

# DETERMINANT ATTRIBUTE ANALYSIS: A TOOL FOR NEW WOOD PRODUCT DEVELOPMENT

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## ABSTRACT

Determinant attribute analysis was employed to identify the physical product characteristics most crucial in the purchase decision process for office furniture substrate materials. Fastener withdrawal strength, surface smoothness, flatness, stiffness (MOE), and edgbanding capability had the most effect on selection decisions. These results were then viewed in terms of the development of a new substrate product and the opportunities that could arise from achieving a superior competitive advantage based on those characteristics. The importance of recognizing customer needs in the new product development process is central to the analysis, and the potential of determinant attribute analysis as a powerful tool for this process is demonstrated.

*Keywords:* Attribute analysis, new products, spaceboard, furniture substrate materials.

## INTRODUCTION

The development of many new wood products has been driven by resource availability, resource cost, and technology—not by customer needs (Rosenberg et al. 1990). This process, while perhaps a rational one for the wood products industry, is counter to the marketing concept where customer needs are the driving force (Levitt 1965). Resource and production factors drive innovation and most new wood product development, while customer needs are typically a secondary concern.

However, in today's increasingly competitive marketplace, understanding the needs of customers and potential customers is becoming more and more essential to success (Day et al. 1979; Cooper 1988; Link 1987; Cooper and Kleinschmidt 1987; Porter 1980). Every product can be viewed as possessing a collection of characteristics or attributes that impact its commercial success. These characteristics may be physical and measurable such as modulus of elasticity, market-related as in the case of price, or more nebulous characteristics such as quality or value.

Our increasing ability to alter the physical characteristics of new products through ad-

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justments in the manufacturing process offers the opportunity to put customer needs back into the forefront of new product development in the wood products industry.

To guide product development more efficiently, efforts should be concentrated on the characteristics that most influence purchase decisions. These characteristics have become known as "determinant attributes." Determinant attributes are those characteristics of a product (or product class) that are not only important to the purchasers of the product, but also vary enough between substitute products and/or suppliers to differentiate them from each other. In other words, if price is important but all substitutes are priced essentially the same, then price is not a differentiating characteristic and is, therefore, not determinant. Service life, on the other hand, may not be as important as price, but may vary greatly between substitutes and consequently has a greater influence, or greater "determinance," on the purchase decision. In automobiles, steering wheels are very important features, but since most cars have steering wheels, that feature rarely drives purchase decisions. By understanding the determinant attributes for products in a given market, competitive advantage may be gained by capitalizing on these attributes when developing new products.

A relative newcomer in the long line of resource/technology driven forest products is FPL Spaceboard II. It is one of a new family of molded fiberboard panel products whose development was driven by a U.S. Forest Service desire to better utilize wood fibers from low-value timber species. The basic product is adaptable to a wide variety of situations by varying the physical properties of the panels to meet users' needs. For the product developer, the question is, "Which properties most influence the purchase decisions of my potential customers?" These are the obvious focal points for development efforts.

The product developers' problem with Spaceboard II is used as an example of how determinant attribute analysis can aid in the development of new wood products.

## METHODS

### *Selection of target market*

Since the critical properties (i.e., determinant attributes) of a product are dependent upon the end-use market, it was necessary to select an end-use market for Spaceboard II. A modification of the market attractiveness/competitive position matrix developed jointly by McKinsey and General Electric in the early 1970s was used as a guideline to help structure the selection process (Day 1986). In selecting an end-use or target market, two objectives were kept in mind. First, the market itself should be attractive, not only to business ventures in general, but also as an outlet for new technologies and products. Second, the market should be one in which the new product has, or could potentially have, a competitive advantage against existing products.

Seven potential product/markets<sup>2</sup> chosen in consultation with the developing scientists were qualitatively investigated along those guidelines. Interior doors, mobile home components, modular and prefabricated housing components, household furniture, office furniture, and movable office partitions were all considered as potential venues for the introduction of Spaceboard.

