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Optimal Defensive Strategies under Varying Consumer Distributional Patterns and Market Maturity

Ulrike Schuster and Jürgen Wöckl*

In this paper we describe a simulation approach to explore optimal defensive strategies concerning an entrant situation in an artificial consumer market. There are two questions of interest concerning the adaptation of the strategy to obtain maximal profits—the effects of (1) varying heterogeneity of the considered consumer aspiration points and (2) the maturity of the market at the time of entry. The resulting optimal price-budget combinations remain stable up to a certain degree of heterogeneity. Then a threshold is reached beyond which further disaggregating the market leads to boundary solutions. The entrant threshold seems to be slightly lower than the incumbent threshold. In the case of very late entry a boundary solution seems to be optimal for the entrant in the sense of minimizing losses.

Keywords: market maturity, heterogeneity, competition, defensive marketing, continuous model, simulation, optimization

1 Introduction

The cornerstone for a series of papers dealing with the problem of finding optimal defensive strategies for firms facing a new competitor in the market was set by the Defender model as developed by Hauser and Shugan (1983). Over time this approach was extended as a consequence of explorations into its recommended strategies under relaxed assumptions. Do these recommendations remain valid?

All papers in this series deal with a mature market which is at a Nash equilibrium and consider a new equilibrium after a new competitor has entered the market. This implies that the firms must have followed their optimal strategies not only after but also before a new entry. They are able to change their prices as well as

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*Authors at: Vienna University of Economics and Business Administration, Austria.

their marketing expenditures for advertising and distribution in order to defend their position in the market. In some investigations they are allowed to change their position in perceptual space too. The optimization task is performed stepwise, which means that first the optimal prices are determined and afterwards the marketing expenditures are optimized given the prices. The main focus is placed on those brands adjacent to the new entrant. Other firms are considered to be only marginally affected and therefore in the majority of cases are assumed to show no reaction and instead keep up their extant strategies.

Firms are profit maximizers and are assumed to act rationally. The entry position is assumed to be fixed exogenously and is known by all brands. Customers are utility maximizers and choose the product closest to their ideal point (deterministic choice). Hauser and Shugan (1983) work with a utility function which is linear in the price-scaled product features. (Most studies only consider two product features.) In contrast Kumar and Sudharshan (1988) use a Cobb-Douglas utility function (here the product features aren't scaled with prices) and ADBUDG functions to model responses to advertising and distribution respectively. Advertising and distribution response functions are always concave but can either be coupled or decoupled (the price strategy is independent of the advertising and distribution expenditures; a firm's marketing expenditures have no effect on the sales of other brands). Since the paper of Gruca et al. (1992) only coupled response functions are considered in all subsequent investigations. As soon as coupled response functions are introduced, there must be lower and upper bounds for price and marketing expenditures in order to guarantee the existence of a unique Nash equilibrium. Usually prices must be greater than or equal to the marginal costs and lower than or equal to the market reservation price. Advertising and distribution expenditures are assumed to be greater than or equal to a small number $\varepsilon > 0$ and an upper bound is also fixed.

All approaches formulate market share models that are used in the profit maximization function. Under the specification of coupled response functions multiplicative attraction models are applied (e.g., MCI models in Gruca et al., 1992, or MNL models in Basuroy and Nguyen, 1998), which means that now the elements of the marketing mix are allowed to interact. For the attraction models the brands are assumed to be symmetric, and in particular they have equal attractions or equal attraction coefficients.

In studies preceding Gruca et al. (2001) a continuous distribution of demand is assumed. Gruca et al. (2001) investigate for the first time the influence of segmentation by defining a discrete preference distribution (customer's preferences are assumed to remain constant over time). The authors work with segment ideal points which represent the means over the ideal points of all segment members. The utility is given by the distance between the brand position and the segment ideal point and also by the size of the segment's choice set. Furthermore with the consideration of stochastic choices by the customers (i.e., product choices not necessarily closest to the individual ideal combination enter the choice set) another new aspect was added.

The original optimal defensive strategies of the Defender model by Hauser and Shugan (1983) proved to be fairly robust even under slightly varied assumptions. If market size does not change, the profits of any brand in the market decrease in the event of a new entry. Concerning the optimal strategies, a price reduction as well as a decrease in advertising and/or distribution expenditures is suggested. But if the market is highly segmented and the entrant attacks one of the incumbent's segments, then the price should be increased. Also if one accounts for all market participants, it is found that brands far away from the entrant should raise their prices (see Gruca et al., 2001).

In Gruca et al. (1992) dominant (i.e., with a market share greater than 50%) and non-dominant brands are considered separately because in markets with coupled response functions the optimal reaction is affected by the relative market share. Here the Defender recommendations could be valid for coupled response functions and non-dominant brands whereas dominant brands should raise their advertising expenditures unless they won't lose their dominance as a consequence of the new entry. Moreover under consideration of market expansion an increase in the advertising and/or distribution expenditures can be optimal provided the market growth is strong enough (see Kumar and Sudharshan, 1988, or Basuroy and Nguyen, 1998).

