ANOTHER PROCEDURE FOR DETERMINING MARKET DEMAND

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ABSTRACT

In the design of marketing and total enterprise business simulation games perhaps the cornerstone is the determination of demand for the simulation companies' products or services. Numerous mathematical models for demand determination have been published in the general academic literature. Too, of course, the topic has received attention in the realm of simulation gaming. Herein is described an approach to determining demand that, while use is made of functions, is different in kind from a single encompassing mathematical model.

INTRODUCTION

Managers of many business simulation games–notably those games focused on the marketing function, but also total enterprise games–must concern themselves with market demand for their companies' products or services. Simply put, strategy variables such as price and advertising affect demand and decisions for such variables are common among the decision mixes available to game participants. Accordingly, at the heart of the software for such games are procedures for transforming these decisions into unit demand for the respective companies' products or services.

Attention to this "heart" has not been lost on researchers generally (Hanssens, Parsons, & Schultz 2001; Lilien & Kotler 1983, Chapter 4) and business game designers and researchers specifically. The latter is reviewed by Gold & Pray (1990) and is further evidenced by many articles authored by Gold & Goosen and numerous others (e.g., Carvalho 1992; Teach 2000).

The present research puts forth a hybrid procedure different in kind from most earlier algorithms, offering considerable flexibility and control to the game designer. The overall procedure may be summarized as:

- modify selected original demand-affecting decision values to reflect phenomena such as time-related effects, competitors' strategies, decision interactions, etc.
- derive any additional factors affecting demand
- normalize the above within a defined "reasonable range" for each decision and derived factor
- transform the normalized values for a given decision according to a function specified for that decision
- weight the transformed normalized values according to importance in affecting demand
- for each company sum the weighted values for the decisions and derived factors

From this procedure is determined industry-level demand which, in turn, is allocated among individual companies.

CONTINUOUS MARKETING STRATEGY VARIABLES

The basic mix of marketing variables controlled by game managers may be summarized: "Demand is a function of price, as well as a number of non-price factors which include: marketing (i.e., advertising and promotion), product quality (i.e., research and development)...[and other factors not controlled by managers]..." (Gold & Pray 1990, p. 120) Lilien & Kotler (1983, p. 68) are similarly general: "...modeling quantity sold Q as a function of some marketing variables (X_1,...,X_n) where X_1 may be advertising, X_2 price, and so on." Though provision may be made for variables that are not continuous (Hanssens, Parsons, & Schultz 2001, pp. 44-45, 49-59), this is the exception. The procedure presented here likewise commences with continuous variables. However, incorporating qualitative decisions is also illustrated.

Continuous marketing strategy variables comprising the decision mix available to managers in the *Marketing Management Experience* (*MME*, Dickinson 2006) include price, advertising dollar expenditures, number of retail stores, sales force size, cooperative advertising allowance, sales force salary, and sales force commission.

"REASONABLE RANGE" AND NORMALIZING

Initially, original decision values are transformed to reflect competitors' strategies, interactions, and time-related factors (all explained below). This yields temporary decision values that are the basis for determining demand.

The foundation of the present procedure for determining demand is the normalizing of these temporary decision values. For each continuous decision a "reasonable range" is specified. Managers' temporary decision values are transformed to be a proportion of that range, i.e., a value between 0 and 1. If, for example, the reasonable range for the number of sales people is 6 through 30, then a decision to employ 10 salespeople would be initially transformed to 0.1667 (=[10-6]/[30-6]). Normalizing decisions in this way allows for considerable flexibility in addressing several issues in arriving at final unit demand.

For nonprice decisions, the lower bound of the reasonable range may be greater than zero, thus possibly constituting a threshold effect. For price, the lower bound leads to the maximum contribution of price to demand. Prices lower than that bound do not increase demand, but do lessen the gross margin of each unit sold. See "Decisions Outside the Reasonable Range."

Eventually the normalized value is transformed by its relevant function (see "Available Functions"), the resulting value also being between zero and one.

The notion of a "reasonable range" is consistent with real-world experience or, more precisely, the *absence* of real-world experience. For example, while a game may accept a price of, say, $2 for a camera costing the marketer $300 or may accept a price of $9999 for that camera, there does not exist any reliable real-world experience on which to model the effects of such prices on demand.

