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Attack-Defense Marketing Strategies: A Full Equilibrium Analysis Based on Response Function Models

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Abstract

We develop full equilibrium analyses of product markets involving response surface modelling of marketing variables, thereby generalising the works of Lane (1980), in economics, and Hauser and Shugan (1983), in marketing. We show how optimal new product entry (attack) strategies and optimal defense strategies for existing brands can be determined. We also illustrate the critical role played by response surface modelling in prescribing optimal strategies.

ABSTRACT

We develop full equilibrium analyses of product-market level response surface modelling of marketing variables, thereby generalizing the works of Lane (1980), in economics, and Hauser and Shugan (1983), in marketing. We show how optimal new product entry (launch) strategies the optimal defensive strategies for existing brands can be determined. We also illustrate the critical role played by response surface modelling in prescribing optimal strategies.

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1. Introduction

This paper addresses the problem of developing an optimal entry strategy for a new product in a competitive environment. Most new products are introduced into markets with existing competitive products. The entry of a new product (attacker) into such an environment is likely to provoke responses from some or all of the existing products (termed defenders). This paper investigates the development of an optimal entry strategy for an attacker based on an understanding of the possible reactions of the defenders.

In so doing, we demonstrate clearly the impact of using response function models for advertising and distribution on the derivation of optimal attack-defense strategies. We show that defense using only distribution and/or advertising strategies is inappropriate. Optimal defense in price alone is suboptimal. Therefore, optimal defense, in markets where response function models for advertising and distribution are valid, necessitates the use of all three marketing variables, when defender position (product) is held constant. Specifically, we show that optimal defense dictates lowering price and reducing advertising and distribution expenditures.

A market with three products (two defenders and one attacker) is used to illustrate our general results. Full equilibrium analyses coupled with the model used allows the development of propositions regarding the relationship between market structure variables (total demand, consumer income), performance variables (profits, market share) and strategy variables (price, position, advertising and distribution).

Past Literature in Brief

Past work that we build on has largely appeared in two streams: (1) micro-economics, and (ii) analytical marketing literature.

Economists have developed detailed models describing competitive behavior in markets characterized by homogeneous products, perfect information, and identical, noncolluding consumers and firms. Excellent reviews are provided by Lancaster (1980), Lane (1980), Scherer (1980), Schmalansee (1981, 1982), and Stigler (1964).

Considerable work in the analytical marketing literature has been done on developing new product entry strategies. This literature provides guidelines for the selection of specific couponing, initial advertising design, dealing and sampling. This literature also develops algorithms for determining the optimal position (brand features) of the new brand without explicitly considering defensive reactions on the part of existing brands.[1] Excellent reviews are available in Shocker and Srinivasan (1979), Urban and Hauser (1980), Wind (1982), Pessemier (1982), Sudharshan (1982), May, Shocker, and Sudharshan (1983).

This body of knowledge does not, in any integrated fashion, prescribe how an entrant firm should optimally position its new brand, choose advertising expenditures, channel expenditures and price--given competitive reactions by defending firms in defense of their existing brands. Notable exceptions to this paucity are the work in marketing of Hauser and Shugan (1983) and in economics of Lane (1980).

Hauser and Shugan (1983)[2] have investigated how defenders should react when a new product enters their domain. Their work on defensive marketing strategy assumes that the strategy a new product will use is given. Their competitive market structure analysis is limited to a partial equilibrium analysis.

Lane (1980) derives full equilibrium pricing and positioning strategies for both the cases of endogenously and exogenously fixed number of brands in the market place. However, he does not consider major marketing strategy variables of advertising and distribution explicitly in his analysis.

In this paper we develop a full equilibrium analysis considering the reactions of all the existing brands in the market (unlike H&S) while explicitly including advertising and distribution levels as other possible defensive response strategies in addition to price (unlike Lane).

Model Worldview

1. Consumers: They are assumed to be utility maximizers. Utility is a function of brand characteristics, price and remaining income available for other purchases.

2. Managers: We assume that they are profit maximizers and rational competitors. Upon knowledge of number of products entering market, they can compute optimal strategies to be competitive. The attacker managers will use optimal market entry strategies of position, price, advertising and distribution (i.e., 4 P's). On the other hand, defender managers will defend their brands optimally through price, advertising and distribution, not brand repositioning.

3. Market structure: Our analysis assumes a market in which brands already exist and are in equilibrium (i.e., no manager has any incentive to modify any of his marketing mix strategy variables unilaterally). The optimal new product strategy we derive is for a brand entering such a market. This strategy is based on the adjustment of existing brands to this entrant. The entire market, including the new brand, achieves a new equilibrium.

We proceed by first presenting the consumer and managerial models in greater detail in Section 2. The next section (3) describes our equilibrium analysis before and after attack. We show general results concerning optimal defensive strategies. We also provide results based on an example of new brand entry into a market containing two existing brands. In Section 4, we present various propositions concerning relationships between performance/strategies and market parameters. We end this paper with a summary of our results and a discussion of directions for future research.