Under the assumption of constant markets (for both coupled and decoupled response functions) and especially for the brand nearest to the new entrant it is advisable to cut prices. But if the market is highly segmented or if the incumbent is dominant, a price increase is recommended. Similarly brands far away from the entrant should increase their prices. Furthermore, market expansion demands an increase in marketing expenditures. On the other hand the presence of a new competitor calls for a reduction in the advertising budget for example. So the strategy recommendations concerning marketing efforts may be ambiguous.

To derive analytical solutions concerning the product price and budget of incumbent and entrant firms, very strict assumptions and restrictions have to be made. To avoid the limitations of an analytical approach, in this study a dynamical market simulation model is implemented. Though the properties of a game-theoretic exercise are lost, the advantage of relaxing these constraints and pursuing a numerical approach seems worthwhile. While the basic assumptions of the Defender model still hold, the influence of other experimental factors (i.e., heterogeneity of the market and maturity of the market) can be examined. In this study a model is developed to perform a numerical market simulation relating to these experimental factors. The market consists of three well-separated consumer segments, each dominated by a single firm. To optimize their individual profits the brands are able to set the price of the product and the advertising budget to evoke higher consumer preferences and thus higher market shares. After a period of increasing market saturation, a new firm enters the market in a specific segment and thus attacks the position of one incumbent. The emphasis in this study is to derive the optimal reaction of the incumbent as well as the optimal entrance strategy concerning prices and advertising expenditures. How these optimal strategies vary with certain experimental factors is presented.

The first factor of interest is the heterogeneity of the considered consumer aspiration points. There can either be a single ideal point per segment (homogeneous case) or a more or less dispersed pall of individual consumer ideal points (heterogeneous case). It is expected that the results of the experiment will become fuzzier with increasing heterogeneity. The second factor considered concerns the maturity of the market, which is related to the time the new brand enters. The earlier the entry occurs the less mature the market. If the market is already fully developed by the time of entry, it is difficult to overcome the incumbent’s head start.

The next section describes the basic mathematical principles of the model used. The last section presents the specification of the experiments and discusses results.

2 Description of the Continuous Artificial Consumer Market (CACM)

In contrast to many discrete approaches of consumer markets (e.g., Buchta and Mazanec, 2001), the CACM implements time as a continuous variable. The temporal development of the quantities in the CACM is described by differential equations. To derive the evolution of a specific quantity, the differential equations are integrated over time. During the simulation process, the continuous time quantity in the CACM requires discretization to enable numerical integration. In order to facilitate the numerical integral, a simple Euler integration method with a constant discretization has been used. The discretization can be chosen arbitrarily with the only requirement that it should be smooth enough to provide proper results.

The continuous model is designed to emulate consumer behavior concerning different brands acting in a segmented market. All firms offer the same type of product but emphasize different attributes, leading to a positioning of each firm in the product attribute space. The consumers are split up in groups of special aspiration patterns and each consumer group has a specific ideal point that constitutes the desired features—the so-called aspirations. At the beginning of the simulation consumer perceptions regarding the product features are located at the origin. Due to the firms' advertising efforts, the perceptions related to the emphasized physical properties of the product move in a direction induced by the advertising claim. To decide in favor of a brand the consumers consider price-weighted perceptions, which are called attitudes. Brands are rated by the consumers by measuring the distance between aspirations and perceptions. This distance represents an inverse measure of the utilities of each consumer for each product. The choice process is based on this utility measure.

2.1 Dynamics of the perceptions

2.1.1 Advertising impact function (aif)

The brand-specific advertising budgets affect the growth process of the consumers' perceptions concerning the position of the firms in the market. Therefore an s-shaped log-reciprocal advertising function is used (see Hruschka, 1996, p. 214, and Lilien and Rangaswamy, 2003):

$$aif\,(budget_i) = e^{\alpha - \frac{\beta}{budget_j}} \,. \tag{1}$$

2.1.2 Differential equation of the perception dynamics

Perception dynamics are driven by the advertising budgets. The differential equation consists of two parts where the first part describes the growth of perceptions of the advertised attributes starting at 0 and increasing up to 1 depending on the actual relative advertising budget. The second part describes the decay due to consumers forgetting product attributes. The appropriate function $b(\cdot)$ is defined later. In the following, i indexes aspiration groups, j brands, k product attributes, and t time. The differential equation responsible for the temporal modification of the perceptions p of those attributes which are advertised is:

$$\frac{dp_{ijk}(t)}{dt} = aif\,(budget_j)(1 - p_{ijk}(t)) - b(t, budget_j)\,p_{ijk}(t) \tag{2}$$

$$p_{ijk}(t) = \int_{start}^{t} \left[aif\,(budget_j)(1 - p_{ijk}(\tau)) - b(\tau, budget_j)\,p_{ijk}(\tau) \right] d\tau \,, \tag{3}$$

where *start* denotes the starting time of the simulation.