More formally, the lower and upper bounds of the reasonable range correspond to what Corkindale & Newall (1978) term threshold and wearout boundaries. Their work, in the context of advertising, is comprehensive. Suffice, though, that, "Thresholds and wearout...represent the upper and lower limits which define the boundaries of advertising effectiveness." (p. 349) Corkindale & Newall (1978) also concur with the general lack of data beyond the threshold and wearout levels: "Most people responsible for advertising decisions believe that threshold and wearout levels of expenditure...do exist. Little generalisable evidence for either phenomena seems to exist. This is mostly because managers, and their agencies, avoid operating at or near the supposed levels." (p. 372)

The reasonable range notion is also consistent with Gold & Pray's (1983, p. 102) recognition that constraints on decision values may be in order. The "reasonable range" manages that issue automatically, in lieu of imposing *a priori* constraints.

AVAILABLE FUNCTIONS

Available in the *MME* are eight commonly prescribed (Lilien & Kotler 1983, pp. 66-79) upward sloping functions, e.g., modified exponential, S-curve, linear, etc. For each continuous strategy variable one of the functions, along with its parameters, is specified. These functions and parameters allow the simulated marketplace to be customized to reflect factors such as product characteristics (e.g., standard or premium, durable or nondurable), customer characteristics (e.g., household income, household size), economic conditions (e.g., employment level, degree of industrialization), and the like. (Not all of the functions are actually used in the *MME*. The software is planned to be used for games generally.)

The *MME* comprises two geographic regions and two products, yielding four region-product segments. Several decision variables affect demand only in a given segment (e.g., price), while other decisions affect demand for both products (e.g., number of retail stores) or demand for both regions (e.g., product quality) or demand company-wide (e.g., sales force salary). Accordingly, four different functions may be specified for price, two different functions for number of retail stores, two different functions for product quality, and one function for sales force salary.

The effect of price is normally a downward sloping function. Complements of the eight functions, then, may be used.

The respective functions are applied to the normalized decision values and result in transformed values between 0 and 1.

QUALITATIVE DECISIONS

Much of the literature regarding demand determination –in gaming and modeling generally–addresses continuous variables only. This ignores numerous commonplace marketing strategy variables, e.g., product features, retail store types, store layouts, and so on. The *MME* decision mix includes two types of qualitative decisions. One type–sales promotions–has a dollar cost. The total cost, though, is not necessarily fixed. For example, point-of-purchase displays has a per store cost with the total cost depending on the number of stores selling the company's products. A second type of qualitative decision–advertising message–does not have a dollar cost. Promotion types and advertising messages are selected from menus by managers.

Sales promotion, then, has a main effect on demand that is a function of the total cost of the promotion and is treated in the same manner as continuous decisions.

Advertising messages *per se* do not affect demand directly. Rather, messages interact with selected continuous variables. For example, where the quality of a company's product is higher than the average quality of its competitors' products, a "comparative" advertising message increases the effect of advertising on demand. Operationally, advertising expenditure is temporarily increased prior to that decision being normalized within the reasonable range. Where a company has more retail outlets and a larger sales force size than the respective means its competitors, a "service" message increases the effect of broadcast and print advertising. A "pioneering" message decreases the effect of trade advertising expenditures. Again, the decrease is by means of temporarily lowering the trade advertising expenditure prior to its being normalized. And so on.

ADDITIONAL ADJUSTMENTS TO ORIGINAL DECISION VALUES

Effects of Competitors Strategies

Invalid studies not withstanding, it is widely recognized (Buzzell & Gale 1997; Dickinson 2003; Pray & Gold 1984, p. 248) that the effectiveness of a company's marketing strategy is not only the result of the strategy itself, but also the result of the strategy *vis-a-vis* competitors' strategies. For example, the effect of a $100000 advertising expenditure on the company's demand is different where competitors' advertising expenditures are around $80000 than when competitors' expenditures are around $120000. Accordingly, the ratio of values of several of a company's continuous decisions to the corresponding mean values of competitors' decisions is calculated. (To moderate the effect of competitors' strategies, half of that difference is taken.)

This is not done on a proportionate basis, but on a disproportionate basis. Thus, an original $100000 in advertising would be 25% greater than its competitors' mean advertising of $80000. Halving the 25% would result in a proportionate temporary advertising expenditure of $112500 for the company. Using a special-purpose function, though, that temporary expenditure might be $115000. Where the competitors' mean advertising is $120000, the temporary expenditure would not equal $83333, but perhaps $80000.