2. The Models

We will deal with a market for a single product class, with two attributes, which can be differentiated. The model characterization will closely follow Lane (1980) rather than H&S due to analytical tractability.[3] We incorporate the marketing strategy variables of advertising and distribution expenditures (from H&S) into Lane's model.

Consumer Side

Consumer tastes are distributed uniformly over a continuous interval [0,1] and a randomly chosen consumer is represented by the parameter $\alpha \in [0,1]$. Each customer is assumed to buy one unit of any brand ($q(\alpha) = 1$ for all $\alpha \varepsilon [0,1]$). Assuming the uniform distribution of consumers is $f(\alpha) = M$, the total demand from this market is

$$\int_0^1 q(\alpha)f(\alpha)d\alpha = M$$

units, where M is set exogenously.

Consumers are assumed to be maximizers of a Cobb-Douglas utility function given by:

$$U(\alpha) = w_i^{\alpha} z_i^{(1-\alpha)}(Y-p_i)$$

where (w_i, z_i) are the attribute values for a particular brand, p_i is its price and Y is the total dollar amount available to the consumer by way of income. We assume that all consumers have the same income Y. Then, the consumer type α weights the attribute values (w_i, z_i) correspondingly with exponential weights of $(\alpha, 1-\alpha)$. The term $(Y-p_i)$ in the utility function signifies the remaining amount of income available to the consumer to spend in other markets.

The differences in this specification and that in H&S are that (i) the latter use linearly weighted attributes which contribute linearly to a consumer's utility, (ii) H&S incorporate price using dollar-metric measurement methods by evaluating the utility value in units per dollar value of the product, and (iii) the H&S model does not incorporate any cross-effects between the product market they analyse and the others that the consumer will necessarily deal in. This interaction effect must be included (although not necessarily in the form that we have chosen) if one is to analyse full equilibrium in a specific market (Salop (1979), Lancaster (1978)).

Managerial Side

We assume that brand managers are profit maximizers and have control over the decisions on brand positioning, in terms of levels for the two attributes of their product, and other marketing decisions in terms of price, advertising expenditures and distribution expenditures. Each brand i faces the same technology constraint which is described by $w_i + z_i = 1$. (This is similar to H&S assumption of efficiently positioned brands.) The net effect is to reduce the product attribute dimension to one, characterized by the ratio $f_i = w_i/z_i$ in Lane (1980) and the angle α_i in H&S.[4]

The profit function facing a brand manager who is in charge of brand i is given by:

$$\pi(p_i, k_{ai}, k_{di}) = (p_i - c)Q_i A(k_{ai}) D(k_{di}) - F - k_{ai} - k_{di}$$

where (p_i, k_{ai}, k_{di}) are the brand's price, advertising and distribution expenditures, respectively, c is the marginal cost of production and F is the fixed cost of production. Both parameters c and F are assumed to be the same for all brands. Q_i is the demand for brand i and is given by

$$Q_i = \beta_i \cdot M$$

where M is the total demand for the industry and β_i is the unadjusted market share for brand i. It must be noted that β_i is dependent on competition only in price and position of all the brands.

The functions $A(k_{ai})$ and $D(k_{di})$ are response functions relating sales to the advertising and distribution expenditures respectively.

Like H&S it is assumed that both functions A and D are concave or are operating on the concave portion of S-shaped response curves. Specifically, the functional form chosen for the response functions is the ADBUDG[5] curve, i.e.,

$$A(k_a) = a_1 + (a_0 - a_1)\frac{k_a^{a_2}}{k_a^{a_2} + a_3^{a_2}}$$

$$D(k_d) = b_1 + (b_0 - b_1)\frac{k_d^{b_2}}{k_d^{b_2} + b_3^{b_2}}$$

with parameters a_0, a_1, a_2, a_3, b_0, b_1, b_2 and b_3.

Although the assumptions of concavity is not serious, the assumption that the sales, for any brand, is affected by changed in the expenditures on advertising and distribution through only the response functions is stringent. As we shall see later in the analysis, this has serious repercussions as far as defending strategy is concerned if a brand is attacked by a new entry.