2.1.3 Calculation of attitudes

In the CACM the attitudes *att* are assumed to arise from the price-weighted perceptions:

$$att_{ijk}(t) = \frac{p_{ijk}(t)}{price_j^*} \qquad \text{with} \qquad price_j^* = \frac{price_j}{\frac{1}{J}\sum_{j=1}^{J} price_j} \quad .$$

2.1.4 Forgetting rate concerning relative budgets

The function of the forgetting rate is formulated for relative budgets. Further, it must be considered whether an attribute is advertised or not. Define

(i) Non-advertised attribute:

$$b(t, budget_j) = b_0 , \tag{4}$$

(ii) Advertised attribute:

$$b(t, budget_j) = \frac{1}{1 + F(t, budget_j)} , \tag{5}$$

with

$$F(t, budget_j) = budget_j(t) \cdot \int_{start}^{t} \frac{budget_j(\tau)}{\sum_j budget_j(\tau)} \cdot f(t-\tau) d\tau . \tag{6}$$

Here the function $f(t-\tau)$ is defined by:

$$f(t-\tau) = e^{-b_0(t-\tau)} \tag{7}$$

$$\Rightarrow F(t, budget_j) = budget_j(t) \cdot \int_{start}^{t} \frac{budget_j(\tau)}{\sum_j budget_j(\tau)} \cdot e^{-b_0(t-\tau)} d\tau . \tag{8}$$

The function F describes a mathematical convolution of former budgets with weighting function $f(t-\tau)$, which is chosen in such a way that smaller weights are imposed on past relative budgets than on actual budgets. In the actual implementation, the weighting function is defined as an exponential function. To calculate the actual value for the forgetting rate an Euler integration method is used where the same step-size as for the integration of the perception rates is chosen.

2.2 Ideal-point model

To measure the satisfaction of a consumer with a product, the distance between the appropriate aspiration point and the attitude (i.e., the price-weighted perceptions) is determined using the Euclidian norm.

2.2.1 Calculation of utilities

The utility of consumers in aspiration group *i* with respect to product *j* can be measured with the aid of the proportional distance between the appropriate aspiration point of the aspiration group and the attitude corresponding to brand *j*. The utilities *uti* are calculated by dividing the maximum distance by the respective one:

$$uti_{ij} = \frac{\max(distance_{ij})}{distance_{ij}} . \tag{9}$$

Thus the smaller the distance the higher the utility.

2.2.2 Calculation of market shares

The volume of the market share MA_{ij} of brand *j* is calculated from the consumers in aspiration group *i*:

$$MA_{ij} = \frac{uti_{ij}}{\sum_i uti_{ij}} . \tag{10}$$

The market shares of each aspiration group *i* must sum to 1 (see Lilien et al., 1992).

2.2.3 Calculation of profits

To calculate profits for each brand in the market, sales is determined first as

(i) Sales of brand *j* in segment *i*:

$$sales_{ij} = N_{C,i} \cdot MA_{ij} \cdot price_j , \tag{11}$$

where $N_{C,i}$ denotes the number of consumers in segment i,

(ii) Profit for brand j:

$$profit_{ij} = \left(\sum_i N_{C,i} \cdot MA_{ij} \right) \cdot price_j - budget_j \ . \qquad (12)$$

Profit serves as a target function in optimization tasks.

3 Experiment

3.1 Experimental market scenario and model calibration

The model described above is used to explore optimal defensive strategies for a brand directly attacked by a new brand that enters the market some time later than the others. We consider three different firms positioned in three different market segments. It is assumed that some time after all other brands have settled down a new brand enters the already mature market and tries to position itself in a segment already occupied by another firm. Now the affected incumbent is able to defend itself by changing its price and advertising budget. All brands are assumed to start at consumer perceptions of 0.1. Also the entrant will have to start at this level, thus facing some disadvantage because it must try to catch up with the incumbent concerning the development of the perceptions. The parameters for the advertising impact function are chosen as $\alpha = 0.5$ and $\beta = 45$ and are assumed to be the same for all firms in the market (see Figure 1).

It is further assumed that each of the three initial brands demands the same price of 3 units and advertises with identical budgets of 90 units. The entrant is hypothesized to join the market with a somewhat smaller price of 2.5 units but higher advertising expenditures of 150 units to regain lost time and catch up with the perceptions already developed for the competitors.

The first experimental factor considered is the consumer distribution in the market, meaning the dispersion of consumer preferences in the product attribute space. Some papers dealing with the derivation of optimal defensive strategies have also considered consumer distribution as a factor of interest (e.g., Ansari et al., 1994, or Gruca et al., 2001). This paper is especially concerned with the degree of