The stage of the product life cycle, as proposed by Levitt (1965), was used as a surrogate for market attractiveness. In turn, market characteristics such as growth, product differentiation, and estimated technological innovativeness of the firms within the market were used to position each product/market in terms of attractiveness.

Competitive advantage was gauged in terms of Spaceboard's theoretical performance in comparison to existing products currently used in a particular application. For each product/market, performance needs were quite varied, so relative comparisons were necessary. In each case, Spaceboard's theoretical capabilities were estimated as anywhere from "strongly superior

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<sup>2</sup> Combination of target market and currently existing products in that market.

to” to “strongly inferior to” existing materials in the product/market.<sup>3</sup> Following this preliminary examination, consultation with the product development scientists<sup>4</sup> led to the selection of the office furniture substrate market as the focus of further research.

#### *Attribute selection*

The selection of attributes for the analysis had three basic requirements. The attributes needed to be physical characteristics of substrate materials affected by design and processes, the number of attributes had to be large enough to allow differentiation among themselves, and the attributes needed to be stated in relatively familiar terms. Several sources were used to compile the list of attributes. Wood technology textbooks, previous research into panel characteristics, and discussions with the product development scientists formed the basis of the list (Suchsland and Good 1968; Hunt and Gunderson 1988; Setterholm 1985; Bodig and Jayne 1982). Interviews with office furniture manufacturers and wood composite specialists were used to refine the final list of 18 attributes as shown in Table 1.

#### *Data collection*

The sample frame in this study was large manufacturers of office and institutional furniture. Larger firms are more likely to use mass-production processes that typically involve substrate/laminate-type construction central to the use of Spaceboard II. These larger firms would, therefore, be essential to the eventual adoption or rejection of a new substrate product.

The identification of office furniture manufacturers began with the FDM Top 300 list, and was cross-referenced with the Secondary

TABLE 1. *Importance of physical attributes of table and desktop substrates to office furniture manufacturers.*

Attributes	Standard deviation	Mean importance <sup>1</sup>
Flatness	0.88	6.00
Surface smoothness	1.19	5.91
Edgebanding capability	1.32	5.91
Fastener withdrawal strength	1.16	5.76
Gluability	1.36	5.74
Dimensional stability	1.22	5.64
Internal bond strength	1.22	5.45
Compatibility with mfg. system	1.62	5.38
Stress relaxation (creep)	1.22	5.24
Loss of smoothness with humidity	1.68	5.19
Stiffness (MOE)	1.48	5.17
Breaking strength (MOR)	1.40	5.12
Loss of strength with humidity	1.64	4.98
Loss of stiffness with humidity	1.58	4.97
Machinability	1.61	4.72
Overall density	1.57	4.62
Strength to weight ratio	1.46	4.22
Fire resistance	1.96	3.69

<sup>1</sup> Scale of 1 to 7: 1 = somewhat important; 7 = absolutely critical.

Wood Products Manufacturers Directory (Furniture Design and Manufacturing 1990; Miller Freeman 1989). Each firm was personally contacted by telephone to confirm its potential as a user of a new wood-based furniture substrate material and to identify the person in the firm best qualified to answer a survey.

A total of 69 office furniture manufacturers were identified from the directories and subsequent telephone conversations as current users of MDF or particleboard substrate materials making them potential users of FPL Spaceboard II as a substrate. The surveys were sent by facsimile to the identified person at each firm, to be returned in the same manner. Follow-up telephone calls were made at one-week intervals after the initial distribution. Fifty-eight manufacturers completed and returned the questionnaire for a response rate of 84%.

#### *Determinant attribute analysis*

The direct dual-questioning approach was used to develop the determinant attributes. This technique (described by Myers and Alpert [1968], and Alpert [1971]) has been used in several studies including Bearden (1977);

<sup>3</sup> The “State-of-the-Art” analysis technique as proposed by Gordon and Munson (1981) can be used to quantitatively compare the attributes of the new product with the attributes of existing products performing the same tasks.

<sup>4</sup> Product development scientists were the scientists directly involved with the development of Spaceboard at the Forest Products Laboratory.