Competitive Interaction

It is assumed that brands enter the market sequentially--one at a time. Each brand prior to entry knows the positions of the existing brands. For the initial market equilibrium, we assume that, given knowledge of the number of brands that might enter a market, every potential entrant has perfect foresight and can determine the optimal responses of all subsequent entrants to its own pricing, advertising, distribution, and position decisions.[6]

The computation of the equilibrium market structure involves the separation between positioning strategies and the other marketing strategies (this is because repositioning is not an allowed defensive move). The optimal price, advertising, and distribution strategies for all brands follow the concept of Nash equilibrium, i.e., given the other brands' Nash strategies, no brand manager has any incentive to unilaterally deviate from his Nash strategies.[7]

3. General Results Under Full Equilibrium

As Lane (1980) points out, the equilibrium outcomes (the list of optimal strategies, one for each firm, given that other firms follow their optimal strategy) are analytically derivable and can be computed numerically. The analytical derivations used in obtaining computational inputs are presented in the Appendix. We proceed to show the optimal attack strategy for a new brand under different assumptions regarding the reaction policies adopted by the defenders. And we also show the impact of response function modeling on optimal defense strategies.

Let us consider a market with two brands. These brands enter the market sequentially and the first brand is assumed to have perfect foresight regarding the second brand, i.e., it can compute the second brand's optimal strategies with respect to its own strategies. It is assumed that the second brand knows the position of the first brand and that a Nash equilibrium will dictate the optimal strategies in pricing, advertising and distribution for both brands. Computationally, given every position pair for the two brands, the first brand manager is treated as being able to evaluate the Nash equilibrium in the other strategies and thus, obtain the optimal (profit-maximizing) positioning strategy of the second brand, i.e., he can compute the reaction function of the second brand. All that remains is for the first brand to pick its own optimal profit-maximizing position given that the second manager behaves according to the reaction function.

For the purposes of concrete illustration we chose the following parameters for our market with two brands: M = market demand = 100 units, Y = income of each individual = $10, F = fixed cost = 0, and C = marginal production cost = $1.[8] Given these parameters, the equilibrium structure that emerges for this two brand market is shown in Table 1.

Table 1

Brand $i=$	Position (w_i, z_i)	Price (p_i)	Advertising expenditures (k_{ai})	Distribution expenditures (k_{di})	Unadjusted market share β_i	Profits π_i
1	(0.5,0.5)	6.56	26.7751	19.7033	.6362	353.78
2	(0.073,0.927) or (0.927,0.073)	5.32	14.6067	10.6153	.3638	157.30

[We have also assumed $a_0 = 2$, $a_1 = 1$, $a_2 = 0.5$, $a_3 = 0.5$, $b_0 = 1.5$, $b_1 = 1$, $b_2 = 0.5$, $b_3 = 0.5$ as parameters for the respective ADBUDG type response functions for all firms.]

Now consider an attacker poised to enter this market. Such an entrant needs to consider possible defensive reactions by existing brands. There are three possible defense strategies: (1) defensive strategies involve only changing either advertising or distribution expenditures, or both, (2) defense occurs through pricing strategies alone, and (3) defense encompasses price, advertising, and distribution strategies.

<u>Case 1</u>

When the defenders use only advertising and/or distribution, optimal attacking position turns out to be the same as the position of the brand with the largest profits, i.e., brand 1. Its optimal pricing strategy is to set a price lower than that of brand 1, and given that consumer choice is based only upon prices and brand positions, the attacker takes the entire market share of the market leader, brand 1. See Figure 1 for the brand position map.

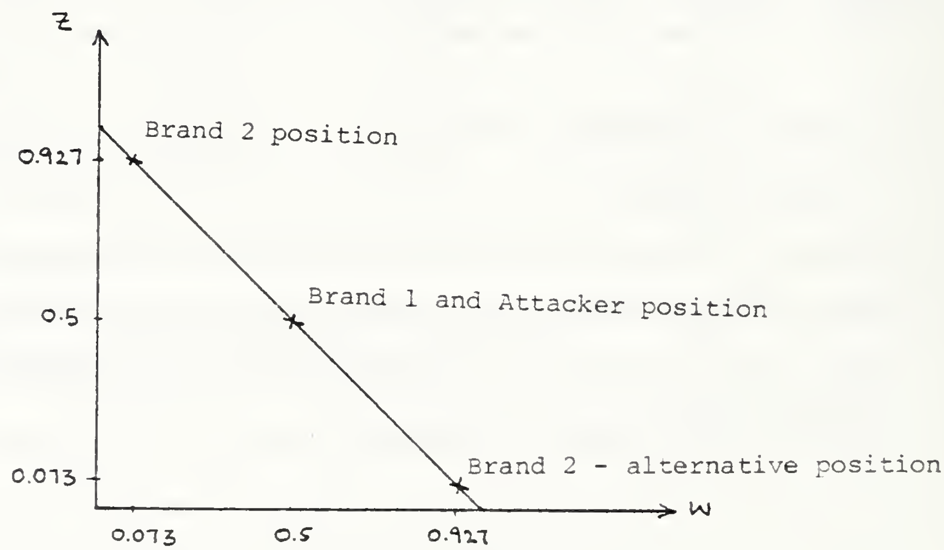

Figure 1. Optimal Brand Position: Case 1

Recall that the effects of advertising and distribution expenditures have been introduced via response functions:

$$\pi(p_i, k_{ai}, k_{di}) = (p_i - c)Q_i A(k_{ai}) D(k_{di}) - F - k_{ai} - k_{di}$$

and Q_i, the demand for brand i is a function only of the positions and prices of all the brands in the market. For brands occupying the same position, the one with the lowest price attracts all the demand that accrues to this position. By the attacker's choice of brand 1's position as its own, and setting a lower price, demand for brand 1 is driven to 0. So, advertising and distribution expenditures by brand 1 only change the magnitude of negative profits obtained by brand 1 (through $- k_{ai} - k_{di}$).

