	1.1	1.5	3.6	30.4	0.0
lets me carry cans	1.7	1.8	5.5	46.1	0.0
lets me carry fruit	5.3	9.6	6.1	53.4	0.0
lets me carry drinks	4.3	4.8	6.1	61.0	0.0
lets me carry ice cream home f	1.0	1.4	3.8	15.9	0.0
lets me carry ice for drinks	4.4	4.6	5.4	30.5	0.0
carryable by a 7-year old	0.5	0.5	2.1	17.4	0.0
can get a good grip on contain	7.8	7.4	6.7	48.4	0.0
won't slide during transport	2.1	2.3	4.9	30.9	0.0
carrying mechanisms are rigid	2.5	2.4	4.8	28.0	0.0
carrying mechanisms don't brea	9.2	8.5	7.4	52.3	0.0
container doesn't slip around	1.6	1.3	5.0	29.2	0.0
food is balanced for carrying	3.8	3.2	5.5	27.7	0.0
lightweight	9.9	8.5	6.3	52.9	0.0
means for carrying doesn't int	6.5	5.9	5.8	31.8	0.0
means of carrying moves out of	1.9	1.7	4.4	26.9	0.0
won't flip over during transpo	3.1	3.4	6.5	36.7	0.0
easy to carry	8.8	14.9	7.1	63.9	0.0
carryable by one person for 15	4.8	9.7	6.8	54.7	0.0
carryable with one hand	4.9	8.3	6.3	53.4	0.0
comfortable in my hand	2.5	3.6	5.4	58.7	0.0
container can be carried sever	2.5	8.1	4.1	45.9	0.0
container molds to leg when ca	0.0	0.2	2.6	22.3	0.0
does not bang into you when ca	4.6	7.1	5.8	49.3	0.0
minimum effort to move contain	1.5	2.8	5.5	49.7	0.0
not clumsy to carry	10.5	15.2	6.0	64.3	0.0
one or two persons can carry	1.6	2.2	6.3	32.6	0.0
two persons can carry the cont	0.2	0.3	4.8	25.3	0.0
comfortable to carry	9.2	18.0	6.2	64.7	0.0
can carry container in front o	0.3	0.4	3.1	38.4	0.0
can carry container at my side	4.4	6.8	4.9	36.2	0.0
can carry container like a sho	3.5	5.2	4.0	37.6	0.0
can carry container in hand or	3.3	4.7	4.8	47.2	0.0
can carry container without us	2.8	6.5	2.9	40.1	0.0
can carry container on my back	3.3	4.7	3.2	39.8	0.0
can move container without car	0.9	1.2	3.2	22.3	0.0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