Lumpkin et al. (1985); and Moriarty and Reibstein (1986). For each attribute, the respondents were asked to rate the attribute in terms of its importance, and also to rate its variability among existing products.

Ratings of the importance of the attributes were combined with ratings of perceived differences among existing products using a multiplicative model as shown in Eq. (1) (Alpert 1971; Anderson et al. 1976; Bearden 1977):

$$D_{ij} = I_{ij}Y_{ij} \quad (1)$$

where

$D_{ij}$  = determinance score for attribute  $i$  and respondent  $j$

$I_{ij}$  = importance rating for attribute  $i$  and respondent  $j$

and

$Y_{ij}$  = variability rating for attribute  $i$  and respondent  $j$

The multiplicative model was suggested by Moriarty and Reibstein (1986) to be superior to an additive model for this purpose because of the implied relationship between the importances and variabilities of the attributes.

The determinance scores ( $D_{ij}$ ) resulting from this calculation may be biased since respondents may differ in the intrinsic attitude scales that they utilize (Moriarty and Reibstein 1986; Bass and Wilkie 1973). In other words, "strongly agree" may not imply the same absolute agreement to a statement for different respondents. Furthermore, those intrinsic scales may not result in interval level responses; the difference between "agree" and "strongly agree" may be different for different respondents (Franke 1985). The same logic applies directly to the variability scores.

Assuming that an individual respondent would use both the importance and variability scales in the same manner, the resulting determinance scores should reflect the bias and may be dealt with accordingly. To compensate for this potential bias, the resulting determinance scores for each respondent were "row-

centered" to a mean of zero using Eq. (2) (Schaninger and Buss 1986; Howell 1987):

$$DN_{ij} = (D_{ij} - \bar{X}_j) \quad (2)$$

where

$DN_{ij}$  = normalized determinance score for attribute  $i$  and respondent  $j$

$\bar{X}_j$  = mean value of  $D_{ij}$  for all  $i$  of respondent  $j$ .

This transformation is preferred because response bias is reduced and the variability within individual respondents is preserved (Green and Carmone 1978).

## RESULTS

### *Importance*

Office furniture manufacturers rated the importance of the eighteen attributes of substrate materials on an interval scale from 1 ("Somewhat Important") to 7 ("Absolutely Critical"). The mean responses for each are shown in ranked order from highest importance to lowest in Table 1. Flatness, the capability of the material to be edgebanded, and surface smoothness were found to be the most important physical characteristics when selecting substrate materials for purchase.

### *Variability*

Office furniture manufacturers also rated the variability of available substrate materials on the same eighteen attributes. Ratings ranged from 1 ("All about the Same") to 5 ("Highly Variable"). Overall density, fastener withdrawal strength, and machinability were perceived to be the most variable of the product characteristics among currently available substrate materials (Table 2).

### *Determinance*

To develop determinance scores, the importance rating for each attribute was weighted by the variability rating for that attribute for each respondent. The determinance scores for each attribute and respondent were then "row-centered," or adjusted to a mean of zero

TABLE 2. Variability ratings on physical attributes of substrate materials by office furniture manufacturers.

Attribute	Standard deviation	Mean variability <sup>1</sup>
Overall density	1.26	3.20
Fastener withdrawal strength	1.36	3.17
Machinability	1.26	3.04
Stiffness (MOE)	1.38	2.98
Breaking strength (MOR)	1.37	2.98
Surface smoothness	1.26	2.96
Internal bond strength	1.30	2.77
Flatness	1.24	2.76
Edgebanding capability	1.22	2.74
Strength to weight ratio	1.25	2.68
Gluability	1.21	2.60
Stress relaxation (creep)	1.09	2.56
Fire resistance	1.32	2.49
Dimensional stability	1.19	2.46
Loss of smoothness with humidity	1.15	2.38
Loss of strength with humidity	1.11	2.32
Compatibility with mfg. system	1.17	2.30
Loss of stiffness with humidity	1.09	2.26

<sup>1</sup> Scale of 1 to 5: 1 = all products about the same; 5 = highly variable.

TABLE 3. Mean row-centered determinance scores for physical attributes of table and desktop substrate materials.