This argument is true no matter how many brands are in the market. If the only permissible defensive strategies are advertising and distribution expenditures, the attacker's optimal strategy is to position itself at the same position as the market leader (in profits), and to charge a price lower than that charged by the leader. This implies the general result:

Theorem 1: Given the structure of competition (in position and prices), if an existing brand is attacked, it has to defend itself in price.

The results of H&S (Theorems 7 and 10) are partially true, i.e., advertising and distribution expenditures will be lowered upon attack. This just ensures that the defender reduces its costs--since it is doomed to obtain only losses!

Case 2

When defense is in prices alone, the market structure that obtains is shown in Table 2. We have assumed that Brand 2 chooses the position (0.073,0.927)--this does not effect the results because of the symmetry of the problem as can be seen in Figure 1.

Table 2

Brand $i=$	Position (w_i,z_i)	Price (p_i)	Advertising expenditures (k_{ai})	Distribution expenditures (k_{di})	Unadjusted market share β_i	Profits π_i
1	(0.5,0.5)	1.9681	26.7751	19.7033	.4233	64.20
2	(0.073,0.927)	3.5571	14.6067	10.6153	.1562	78.68
3	(0.4205,0.5795)	2.0694	5.4794	3.8666	.4205	99.401

Comparing Tables 1 and 2, we can clearly see that the new entrant has chosen to position in the unattacked portion of the pre-entry market of brand 1. After entry, prices and total profits in the market have declined as has the individual profits and market shares of brands 1 and 2. The profits for brands 1 and 2 can be raised over the post-attack profits shown in Table 2 by decreasing advertising and distribution. That this is due to the response function modelling of advertising and distribution is clearly shown in the proof of the following theorem.

Theorem 2: Given the structure of competition (in position and prices), upon attack, if a defending brand defends only in price, its advertising and distribution expenditures are excessive.

Proof of Theorem 2

Consider the marginal product of advertising and distribution

$$\frac{\partial \pi_i}{\partial k_{ai}} = (p_i - c)Q_i D(k_{di}) \frac{\partial A}{\partial k_{ai}} - 1$$

$$\frac{\partial \pi_i}{\partial k_{di}} = (p_i - c)Q_i A(k_{ai}) \frac{\partial D}{\partial k_{di}} - 1.$$

At the pre-entry stage, $\frac{\partial \pi_i}{\partial k_{ai}} = \frac{\partial \pi_i}{\partial k_{ai}} = 0$ at the optimal strategies.

After entry, p_i and Q_i have reduced from pre-entry optimal levels. This implies

$$\frac{\partial \pi_i}{\partial k_{ai}} < 0, \frac{\partial \pi_i}{\partial k_{di}} < 0$$

when pre-entry levels of advertising and distribution are maintained. This in turn implies that pre-entry levels of advertising and distribution expenditures are greater than the optimal level needed after attack. □

Theorem 1 demonstrates the necessity of defending in price and Theorem 2 indicates that advertising and distribution expenditures must be decreased upon attack. This gives rise to our main general result which obtains for all models of this type, i.e., competitive in price and position and response function modelling of advertising and distribution.

Theorem 3: When market demand M is constant, advertising and distribution is modelled via response functions and consumer choice depends only on price and position, the optimal defense strategies, upon attack, must include decreasing price, advertising and distribution levels.

The realization of this result for our example is shown in Case 3.

Case 3

When defensive strategies are permissible in price, advertising, and distribution, the only changes to the results of Case 2 are that the advertising and distribution expenditures for brands 1 and 2 change as does their corresponding profits. These are shown in Table 3.

Table 3

Brand $i=$	Position (w_i, z_i)	Price (p_i)	Advertising expenditures (k_{ai})	Distribution expenditures (k_{di})	Unadjusted market share β_i	Profits π_i
1	(0.5,0.5)	1.9681	5.0802	3.5747	42.33	89.788
2	(0.073,0.927)	3.5571	4.9737	3.4969	15.62	87.2749
3	(0.4205,0.5795)	2.0694	5.4794	3.8666	42.05	99.401

As expected, the optimal advertising and distribution expenditures for defending brands are lower than the corresponding expenditures before attack and their profits increase.