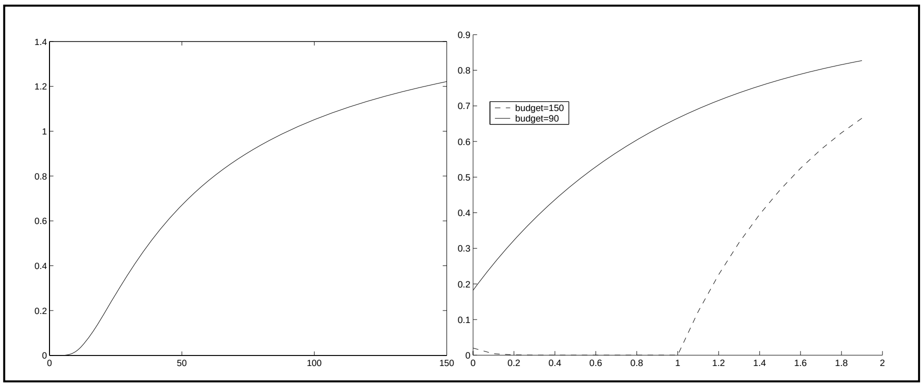

Figure 1. Advertising impact function with $\alpha = 0.5$ and $\beta = 45$ (left); temporal growth of the perceptions under this advertising impact for incumbent (budget=90) and entrant (budget=150) (right)

heterogeneity in each consumer segment. In principle, the market segments are homogeneous. This means that though each consumer segment consists of 100 consumers, they are assumed to have the same aspiration point. This common aspiration level can be interpreted as the segment ideal point. The assumption of only one ideal point per segment can be relaxed by allowing different individual ideal points for each consumer in a segment. Those individual aspiration levels are modelled as more or less dispersed around the above mentioned segment ideal point. Thus the parameter of interest is the amount of dispersion of the aspirations in each segment, and the optimal defensive strategies under those varying aspiration points are analyzed.

The second experimental factor—the market maturity—is represented by the time at which new entry occurs, meaning the moment when the new brand enters the market (Carpenter and Nakamoto, 1990, consider the problem of a late entry). At first all brands start developing their perceptions from the origin. The entrant has to start promoting the product attributes and developing consumer perceptions in order to attain consumer preferences. The greater the head start of the incumbents or the later the new brand enters, the more mature the market and the more difficult this is.

3.1.1 Target function

The optimal strategy is that price-budget combination which leads to the maximum profit of the incumbent. Therefore, the profit of the attacked brand is used as the target function:

$$ZF_j = \max_{price_j, budget_j} \left(profit_j \right). \qquad (13)$$

3.2 Results

3.2.1 Heterogeneity of consumer aspirations

• Optimization of the incumbent under the assumption of segment ideal points

At first the experiment is performed for the homogeneous case or, in other words, under the assumption of segment ideal points: every consumer in a segment has the same aspiration level. This means that there's no dispersion of the individual ideal points. It could also be said that they are normally distributed with mean the segment ideal point and variance 0. To find the optimal defensive strategy a surface plot is created which shows the profits for different price-budget combinations of the incumbent.

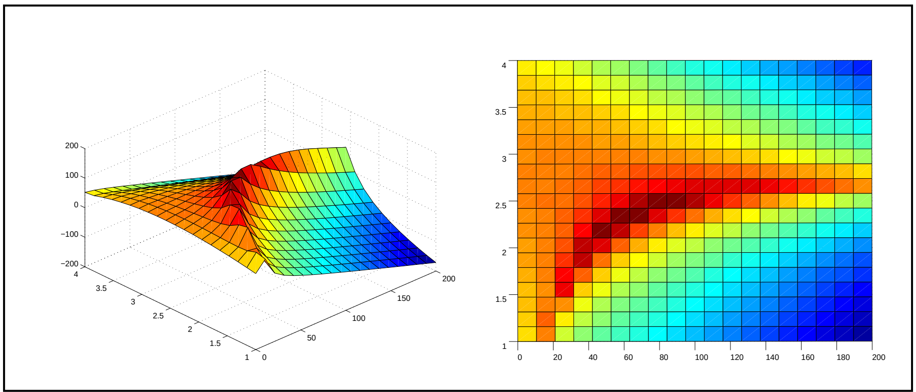

Figure 2. Surface plots of the profits of the incumbent for several price-budget combinations under a fixed entrance strategy in a homogeneous market (σ^2 = 0)

As can be seen in Figure 2 there is no unique optimum. There exist different price-budget combinations resulting in the same optimal profit for the incumbent. But at least a general tendency concerning price and budget reactions can be read off. More precisely, the incumbent should reduce its price (down to a value between 2 and 2.5 units) as well as its advertising budget (down to a value between 50 and 100 units) when it is facing a new brand entering the market and directly jeopardizing its monopoly in this special market segment. Conversely, the entrant's strategy is optimized by maximizing the new brand's profit given an optimal price and budget for the incumbent shown below (Figure 3); an optimal price of about 1.7 units and an optimal budget of around 50 units is recommended.