Attributes	Standard deviation	Mean determinance <sup>1</sup>
Fastener withdrawal strength	5.56	3.54
Surface smoothness	6.49	3.52
Flatness	6.07	2.27
Stiffness (MOE)	4.29	1.92
Edgebanding capability	5.61	1.35
Internal bond strength	6.35	0.95
Breaking strength (MOR)	5.74	0.94
Machinability	7.46	0.65
Gluability	6.69	0.52
Overall density	5.50	0.52
Dimensional stability	5.31	-0.20
Stress relaxation (creep)	4.61	-0.76
Loss of smoothness with humidity	4.67	-1.67
Compatibility with mfg. system	5.15	-1.80
Loss of strength with humidity	4.07	-2.20
Loss of stiffness with humidity	4.29	-2.52
Strength to weight ratio	3.89	-2.73
Fire resistance	7.68	-4.31

<sup>1</sup> Mean overall score is 0. Scores above 0 have more impact on purchase decisions than scores below.

(Schaninger and Buss 1986). Mean determinance scores were then calculated for the product attributes across respondents (Table 3).

The Tukey HSD multiple comparison test at the 0.05 level (Howell 1987) was then employed to select the group of attributes most determinant to the material selection process. Attributes that were included in groups (based on the Tukey test) falling wholly or partly above the mean of all the attribute scores were considered to be the most determinant. Fastener withdrawal strength, surface smoothness, panel flatness, panel stiffness (MOE), and edgebanding capability emerged as the substrate material attributes that most affect purchasing decisions.

#### DISCUSSION

Determinant attribute analysis calls attention to product characteristics (attributes) that can be manipulated by design and manufacturing processes to provide a competitive advantage and set the stage for commercial success by a new product in the marketplace. Product developers must be aware not only of the relative determinance of specific physical

characteristics in affecting purchase decisions, but also of the importance and variability that combine to achieve determinance.

In the Spaceboard/office furniture example, the physical characteristics of flatness, surface smoothness, edgebanding capability, and fastener withdrawal strength were the most important. Any characteristic scoring high in importance is perceived as being critical to the performance of the product and must obviously be accounted for in the design process. Although flatness is not a characteristic that readily differentiates existing products competing in the office furniture substrate market, any product that would enter the market as a substitute must be designed to meet the requirements of the market in terms of flatness at least to the level of existing products.

Interpretation of the variability of the product characteristics allows for even greater opportunities in new product development. A high variability rating may mean that currently available products may be easily differentiated and that some products are clearly superior in terms of a given physical characteristic. Fas-

tener withdrawal strength, for example, again ranks highly in terms of variability. In this case, a product with high design values for this characteristic/attribute would have a competitive advantage over most existing substrate materials.

Clearly, product characteristics that rank highly in terms of determinance offer the most obvious opportunities for new product developers. High determinance scores indicate that the characteristics are not only important in terms of purchase decisions, but also that enough variability exists between existing products that superiority on those characteristics will lead directly to a competitive advantage in the marketplace for a new product. In the case of office furniture substrates, a new product developed to have superior fastener withdrawal strength for stronger and more durable construction, better edgebanding capability to meet changing design requirements, and a higher quality surface to meet the requirements of today's laminates should certainly have a competitive advantage in the marketplace.

Remembering that *perceived* characteristics are central to this analysis, further opportunities from a marketing standpoint exist for successful new product introduction. Consider the potential for a new substrate material that has superior and consistent machining characteristics. At this time, machinability has limited persuasive power in an office furniture substrate selection decision (ranked 8th in terms of determinance). The culprit is a relatively low perceived importance associated with that feature. If a producer of substrates was able to demonstrate to its customers that improved machinability would give them a competitive advantage, *and* that its product could consistently provide that improved machinability at a reasonable cost, the producer should enjoy a strong competitive advantage of its own in the marketplace.

New product design is only one of many applications of determinant attribute analysis that can be valuable to the wood products industry. Most importantly, it allows firms to

look beyond resource-driven technology and put market needs into the forefront of new product development.

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