

# Developments in Business Simulation & Experiential Exercises, Volume 11, 1984

## USING SPATIAL RELATIONSHIPS TO ESTIMATE DEMAND IN BUSINESS SIMULATIONS

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### ABSTRACT

This paper presents an additional, approach to modeling and simulation that combines the economic factors with a set of physical, product characteristics factors to determine the allocation of demand to the competing firms. The product characteristics are modeled using a growth flow model. A market segment is defined which desires an ideal, or best product based on the characteristics of the product. Although all products are purchased, the amount demanded is a function of the difference between each actual product and the ideal, product. This paper then expands the concept from a single market, multi-firm-single product model, to a multiple market segment mode' in which each firm has the capability to produce several, different products.

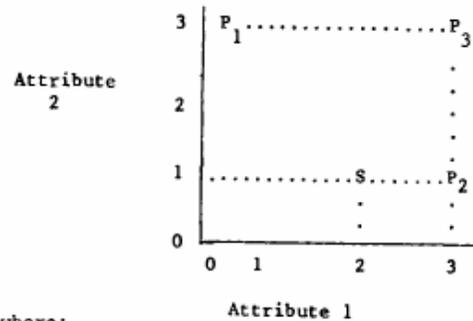
### The Model.

Most business simulations have been developed to represent competitive firms in an oligopoly where all firms start with equal, asset structures and sales. Substantial, care has been taken to develop demand equations that represent kinked demand curves with appropriate industry and firm price and other marketing variable elasticities. Last year at the ABSGL meeting, Gold and Pray reported on a set of generalized econometric equations that would be suitable for the majority of business simulations.<sup>2</sup>

Most of these models represent pure oligopolies. That is, where a few firms are sellers of a homogeneous commodity to a large number of buyers. Almost, if not all, consumer goods and the vast majority of industrial, products are differentiated from one another. This differentiation usually takes the form of differences in physical, characteristics, product attributes, packaging, brand names, etc. This fact of expected product differentiation has been recognized by authors.<sup>3</sup> However, with the exception of Markstrat, these simulations all have compensatory demand functions.<sup>4</sup> Excessive expenditures on one variable in the marketing mix will, compensate in the demand function for underspending on another variable in the marketing mix. There are numerous examples of products that failed in the market place, in spite of heavy expenditures on the marketing mix because they did not provide the product attributes demanded in the market place (the Edsel for example). Most of the multiproduct, and multiattribute product simulation approach this problem in a variety of ways. What is described in this paper is a generalized method to represent demand for products that includes competitive market response for the marketing mix variables as well, as a competitive market response for desired product attributes.

A model, known as gravity flow works well to describe choice behavior in a situation where product attributes are both continuous and independent. As an example, consider a single market segment  $S_i$  ( $L=1$ ) a three firm simulation, with each firm producing one product  $P_j$  ( $j=1,2,3$ ); and a two attribute space  $A_k$  ( $k=1,2$ )  $P_j^1 A^1 A^2$  is then the two tuple attribute combination for product  $P_j$  and  $S_i^1 A^1 A^2$  is the ideal point or most desired product in the market.

This can be shown graphically in two dimensions as:



where:

$S = 2,1$   
 $P_1 = 0,3$   
 $P_2 = 3,1$   
 $P_3 = 3,3$

If one uses the standard gravity flow mode' in which the attraction of product  $P_j$  is inversely proportional, its distance from  $S$  is then:

$$d_{S_i P_j} = \sqrt{\sum_{k=1}^M (A_{S_i}^k - A_{P_j}^k)^2}$$

Where:

- $d_{S_i P_j}$  is the distance between the ideal, product for segment  $S_i$  and the actual, product  $j$ ,
- $M$  is the number of attributes, and
- $r$  is the distance function. If  $r=2$ , then Euclidean distance is used. If  $r=1$ , then city block distance is used. While any value of  $r$  can be used,  $r=2$  or  $1$  is recommended.

From the example using  $r=2$ ;

$$d_{S_1 P_1} = \sqrt{2^2 + 2^2} = 2.63$$

$$d_{S_1 P_2} = \sqrt{0^2 + 1^2} = 1.00$$

$$d_{S_1 P_3} = \sqrt{1^2 + 2^2} = 2.24.$$

The inverse of these distances are  $1/d$  or

$$1/2.63 = .38;$$

$$1/1 = 1.00;$$

$$1/2.24 = .45;$$

and the corresponding market shares due to product differentiation would be  $(1/d_j) / \sum_{i=1}^M (1/d_i)$  for product  $j$  where  $M$  = the number of products.

From the example, the shares are:

$$P_1 = .38 / 1.83 = .21$$

$$P_2 = 1.00 / 1.83 = .54; \text{ and}$$

$$P_3 = .45 / 1.83 = .25$$

To determine the size of the market segment  $S$ , use the market demand equation described by Gold and Pray (1983).

To determine the actual demand for each firm, the results of the market share as derived by product attributes are averaged in a weighted fashion with the market shares as derived by the

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firm demand equation described by Gold and Pray (1983). All this requires is a weighting function  $W$  where

$$\begin{aligned} 0 \leq W \leq 1; \text{ and} \\ w_1 + w_2 = 1; \text{ where} \\ w_1 = W \text{ and} \\ w_2 = 1 - w_1 \end{aligned}$$

$W$  determines the proportion of weight placed on the product attributes. If  $AS_i$  is the share based on product attributes and for product  $i$  and  $MMS_i$  is the share based on the marketing mix variables for product  $i$ , then  $MS_i = w_1 \cdot AS_i + w_2 \cdot MMS_i$  is the final, market share for product  $i$ .