The attacking brand's strategies remain unchanged from Case 2. In both Cases 2 and 3, the first brand into the market retains market leadership in terms of unadjusted and adjusted market share. Unadjusted market shares remain the same whether the defenders react using only price or a combination of price, advertising and distribution.

4. Market Structure-Performance-Strategy Relationships

The major market parameters of our model are the market demand M, the consumer income Y, and the fixed cost of entry F. It is evident from the form of the profit function that increasing F decreases profits alone and does not affect any of the optimal attack-defense strategies.

Tables 4 and 5 represent sensitivity analyses of the optimal attack-defense strategies to changes in the market demand M and consumer income Y respectively.

Different values of M, the market demand, can be thought of as occurring due to two factors: (a) inherent environmental changes, which is constant during attack and (b) a change in M brought about by the attack itself. The results deduced below (from Table 4) are independent of which factor brought about the changes in M.[9]

Proposition 1. Ceteris paribus, higher market demand implies higher profits for all brands.

Proposition 2. Unadjusted post-entry market share for every brand is independent of the market demand M. Adjusted post-entry market demand, for each brand, increases with increase in M; however, adjusted market share leadership changes from the attacker to defending brand 1 with increase in M.

Proposition 3. Optimal price for every brand is independent of the market demand M.

Table 4

Variation M (Y = 10.0)

Unchanged with M:

$(w_1^*, z_1^*) = (.5, .5)$; $p_1^* = 1.9681$; $\beta_1 Q_1^* = .4233$

$(w_2^*, z_2^*) = (.927, .073)$; $p_2^* = 3.5571$; $\beta_2 Q_2^* = .1562$

$(w_3^*, z_3^*) = (.4205, .5795)$; $p_3^* = 2.0694$; $\beta_3 Q_3^* = .4205$

M	Brand (i)	Advertising Expenditures (k_{ai})	Distribution Expenditures (k_{di})	Profits (π_i)	Unadjusted Demand (Q_i)	Adjusted Demand	Unadjusted Market Share (β_i)	Adjusted Market Share
50	1	2.8408	1.9486	41.7254	42.33	96.098	.4233	.422
	2	2.7787	1.9038	40.5498	15.62	35.378	.1562	.155
	3	3.0766	2.1185	46.2719	42.05	96.25	.4205	.423
100	1	5.08	3.5747	89.788	42.33	101.681	.4233	.4222
	2	4.9737	3.4969	87.2749	15.62	37.45	.1562	.1556
	3	5.4794	3.8666	99.4010	42.05	101.688	.4205	.4222
200	1	8.8429	6.3409	190.8338	42.33	106.405	.4233	.4225
	2	8.6669	6.2109	185.6205	15.62	39.203	.1562	.1556
	3	9.5088	6.8330	210.9406	42.05	106.265	.4205	.4219
500	1	17.8448	13.0274	508.5936	42.33	111.448	.4233	.4227
	2	17.5042	12.7735	494.9398	15.62	41.078	.1562	.1557
	3	19.1311	13.9872	561.2068	42.05	111.149	.4205	.4216
1000	1	29.8297	21.9922	1056.49	42.33	114.485	.4233	.4228
	2	29.2742	21.5759	1028.4364	15.62	42.205	.1562	.1558
	3	31.9286	23.5648	1164.5382	42.05	114.084	.4205	.4214

Table 5

Variation in Y (M = 100)

Y	Brand (i)	Position (w_i, z_i)	Price (p_i)	Advertising Expenditure (k_{ai})	Distribution Expenditure (k_{di})	Profit (π_i)	Unadjusted Demand (Q_i)	Adjusted Demand	Unadjusted Market Share (β_i)	Adjusted Market Share
5	1	(.5,.5)	1.4388	2.607	1.7804	37.3486	42.33	95.22	.4233	0.4223
	2	(.927,.073)	2.1364	2.5085	1.7097	35.5467	15.62	34.99	.1562	0.1553
	3	(.4025,.5795)	1.4753	2.7805	1.9052	40.5837	42.05	95.24	.4205	0.4224
10	1	(.5,.5)	1.9681	5.08	3.5747	89.788	42.33	101.68	.4233	0.4222
	2	(.927,.073)	3.5571	4.9737	3.4969	87.2749	15.62	37.45	.1562	0.1555
	3	(.4205,.5795)	2.0694	5.4794	3.8666	99.4010	42.05	101.69	.4205	0.4223
20	1	(.5,.5)	3.0438	9.2252	6.6233	202.301	42.33	106.78	.4233	0.4226
	2	(.927,.073)	6.3894	9.0420	6.4880	196.78022	15.62	39.33	.1562	0.1556
	3	(.4205,.5795)	3.2576	9.9176	7.1353	223.5845	42.05	106.58	.4205	0.4218
30	1	(.5,.5)	4.1194	12.7914	9.2659	318.5432	42.33	109.18	.4233	0.4225
	2	(.927,.073)	9.2397	12.5430	9.0814	309.9332	15.62	40.24	.1562	0.1558
	3	(.4205,.5795)	4.4457	13.7311	9.9641	351.7602	42.05	108.97	.4205	0.4217
50	1	(.5,.5)	6.2707	19.0207	13.9048	556.6277	42.33	111.85	.4233	0.4227
	2	(.927,.073)	14.9222	18.6593	13.6351	541.7219	15.62	41.23	.1562	0.1558
	3	(.4205,.5795)	6.8221	20.3868	14.9248	614.1098	42.05	111.54	.4205	0.4215

Proposition 4. Optimal advertising and distribution levels for every brand is higher for a market with higher demand M.