Research and Development (Product Quality)

In the *MME* the means by which product quality is improved is via research and development expenditures. Like the other continuous decisions, managers may increase or decrease (or hold constant) research and development expenditures from one period to the next. However, product quality is treated as a step-function, including diminishing marginal return, of cumulative research and development expenditures. Improvement in product quality is constrained to at most a single step in a given period. A minimal expenditure may result in no improvement in quality, while a very large expenditure results in a single step up in quality and possibly additional step improvements in subsequent periods, even with no additional expenditures. It is product quality, operationalized as an index, that influences demand, not research and development expenditures *per se.* The product quality index is processed in the same fashion as other continuous decision variables.

INTERACTIONS

The Gold/Pray model is multiplicative, which is to say all strategy variables interact amongst themselves (Gold & Pray 1983, p. 102). Goosen (2010, pp. 103-104) questions the desirability or superiority of this model. In response, it is clarified that this model form "...is at least very sound, if not desirable and even, perhaps, superior" to linear and nonlinear forms. (Gold, Markulis, & Strang 2011, p. 34).

The approach to demand determination described here is basically additive. However, several types of interaction effects have been described. For example, the effect of advertising expenditures is multiplied where a message is synergistic with other elements of the marketing mix. Such an additive model, augmented with the specification of interactive terms, is consistent with Lilien & Kotler's (1983, pp. 72-73) approach to interactions. Here, interactive effects are operationalized in arriving at values that are eventually normalized. Recall that each of the normalized variables is transformed by a specified function (see "Available Functions").

Generally, the normalizing of decision strategy values could especially facilitate multiplying decisions to incorporate such interaction effects. Multiplying variables all normalized to a range of 0 to 1 yields more interpretable results than multiplying original strategy decisions in differing ranges and measured in disparate units.

DECISIONS OUTSIDE THE REASONABLE RANGE

Normalized (temporary) decision values within the reasonable range, then, are initially transformed according to the relevant specified function; they are treated in a regular fashion. Values outside that range may be treated in a variety of ways. For unreasonably low values, the effect on demand may be set to zero, reflecting a threshold effect. Continuing with the sales force size example with a reasonable range of 6 to 30, any number of salespeople less than six would have zero effect on demand. Also available is for the effect to decrease linearly to zero (a threshold effect thus being signaled to the manager). A sales force size of 5 would have a dramatically less effect on demand than 6, perhaps decreasing to zero effect with a size of, say, 3 or less. Thirdly, for price, the effect may be set equal to the effect of the lower bound value. Any price less than the lower bound will have the same effect as the lower bound price. The same number of units will be demanded, but with lower revenue per unit.

Unreasonably high decision values are handled in three counterpart ways. The effect may be set equal to the effect of the upper bound value; an asymptote. Sales force sizes greater than 30 would have no incremental effect on demand, yet the costs associated with those greater sizes (e.g., salary) would increase. Second, the effect may decrease linearly to zero. Though not used in the *MME*, this would reflect the oversaturation phenomenon cited by Gold & Pray (1983, p, 105) and Gold, Markulis, & Strang (2011, p, 33), but contended by Goosen (2010, pp. 102-103). Thirdly, for price the effect on total demand may be set equal to zero, reflecting the phenomenon of a reservation price (Tellis 1986).

It bears repeating that not all of the options available in the *MME* software are actually employed. The purpose here is to present a general approach for determining demand, with this approach making available capabilities for use by game designers.

TIME-RELATED EFFECTS

Advertising Lagged Effects

"The demand for a product depends not only on the current values of the independent demand variables, but also on their historical values. For instance, both current and past expenditures on advertising impact the sales potential of a firm." (Gold & Pray 1983, p. 103). Gold & Pray employ exponential smoothing to reflect this phenomenon, as could the present procedure. Alternatively, though, in the present procedure, (temporary) advertising expenditure values that are normalized within the reasonable range are a weighted average of the current period's expenditure and the expenditures of two previous periods.

Inconsistent Strategies

The consistency over time of a company's marketing strategy is a conundrum. Companies generally strive for reputation, market position/niche, brand/company equity, types of retailers, etc.; i.e., companies strive to be "known" in these ways. Correspondingly, customers rely on such so that each shopping trip is not a completely new experience. Thus, consistency in strategy over time, if not increasing demand, at least tends to not decrease demand.