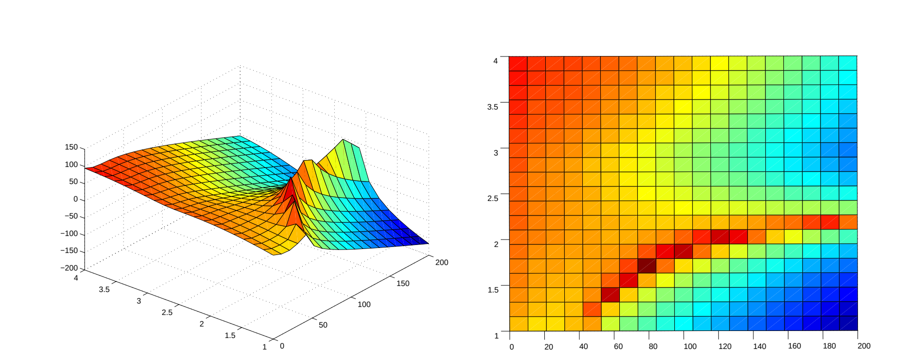

Figure 3. Surface plots of the profits of the entrant for several price-budget combinations under a fixed incumbent strategy in a homogeneous market (σ^2 = 0)

• Optimization of the incumbent under weak dispersion of individual ideal points

In this section the incumbent's reaction in the case of a fixed entrance strategy is investigated under the assumption that the individual ideal points of the consumers are normally distributed with mean the segment ideal point and a relatively small variance of 0.04 in each segment. Again a surface plot serves to present the resulting profits for the incumbent under a fixed entrance strategy (Figure 4).

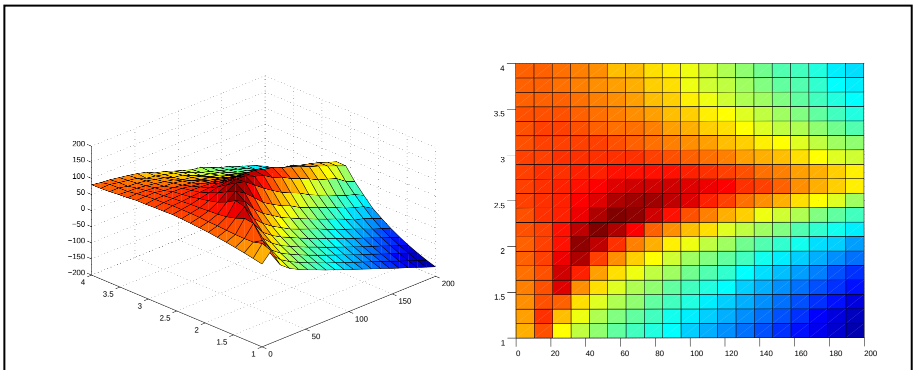

Figure 4. Surface plots of the profits of the incumbent for several price-budget combinations under a fixed entrance strategy in a heterogeneous market (σ^2 = 0.04)

In this case as before there is no unique optimum. But in general there can again be given general advice as to how to change prices and budgets in a profit-maximizing way. A comparison of the heterogeneous with the homogeneous model above shows that under an increased variance of the ideal points around the mean, the surface of the target function becomes cliffy and isn't as smooth as in the homogeneous case. Also the defensive strategy changes slightly, especially with respect to advertising expenditures. In particular with a recommended 40 to 60 units the budget should be smaller in contrast with the homogeneous case. Concerning the price, no significant difference can be found. The strategy for the new brand (see Figure 5) generally stays the same as in a homogeneous consumer market with a price between 1.5 and 2 units and a budget between 40 and 60 units. However, another interesting phenomenon can be observed: it can be seen that a boundary solution (i.e., charging the highest price possible with no advertising) becomes an almost equally attractive alternative to an inner solution.

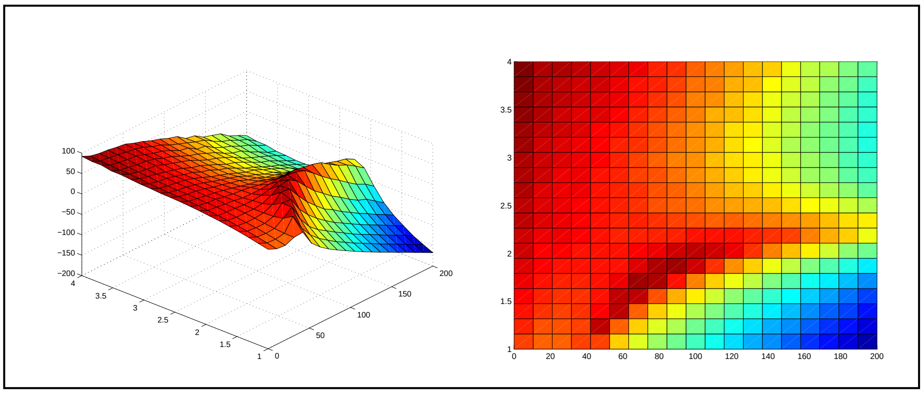

Figure 5. Surface plots of the profits of the entrant for several price-budget combinations under a fixed incumbent strategy in a heterogeneous market (σ^2 = 0.04)

• Optimization of the incumbent under strong dispersion of individual ideal points

The third experiment concerns a slightly stronger dispersion of the individual aspiration levels of the consumers in each segment than in the previous case. They are again assumed to be normally distributed with mean the segment ideal point and now twice the variance (σ^2 = 0.08). Under the new variance the surface plot for the incumbent exhibits even more cliffs than before (Figure 6).