Marketing models, typified by H&S, have ignored the effect of consumer income in choice models. The following propositions, deduced from Table 5, demonstrate the impact of consumer income on attack-defense strategies.

Proposition 5. Ceteris paribus, higher consumer income Y implies higher profits for all brands.[10]

Proposition 6. Unadjusted post-entry market share after attack, is independent of consumer income Y. Adjusted post-entry market demand, for each brand, increases with increase in Y; however (as in Proposition 2), adjusted share leadership changes from the attacker to defending brand 1, with increase in Y.[11]

Proposition 7. Optimal post-entry price for every brand increases with higher consumer income Y.

Proposition 8. Optimal post-entry advertising and distribution levels for every brand increases with higher consumer income Y.

The following propositions pertain to changes in both the consumer income Y and market demand M and follow from Tables 4 and 5.

Proposition 9. The optimal positioning of all brands is independent of both Y and M.

Notice that the attacker obtains highest profits, the first brand obtains the next highest profits and the second brand the lowest profits in the market, independent of Y and M. Also, the first brand obtains highest unadjusted market share followed by he attacker and the second brand (in that order), independent of Y and M. This leads to:

Proposition 10. The relationship between unadjusted market share and profits is not monotonic, i.e., profits increase with increasing market share in certain ranges of market share and the contrary holds in certain other ranges of market share.

It should be noted that these propositions are deduced from the simulation results involving entry into a market with two initial brands.

Summary and Directions for Future Research

In this paper we have generalized the economic model proposed by Lane (1980), and the marketing analysis suggested by Hauser and Shugan (1983). We have developed a procedure for computing/identifying the optimal attack strategies for a new product entry as well as optimal defense strategies for existing brands in the market.

We have shown that defending in only advertising and/or distribution is catastrophic when consumer choice depends on price, position and consumer income only. It is necessary to defend in prices also. We have also shown that the defenders should drop their advertising and distribution expenditures upon attack--this is in consonance with the results of H&S. However, it is worthy to note that these results are crucially dependent on the incorporation of the impact of advertising and distribution expenditures on sales through response function models (which has a lot of proponents, for example, Wind and Robertson, 1983, p. 15).

Several propositions relating consumer income Y and market demand M to optimal-defense strategies have been deduced from simulations. Especially notable among these is the importance of estimating consumer income in determining entry (go-no go) decisions.

Other open questions which are currently under study, are

(i) the optimal attack strategy for a firm which already has some brands in this market, incorporating synergy (modelled as in Sudharshan and Kumar (1984)),

(ii) the development of a procedure for generating the optimal strategies for attack and defense considering more than two attributes, and

(iii) the incorporation of other distributions for consumer tastes.

Footnotes

[1]Other important articles in this area are those by Hotelling (1929), Leland (1974) and Lancaster (1975).

[2]Referred to henceforth as H&S.

[3]The analytical intractability of the H&S model involve solving equations with trigonometric functional forms. We would gladly supply details to the interested reader.

[4]This reduction by one attribute results for any number of original attributes, if we can specify a technology constraint of the from $\sum_{j=1}^{t} w_i(j)$, where t = number of original attributes and i is the ith combination of the j=1,...,t original attributes. This constraint reduces the search space in finding the optimal brand positions. Also, our results can be generalized to situations with more than two attributes. The complexity of the search space for optimal brand positions increases, but our general results hold.

[5]This curve best suited Little's (1979) five requirements for response functions.

[6]Repositioning may not be viable because of a large fixed cost F associated with it.

[7]The interested reader is referred to Lane (1980) for proofs of existence of Nash equilibrium in prices. Existence of such equilibrium in advertising and distribution follows a similar line of proof.

[8]In section 4 we shall show that our choice of these values, while impacting on the specific solutions of positions, prices, advertising, distribution and profits, does not in any way change our general conclusions.

[9]The attack-defense strategies do not depend on the change in M from pre-attack levels to post-attack levels since the price, advertising and distribution levels are computed following Nash equilibrium and the defending brands cannot re-position. This implies that there is no "memory" of the pre-attack demand level and hence, only the value of post-attack demand matters.