On the other hand, managing a simulation company is intended to foster learning. Competitions that progress from period to period provide experience and data and performance information. Particularly, where a company is performing poorly, it should be expected for management to alter its marketing strategy.

Inconsistencies in strategy decisions are processed according to a program-coded schedule. For example, where price changes by an absolute value of 30 percent from the preceding period, the corresponding temporary price value changes by 20 percent prior to being normalized. For nonprice decisions the same schedule applies.

Planning Ahead

To further encourage managers to plan beyond the current competition period, two types of decisions–numbers of retail stores and sales force sizes–do not take effect in the same period when the decisions are made. To recognize start up and training delays, respectively, additional stores and additional salespeople do not actually influence demand (i.e., they do not sell) until the period following the decisions. Regardless, the numbers of stores and salespeople actively selling in the current period are readily determined, taking into account store closings and salesperson firings and resignations, and it is these values that are normalized and, in turn, affect demand.

DERIVED EFFECTS ON DEMAND

Not only company strategy decisions may affect demand. For example, customer brand loyalty and sales force experience and morale are derived from company decisions, but are not themselves decisions. Factors such as these are treated with the same normalized–>specified function approach as strategy decisions. A dynamic customer characteristic–target customer stages of awareness–interacts with the various types of advertising expenditures.

IMPORTANCE OF DECISION VARIABLES

One of the benefits of normalizing decision values as described above lies in weighting the decisions. For some conditions, say, advertising might be deemed to have a greater effect, i.e., weight, on demand than sales force size. However, the various marketing strategy decisions may (1) be measured in different units, e.g., dollars versus people, and (2) take on widely different ranges of values, e.g., hundreds of thousands versus dozens. Thus, assigning weights to the original decision values that achieve the desired comparative importance is problematic. The normalized values, of course, are all proportions between 0 and 1. Assigning a weight of, say, 4 to advertising and 8 to sales force size ensures that a one percent change within the "reasonable range" of the former will have half the effect of a one percent change in the latter.

As is common with business games, the structural decision weights programmed in the *MME* software are subject to adjustment by the game administrator.

FINAL DEMAND DETERMINATION

Industry-Level Demand

Game managers are informed of the maximum potential unit sales (for each of the four region-product segments in the *MME*). These are stated "per company" to allow comparison for administration purposes across industries comprising different numbers of competing companies, addressing a concern expressed by Goosen (2010, p. 104). Maximum potential unit sales, of course, is not profit-maximizing sales.

After the normalization–>function transformation process, each strategy decision may take on a maximum value of 1 and a minimum value of 0. If, then, say four strategy variables and derived factors affect demand, company maximum potential unit sales will be realized when the sum of the transformed values equals 4. (The transformed values are actually weighted by importance, but that is ignored here for simplicity of presentation.) For an industry comprising 5 companies, the maximum transformed values across those companies equals 20.

Where a given company's nonprice decisions are less than the upper bound of the reasonable range and its price decision is greater than the lower bound, the sum of its transformed values will be less than 4 (again, ignoring importance weights). These company sums are then totaled and that total divided by 20. That is the fraction of potential unit sales actually realized by the industry.

This approach is essentially equivalent to Carvalho's (1992, p. 39) and Pray & Gold's (1984, p. 248) use of decision values averaged across companies comprising the industry to arrive at industry demand.

Company-Level Demand

A basic mechanism for allocating industry-level demand to individual companies would simply be the proportion contributed by a company to the determination of industry demand. Such a proration does take place, but on a basis that balances the effects of price and nonprice decisions.

In the present procedure, allocating industry-level demand to individual companies recognizes (1) the opposite effects on demand of price and nonprice decision variables and (2) the large difference in the numbers of the two effects: one for price against the number of nonprice decisions plus derived effects. For a given region-product segment in the *MME*, increases in on the order of 14 of the latter serve to increase sales against increases in the single price decision decreasing sales.

The various marketing strategy decisions have importance weights initially set in the software. Balancing price versus nonprice effects, then, might have the price weight equal the sum of the nonprice weights. However, the software-set weights are planned to reflect the same sorts of factors considered in assigning a specific functional form (see "Available Functions") to a particular decision, i.e., product characteristics, customer characteristics, economic conditions, etc.; they are not planned to balance price versus the collective nonprice effects.