Simply multiply this market share by the total market demand to determine the demand for each firm or product. If in the example all these firms had equal expenditures in the marketing mix or balanced compensatory expenditure and if the weighting scheme were equal, or  $W = .50$  then the resulting market shares would be:

$$\begin{aligned} \text{Market Share of } P_1 &= (.5 \cdot .21) + (.5 \cdot .33) = .27; \\ \text{Market Share of } P_2 &= (.5 \cdot .54) + (.5 \cdot .33) = .44; \\ \text{Market Share of } P_3 &= (.5 \cdot .25) + (.5 \cdot .33) = .29. \end{aligned}$$

A problem.

The development of this mode' and the corresponding example appear to work, however, if the ideal, point for a segment and the product attributes of any particular product are exactly the same, the distance between becomes zero and the inverse is undefined. Luckily, there is a simple solution and one that adds versatility to the model. There is nothing limiting the dimensionality of this mode' to two dimensions. The number of dimensions can be defined as one greater than the number of attributes. The extra attribute dimension has a value of zero (0) for each product. The value of the market segment on this dimension can take on any value. The greater the value, the less important product differentiation becomes. This feature becomes more important when additional, market segments exist in the market place. The example can be continued to show the result of defining a third dimension. Each product has the value of zero (0) assigned to this attribute and the market segment has the value of one (1). The distances become:

$$\begin{aligned} d_{S_1 P_1} &= \sqrt{2^2 + 2^2 + 1^2} = 3.00 \\ d_{S_1 P_2} &= \sqrt{0^2 + 1^2 + 1^2} = 1.42 \\ d_{S_1 P_3} &= \sqrt{1^2 + 2^2 + 1^2} = 2.45 \end{aligned}$$

The corresponding shares are

$$\begin{aligned} P_1 &= .33/1.44 = .23; \\ P_2 &= .70/1.44 = .49; \\ P_3 &= .41/1.44 = .28 \end{aligned}$$

The reader can verify that as the market segment value along the extra axis becomes larger, the corresponding market shares asymptotically approach equal shares.

### Relationships Between the Spatial, and Economic Models

The size of the market segment is a direct function of the marketing mix variables. Gross margins which frequently affect the marketing expenditures end the prices can be affected by the product attributes. Let the previous example be defined as a soft drink market which attribute one being sweetness and attribute two

being carbonation level. Assume linear costs of both attributes. Five cents per unit of sweetness and four cents per unit of carbonation should have the effect of altering the optimal prices of the brands. As a result, interaction effects between the spatial and the economic model, can be developed.

Extensions.

The spatial model, has been developed using a single market segment and a set of firms, each producing a single product. Neither of these constraints are necessary. In fact, the spatial, mode' enhances the simulation as firms develop additional, products to meet the demand for multiple market segments. When several, market segments exist in the market place, interesting and realistic strategy problems can be developed and explored.

In order to show the value of these extensions, consider the following possibility. Assume a three market segment situation -- say in the soft drink industry and the product differentiation is based on sweetness and carbonation level.

- Let  $S_1$  represent the teenage market which is not price sensitive but highly sensitive to advertising. This market strongly prefers high sugar drinks with low carbonation.
- $S_2$  represent the adult away from home market which is much smaller than the teenage market, slightly more price sensitive, less sensitive to advertising and have a lot of carry over effects. This market prefers a much less sweet drink and wants more carbonation.
- $S_3$  represent the at home consumption which is highly price conscience with low advertising sensitivity and very long carry over effects but no strong product characteristic requirements.

Also assume each firm can produce multiple products.

Each segment has a Gold-Pray type demand equation with different parameters. The varying in carry over effects can be modeled using different exponential, smoothing values.

Segments  $S_1$  and  $S_2$  are far apart on the two dimensional plane but close to the surface -- (The third dimension equals about one). Segment  $S_3$  would appear in the middle but away from the surface. (The third dimension in this case could equal, four or five.)

A firm could produce products for each market or produce multiple products for a single market. In the same way they could allocate their promotion to any segment but each segment would see the same price structure.

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In conclusion, this hybrid model is simple to implement in modeling and simulations but adds greatly to the realism of the games. Marketing strategies can be developed which are firm specific and different strategies can be successful. Thus, the firms in the simulation do not have to converge to a one best strategy situation.

### FOOTNOTES

<sup>1</sup>For an analysis of eight simulation's demand equations, see Thomas F. Pray and Steven Gold, "Inside the Black Box:" in Development in Business Simulations and Experiential Exercises Vol., 9 Editors David Fritzsche & Lee A. Grof, 1982. pp. 110-115.

<sup>2</sup>Gold and Pray "Simulating Market and Firm Demand - A Robust Demand System" in Development in Business Simulations and Experiential Exercises, Vol. 10 Editors Lee A. Grof and David M. Currie. 1983. pp. 101-106.

<sup>3</sup>Ness and Day, 1978, in Marketing in Action; Faria, Nelson, and Wozine, 1974, in Compete, Brolest and Bush, 1979, in Marketing Simulations; Larreche and Categmon, 1977, in Markstrat and others.

<sup>4</sup>Davis R. Lambret, "On Compensatory Demand Functions in Marketing Simulations, Experiential Learning in the 80's. Editors Daniel C. Brenenstuhl and Williams Biggs, 1980, pp.80-82.