[10]This proposition seems to suggest that errors in estimating market demand could make the difference between entering and not entering a market, e.g., in Table 5, if Y is 5, the profit for the new product is 40.5837. Suppose the hurdle profit to be cleared by the new product for entry is 45. Then if Y is estimated to be 5, a no-go decision will result. However, if Y is estimated to be 10, then an enter decision will result.

[11]This proposition, like proposition 5, seems to suggest the importance of estimation Y in making an entry decision. The difference between the two implications is that if the entering brand is required to be market share leader (rather than a profit hurdle clearer), then mis-estimation could lead to a wrong entry/no entry decision.

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Appendix

This section contains all the computational equations used in the calculation of the various strategies and performance measures (such as unadjusted market share, profits) for the initial equilibrium as well as the equilibrium after entry.

The notations used in this section are:

i = index for firm, $i=1,2,3$

p_i = price

k_{ai} = advertising expenditure

k_{di} = distribution expenditure

(w_i, z_i) = brand position on attributes (w, z)

constrained to $w + z = 1$, $i=1,2,3$

β_i = unadjusted market share

$A(k_{ai})$ = advertising response level (ADBUDG form)

$D(k_{di})$ = distribution response level (ADBUDG form)

c = marginal cost

F = fixed cost of entry

M = total market demand

π_i = profit given by

$\pi_{ij} = (p_i - c)\beta_i MA(k_{ai})D(k_{di}) - F - k_{ai} - k_{di}$.

The adjusted market share is computed by $\beta_i A(k_{ai})D(k_{di})$ and the adjusted demand by $\beta_i MA(k_{ai})D(k_{di})$.

Initial Equilibrium

(1) Location Strategy Computation:

a) For fixed (w_1, z_1), and for every (w_2, z_2) compute the Nash equilibrium price, advertising and distribution strategies (this computation is discussed below). Brand 2's optimal strategy is to compute $(w_2^*(w_1, z_1), z_2^*(w_1, z_1)) = \underset{(w_2, z_2)}{\text{argmax.}} \; \pi_2$

given (w_1, z_1)

i.e., optimal location to maximize profits.

b) Brand 1's optimal strategy is to compute

$$\underset{(w_1, z_1)}{\text{max.}} \; \pi_1$$

given $w_2^*(w_1, z_1)$

$z_2^*(w_1, z_1)$

i.e., optimal location knowing firm 2's reactive optimal location and the ensuing Nash equilibrium in the other strategies. This is possible due to the assumption of perfect foresight for brand 1.

(2) Nash Price, Advertising and Distribution Strategies Computation

Given (w_1, z_1) and (w_2, z_2),

$$\frac{p_1-c}{Y-p_1} - \ell n(Y-p_1) = \ell n(z_1/z_2) - \ell n(Y-p_2) \qquad (1)$$

$$\frac{p_2-c}{Y-p_2} - \ell n(Y-p_2) = \ell n(w_2/w_1) - \ell n(Y-p_1) \qquad (2)$$

$$(p_1-c)\beta_1 MD(k_{d1}) \frac{\partial A}{\partial k_{a1}} - 1 = 0 \qquad (3)$$

$$(p_1-c)\beta_1 MA(k_{a1}) \frac{\partial D}{\partial k_{a1}} - 1 = 0 \qquad (4)$$

$$(p_2-c)\beta_2 MD(k_{d2}) \frac{\partial A}{\partial k_{a2}} - 1 = 0 \qquad (5)$$

$$(p_2-c)\beta_2 MA(k_{a2})\frac{\partial D}{\partial k_{d2}} - 1 = 0 \tag{6}$$

where $$\beta_1 = \frac{\ell n[\frac{z_1}{z_2}\cdot\frac{(Y-p_1)}{(Y-p_2)}]}{\ell n[\frac{w_2}{z_2}\cdot\frac{z_1}{w_1}]} \tag{7}$$

$$\beta_2 = 1 - \beta_1 \tag{8}$$

$$\frac{\partial A}{\partial k_{ai}} = (a_0-a_1)\frac{a_2\, a_3^{a_2}\, k_{ai}^{a_2-1}}{(a_3^{a_2} + k_{ai}^{a_2})^2} \tag{9}$$

$$\frac{\partial D}{\partial k_{di}} = (b_0-b_1)\frac{b_2\, b_3^{b_2}\, k_{di}^{b_2-1}}{(b_3^{b_2} + k_{di}^{b_2})^2} \tag{10}$$

See Lane (1980) for a deviation of equations (1) and (2), which represent first order conditions of profit maximization with respect to price and equations (7) and (8), which represent the market demand allocation through consumer utility maximization. Equations (3)-(6) represent first order conditions with respect to advertising and distribution while (9) and (10) are the partial derivatives of the ADBUDG type advertising and distribution functions.

a) Using (1) and (2), compute p_1^*, p_2^*.

b) Using (3), (4), (7), (9) and (10), compute k_{a1}^*, k_{d1}^*.

c) Using (5), (6), (7), (8), (9) and (10), compute k_{a2}^*, k_{d2}^*.