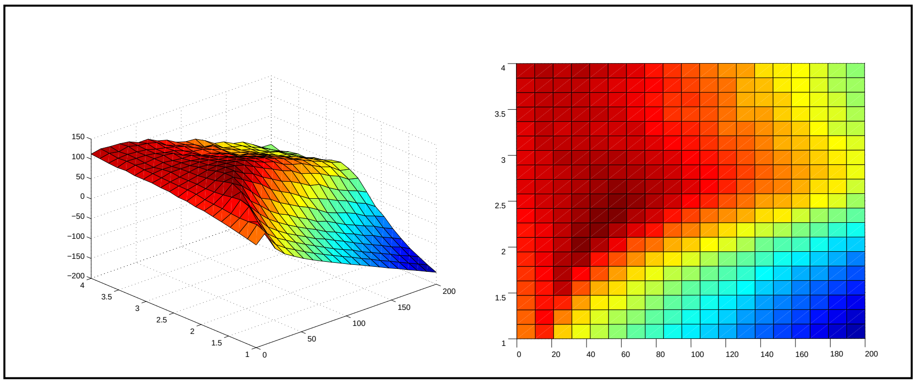

Figure 6. Surface plots of the profits of the incumbent for several price-budget combinations under a fixed entrance strategy in a heterogeneous market (σ^2 = 0.08)

The tendency of the prices to stay constant and the budgets to decrease still holds. A price should be selected from the interval [2, 2.5] and a budget from [40, 60]. Again one finds the interesting result that there is a tendency towards a boundary solution. Boundary values of no advertising expenditures and the highest price possible become more and more attractive.

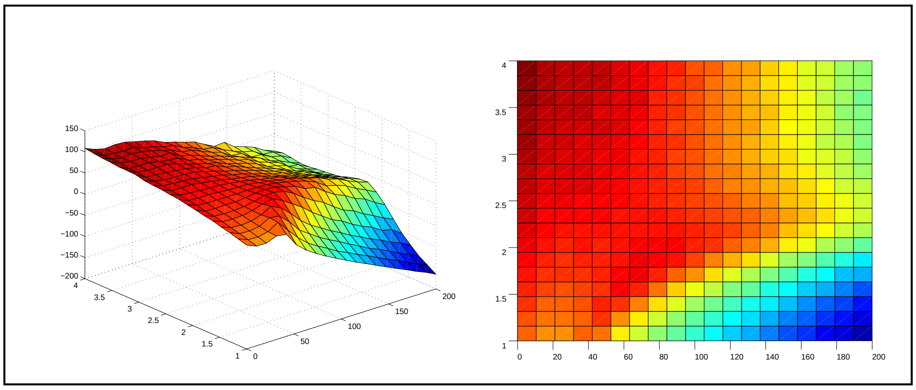

Figure 7. Surface plots of the profits of the entrant for several price-budget combinations under a fixed incumbent strategy in a heterogeneous market (σ^2 = 0.08)

By increasing the variance above σ^2 = 0.11, the optimal result for a defensive strategy actually becomes a definitive boundary solution, with the highest price possible and a lower bound for the advertising budget recommended. For the entrant the appearance of boundary values as an optimal strategy arises much earlier (even for σ^2 = 0.08). Thus heterogeneity has a stronger effect on the entrant than on the incumbent (see Figure 7).

3.2.2 Time of entry

The following experiments are conducted under the assumption of homogeneous aspiration groups. This means there is only one single ideal point representing the aspirations of all consumers in each segment.

• Early time of entry

By early time of entry it is meant that the new brand enters the market after a fourth of the time period of interest has passed. This can be interpreted as an entrance in a just emerging market or product category. All other incumbents which were located in the market since the beginning have been able to start advertising their brands but only for a short time.

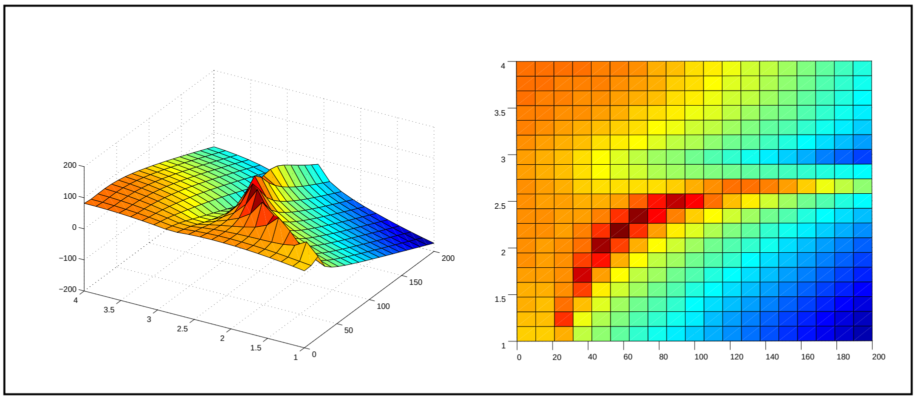

Figure 8. Surface plots of the profits of the incumbent for several price-budget combinations under a fixed entrance strategy in an emerging market (time of entry = 0.5)

In the case of an early entry the incumbent should reduce its advertising budget down to about 60 units. The price should also be decreased to a value of approximately 2.3 units, which leads to an optimal profit (see Figure 8). In the other case where the entrance strategy is optimized, these mean optimal values for price and budget for the incumbent are assumed to be constant. The entrant should select a price of 2.4 units, slightly higher than for the incumbent, and start advertising with a budget of 140 units, considerably more than its nearest competitor (see Figure 9).