In arriving at company-level demand, the collective nonprice effect relative to the single price effect is recognized. This is accomplished by an inflection-point function whose curvature reflects that ratio. With the normalized price being on the horizontal axis (0=price at upper bound of the reasonable range, 1=price at the lower bound), the function determines a proportion on the vertical axis. As a company's price approaches the lower bound of its reasonable range, the greater the proportion of the company's collective nonprice effect will apply. That proportion of the company's collective nonprice effect is the basis for allocating industry-level demand.

Where the collective nonprice effect is much greater than the price effect, the function will approach a 45° diagonal. As the collective nonprice effect approaches the price effect, the function will have a more pronounced concave down arc at the left, inflecting to a more pronounced concave up arc on the right. In this case, prices toward the higher bound of the reasonable range will dramatically reduce the collective nonprice effect and the reduction will be dramatically less as price approaches the lower bound of its reasonable range.

Company-level demand, then, depends on the effect of its collective nonprice decisions, that collective effect offset by the effect of its price. The greater the ratio of the former to the latter, the less pronounced is the offset.

It should be clarified that "reducing" the collective nonprice effect of a company does not necessarily lead to a reduction in unit demand for the company. This is but a recognition of the counter effect of price. A given company's "reduced" effect is taken as a proportion of the total "reduced" effect for all companies comprising the industry. The company, then, is allocated that proportion of industry-level demand. Final unit demand totaled across the companies equals industry-level demand as previously explained.

DISTRIBUTION OF STOCKOUTS

It is possible, of course, that unit demand stimulated by a company's marketing strategy is greater than the number of units the company has available to sell; i.e., a stockout occurs. Pray & Gold (1984) reported that business games at the time handled stockouts in a mix of ways, one of which was "Go to Competitors" (p. 248). Indeed, when an *MME* company stocks out, some of its would-be customers buy from competitors. That is, a portion (defined in the software) of the stocked out volume increases demand for competitors' products in the same proportions used for determining company-level demand.

DISCUSSION

The multiplicative model for determining demand and its refinements put forth by Gold with others is well known. In contrast, Goosen (1986) put forth an approach based on (interpolations of) tabled values that may be customized as the game designer deems. Tables for a given marketing strategy decision contain values for the decision paired with the corresponding unit demand (e.g., Figure 4, p. 251). "...the elegance and symmetry of a true curvilinear functional equation..." (p. 249) are sacrificed, in favor of control over results (i.e., demand) for individual strategy variables, including minimum and maximum decision values.

The approach presented here contains elements of the two contrasting approaches. The "Available Functions" are "true curvilinear functional equations" though different functions and parameters may be configured for individual strategy decisions. At the same time, the "reasonable range" imposes limits on decision values submitted to the functions. Decision values outside that range are managed on an heuristic basis. Qualitative strategy variables are incorporated, including in the form of interactions with other strategy variables, in a way that is neither as elegant as Pray & Gold's (1984) curvilinear completely interactive model nor as inelegant as Goosen's tabled values.

Industry-level demand is determined in a manner consistent with Carvalho (1992) and Pray & Gold's (1984), while that industry demand is allocated among companies on a basis that balances price and collective nonprice effects.

It would seem that several features of the present procedure could be incorporated into the Gold/Pray model: creating temporary decision values to reflect various factors, including interactions with qualitative decisions, derived effects, the step function for product quality, and the imposition of reasonable ranges and normalizing of temporary decision values within those ranges. Allowing a separate function for each decision and derived effect remains a marked distinction.

Models (and heuristic approaches) are simplifications. The purpose of (academic) business games is to educate managers as to basic concepts and principles. The *MME* game is no more intended to teach managers how to market digital cameras than the preeminent *MarkStrat* game (LarrÁchÁ & Gatignon 1990) is intended to teach managers how to market mythical Sonites. While consistency with the real world is, of course, desirable, that consistency is in the form of embodying generally accepted phenomena such as elasticity, diminishing marginal return, strategy integration and synergy (e.g., interactions), time-related effects, effects of competitors' strategies, economies of scale, and so on.

Perhaps the procedure for determining demand presented here may be taken in the context expressed by Gold, Markulis, & Strang (2011, p. 34): "The Goosen (2010) paper is consistent with the intent of the Gold & Pray (1983) article to encourage a healthy debate on the design of demand and other functions in computerized business simulations..."

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