This gives the equilibrium price, advertising and distribution strategies as functions of (w_1, z_1) and (w_2, z_2), to be used in the optimal location strategy computation discussed earlier.

Equilibrium after entry

Consider the positions of brands 1, 2 and 3 in the order 3 - 1 - 2, i.e., $w_3 < w_1 < w_2$ (or alternatively $\frac{w_3}{z_3} < \frac{w_1}{z_1} < \frac{w_2}{z_2}$). Given (w_1^*, z_1^*) and (w_2^*, z_2^*), (this is possible since brands 1 and 2 are assumed not to use repositioning as a defensive strategy),

$$\frac{(p_3-c)}{(Y-p_3)} - \ell n(Y-p_3) = \ell n(z_3/z_1) - \ell n(Y-p_1) \tag{11}$$

$$\frac{(p_1-c)}{(Y-p_1)} - \ell n(Y-p_1) = \sigma_1 - \gamma_1 \ell n(Y-p_2) - (1-\gamma_1)\ell n(Y-p_3) \tag{12}$$

$$\frac{(p_2-c)}{(Y-p_2)} - \ell n(Y-p_2) = \ell n(w_2/w_1) - \ell n(Y-p_1) \tag{13}$$

$$-\frac{z_3}{w_3}\ell n\frac{z_3}{z_1} + \ell n\frac{w_1}{w_3} - \frac{1}{w_3}\ell n(\frac{Y-p_3}{Y-p_1}) = 0 \tag{14}$$

where
$$\sigma_1 = \frac{\ell n(w_2)\ell n(z_1/z_3) + \ell n(w_1)\ell n(z_3/z_2) + \ell n(w_3)\ell n(z_2/z_1)}{\ell n[\frac{w_2}{z_2}\cdot\frac{z_3}{w_3}]} \tag{15}$$

$$\gamma_1 = \frac{\ell n[\frac{w_1}{z_1}\cdot\frac{z_3}{w_3}]}{\ell n[\frac{w_2}{z_2}\cdot\frac{z_3}{w_3}]} \tag{16}$$

For i=1,2,3

$$(p_i-c)\beta_i MD(k_{di})\frac{\partial A}{\partial k_{ai}} - 1 = 0 \tag{17}$$

$$(p_i-c)\beta_i MA(k_{ai})\frac{\partial D}{\partial k_{di}} - 1 = 0 \tag{18}$$

where $$\beta_3 = \frac{\ln[\frac{z_3}{z_1} \cdot \frac{(Y-p_3)}{(Y-p_1)}]}{\ln[\frac{w_1}{z_1} \cdot \frac{z_3}{w_3}]} \tag{19}$$

$$\beta_2 = \frac{\ln[\frac{w_2}{w_1} \cdot \frac{(Y-p_2)}{(Y-p_1)}]}{\ln[\frac{w_2}{z_2} \cdot \frac{z_1}{w_1}]} \tag{20}$$

$$\beta_1 = 1 - \beta_3 - \beta_2 \tag{21}$$

See Lane (1980) for a derivation of equations (11)-(13), (15) and (16) which represent profit derivatives with respect to price and equations (19)-(21) which represent market demand allocation. Equation (14) represents the first order condition for otpimal positioning (variable z_3) of attacker. Equations (17) and (18) represent first order conditions with respect to advertising and distribution.

a) Using (15), (16) and the fact that $w_i + z_i = 1$, equations (11)-(14) are four non-linear equations involving (p_1, p_2, p_3, z_3) which can be solved for (p_1^*, p_2^*, p_3^*, z_3^*).

b) Using (9), (10), (17), (18) and the corresponding equation choice in (19)-(21), the strategic variables (k_{ai}^*, k_{di}^*) can be obtained for each i=1,2,3.

The above procedure is used when the defensive strategy for brands 1 and 2 encompass price, advertising and distribution (as in Case (3) of the paper). For Case (2), which entails defense only in prices, the computations regarding (k^*_{ai}, k^*_{di}) i=1,2 are omitted and these brands are assumed to use the same levels of advertising and distribution as prescribed by the initial equilibrium. For Case (1), which entails defense in advertising and/or distribution only, equations (11) and (14) are solved for p^*_3 and z^*_3, for fixed p_1 and p_2 given by the pre-entry levels.

Note that we assumed an ordering of 3-1-2 initially, which implies the attacker to position somewhere before brand 1 along the w-axis (or f-axis). We can derive alternative equations (11)-(13), (15), (16) and (19)-(21) for the cases when the ordering is 1-3-2 or 1-2-3. As intuitively expected, these latter cases do not provide the optimal entry point for the attacker.