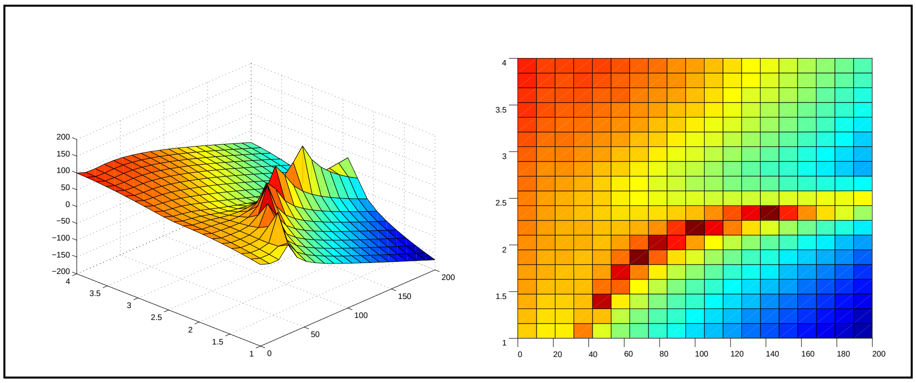

Figure 9. Surface plots of the profits of the entrant for several price-budget combinations under a fixed incumbent's strategy in an emerging market (time of entry = 0.5)

• **Moderate time of entry**

Now the new entry is assumed to occur in the middle of the time period considered. This means that the market is already rather mature with known brands in it. To be successful, the entrant must apply a deliberate strategy to turn out to be a real danger to the incumbent located at the segment under attack. It's not as easy as in the first case for the new brand to be accepted by consumers by the end of the time horizon.

The optimal price should be close to that for an early entrance time (between 2.3 and 2.5 units). Differences can only be found considering the advertising efforts (see Figure 10). To maximize the incumbent's profit it is again recommended that it reduce its budget (down to between 60 and 100 units) but not by as much as in the other two situations. On the other hand the entrant should choose a rather low budget of about 80 units and very low price of 1.7 units as shown in Figure 11.

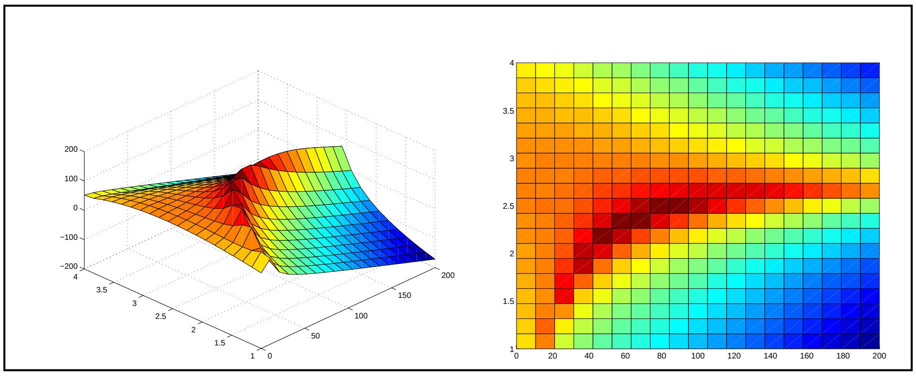

Figure 10. Surface plots of the profits of the incumbent for several price-budget combinations under a fixed entrance strategy in a mature market (time of entry = 1)

• Late time of entry

The new brand enters the market only after three fourths of the time period has passed. This experiment concerns a very mature market where the incumbents have a great advantage in comparison to the entrant because they've already had enough time to strongly develop their consumer perceptions. They've also had the opportunity to build up brand loyalty. This makes it very difficult to enter such a fully developed market as an unknown brand. This fact is reflected in the optimal strategies for the entrant as well as the incumbent under attack.

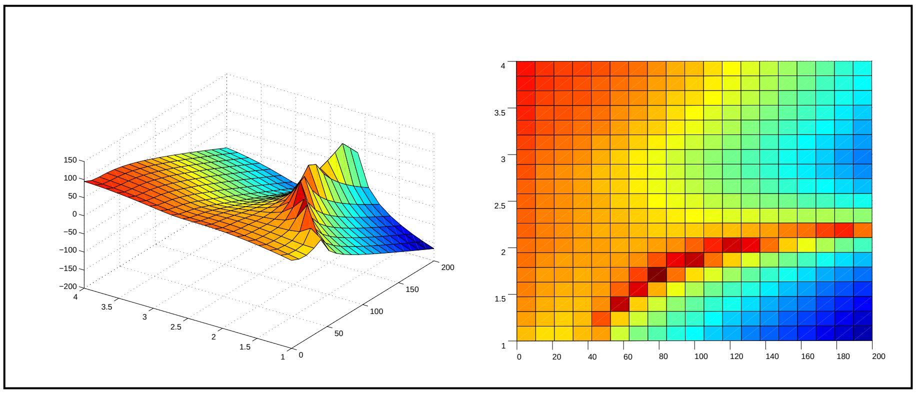

Figure 11. Surface plots of the profits of the entrant for several price-budget combinations under a fixed incumbent's strategy in a mature market (time of entry = 1)

The incumbent is not forced to expend great efforts to defend itself because the new brand does not represent a signficant challenge to its position. It suffices to use a lower price between 2.3 and 2.5 units (similar to the other cases) and a low budget of about 30 to 60 units (see Figure 12). In contrast the entrant is forced to stop advertising and to raise its price up to the maximal value allowed (see Figure 13).

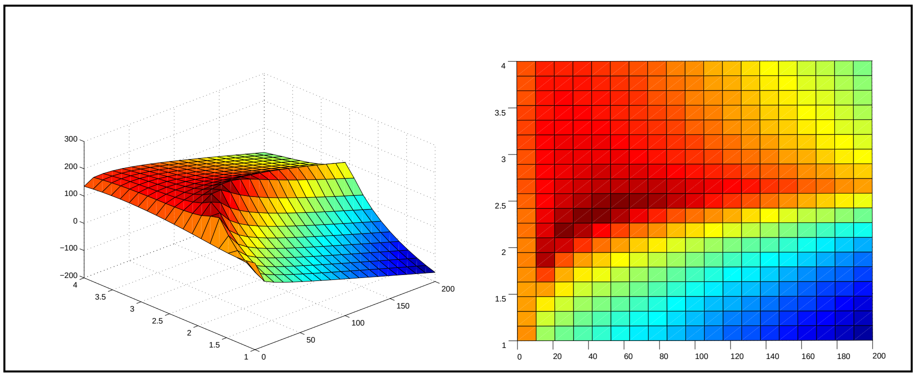

Figure 12. Surface plots of the profits of the incumbent for several price-budget combinations under a fixed entrance strategy in a saturated market (time of entry = 1.5)

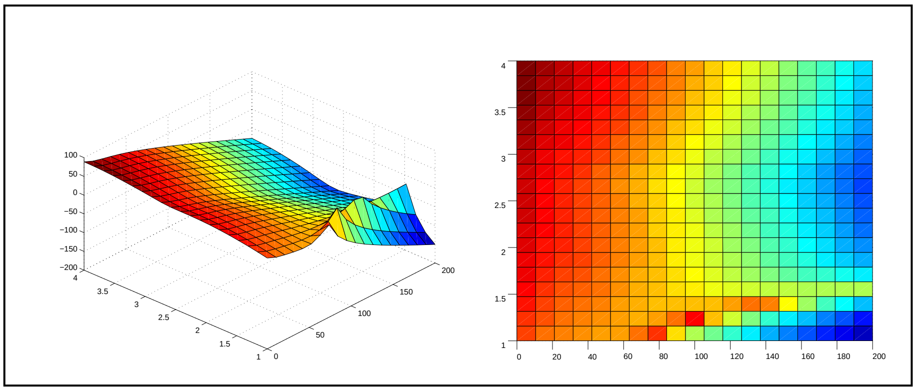

Figure 13. Surface plots of the profits of the entrant for several price-budget combinations under a fixed incumbent's strategy in a saturated market (time of entry = 1.5)

Since it is nearly impossible to make up for lost time, the entrant can save money and thus increase its profit by reducing its advertising effort to a minimum. This is why a boundary solution (a price of 4 units with no advertising budget) turns out to be the only optimal strategy for the new brand.

4 Conclusion

One main conclusion of the experiments is that there's no unique optimum in the defensive strategy, but rather there are several price-budget combination that lead to maximum profits. For varying consumer distribution patterns in both homogeneous and slightly heterogeneous markets, prices and advertising budgets should be decreased in response to a new brand entering the market. Only if the market is very heterogeneous in the sense that consumer preferences in each segment are strongly dispersed around the segment ideal point, then a boundary solution (the highest price possible with no advertising) may be optimal. For the entrant, the optimal strategy consists of a somewhat lower price than the one the incumbent should demand with about the same advertising expenditures.

The phenomenon of a boundary solution being the optimum already appears at a lower level of heterogeneity in the market. Comparing different times of entry, it can be seen that for a new brand entering very late—meaning in a mature market—it's almost impossible to gain market share and profit. The later the entry occurs, the easier it is for the incumbent to defend its position. Also, the simulation approach in general agrees with the results of Hauser and Shugan's Defender model (1983). This result for varying market maturity is particularly interesting because no other paper has investigated the effect of this factor on optimal defensive strategies.

It seems worthwhile for future research to explore stationary strategies for both the incumbent and the entrant. These can be obtained by optimizing their strategies sequentially by alternately updating optimal prices and budgets for the incumbent and the entrant until convergence to a stable strategy is achieved. Alternatively, it may be possible to optimize both strategies simultaneously.

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