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Evaluation of Aggressive Competitive Pricing Strategies

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Abstract

The main contribution of this paper is a method that allows one to study the effects of different degrees of competition. We find that optimal prices and profits are more sensitive to cooperative than to aggressive behavior on the part of competitors. With more aggressive policies, the average pricing level decreases and the average difference between high and low prices increases. An empirical model of the detergent market illustrates the methodology.

Key words: Aggressive strategies, pricing research, competitive strategy

Introduction

A competitive strategy requires a firm to be positioned in the market place in such a way that the value of its most outstanding capabilities is maximized. Porter (1980) defines the objectives of a competitive analysis as assessing a) chances of success of possible strategies for each competitor, b) reactions to possible strategies of competitors, and c) the probability of reactions in case of strategic changes. A specific analysis is required to find out the strengths and weaknesses of each competitor so as to improve a firm's own situation and to avoid attacking a competitor in fields where counter-reactions could adversely affect profits in the long term. Such an analysis should provide information about the vulnerability of all competitors and suggest strategic steps that have asymmetric profit impacts, i.e. measures that have a stronger negative effect on the competitors than on the firm's profits even if the rivals respond aggressively. As some forms of competition—like price competition—are highly unstable and jeopardize the profitability of the whole industry, information on the effects of different degrees of competition is of high practical relevance and necessary to prevent undesirable results.

In our contribution, we propose a model that explicitly includes the competitors' profits in the objective function. This allows us to study the effects of aggressive, cooperative and "ultra-altruistic" behavior on both pricing decisions and profits. A firm is classified as acting aggressively (cooperatively) if it negatively (positively) weights the competitors' profits. However, the extent of the losses may be asymmetrically distributed among the competitors, so that firms losing disproportionately little can take advantage of this asymmetry. We illustrate our methodology with the aid of an empirical model of a detergent market.

1. Measuring the impacts of aggressive strategies on pricing decisions

It is not possible to make general statements about the optimal price in a competitive situation. In an oligopolistic market, the optimal price depends on the assumptions made about the competitors' behavior and is, therefore, also to be dealt with in reaction function approaches or game-theoretic studies (for an overview, see Moorthy (1993)).

In a typical situation, there are several firms manufacturing several products, and managers have to coordinate the strategies regarding their product line so as to maximize overall profits. Many game-theoretic approaches examine strategies resulting from Nash equilibria where games are defined in which every 'player' reacts in an optimal way to the steps taken by all the others. Obviously, in a strategic planning phase, this is but one interesting alternative covering only part of the information required.

In the following, we develop a model that allows one to study the impact of different degrees of aggressiveness on pricing decisions. The main idea is that we not only look at the scenario involving optimal reactions by all parties but at various scenarios in which all firms f maximize the following objective function:

$$\pi_f(p_j, \zeta_{f,j}) = \sum_{j=1}^{J} \zeta_{f,j} \sum_{t=1}^{T} \left(\left(Q_{j,t} \left(P_{j,t} - C_j'\right) - C_{j,fix} \right) (1 + r)^{-t} \right) \tag{1}$$

All firms f sum the discounted profits π over brands j and periods $t = 1, \ldots, T$, where profits are a function of all prices and weights ζ. C_j' denotes constant marginal costs[1] (i.e. a linear cost function) of brand j and $Q_{j,t}$ the sales for brand j in period t for a given pricing strategy. In the following optimizations fixed costs $C_{j,fix}$ are set to zero. High positive fixed costs reduce dicounted profits and product variety (i.e., the number of brands offered by a firm). The discount rate r depends on the best alternative investment and is assumed to be $r = 0.1\%$ per period (week). $\zeta_{f,j} = 1$ if j is a brand of firm f. If j is a brand of another firm $-\zeta_{f,j}$ measures the aggressiveness of firm f with regard to the profits of this brand. A more negative $\zeta_{f,j}$ means a more aggressive attitude of the firm towards profits of foreign brands. The firm accepts somewhat lower own profits if foreign profits are reduced. If $\zeta_{f,j} = -1/(n - 1)$, the firm tries to achieve a higher profit than the average brand or firm where n is the number of brands or firms. This may be called a "beat-the-average" solution. For $\zeta_{f,j} = -1$ the firm evaluates own profits and foreign losses equally, i.e., a profit of 1 $ is equal to the loss of 1 $ by another firm. $\zeta_{f,j} < -1$ means that foreign losses are weighted more than own profits. $\zeta_{f,j} = 0$ means that firm f ignores profits of foreign brands and considers only profits of its own brands. It can be said that the firm is indifferent to foreign profits. This is equivalent to the non-cooperative solution. Positive $\zeta_{f,j}$ values stand for non-aggressive behavior. $\zeta_{f,j} = 1$ gives equal weight to profits of own and foreign brands. The firm treats foreign brands just like its own brands. This leads to the cooperative solution maximizing the profits of the whole industry. Situations with $\zeta_{f,j} > 1$, where more weight is put on profits of foreign brands as compared to own brands ("ultra-altruistic behavior"), also adversely affect market profits.

The above objective function has the advantage that it reflects the trade-off between a company's own profits and those of competing firms. This formulation allows us to direct aggressiveness with individual weights against competitive brands and is, therefore, extremely flexible and general. Expression (1) is a multi-period generalization of a solution concept introduced by Shubik (1980) based on earlier work of Edgeworth (1881). Shubik specifies the objective function of a firm as weighted sum of its own profits and the profits of all other firms:

$$\pi_f(p_j, \zeta_{f,j}) = \sum_{j=1}^{J} \zeta_{f,j} Q_j(P_j - C_j') \tag{2}$$

A key question with respect to the success of an aggressive strategy is the prediction of the probability and strength of retaliatory strikes. The probability of a reaction and its degree of aggressiveness depend on the way the rivals perceive the strategies applied by another firm and the extent to which the goals followed by management are influenced. Typical goals that management pursues are market share, realized sales or profits obtained in one period (e.g., quarterly profits). For a firm that has to expect negative overall effects from aggressive counter-reactions, one approach to formulating a strategy is to adopt a plan that does not threaten the competitors' targets.

Blattberg, Briesch and Fox (1995) find generalizable evidence that cross-promotional effects are asymmetric, and that promotion of higher quality brands impacts weaker brands disproportionately. As promotions are asymmetric, it becomes possible for firms to use promotions to gain an advantage. Under certain circumstances, a firm should start a promotional war. Blattberg and his coauthors point out that by promoting heavily, a firm can capture a significant share from other brands whose manufacturers cannot easily retaliate because of the asymmetry in promotional response.

In investigating marketing persistence (a measure of the extent to which changes in current conditions lead to permanent future changes), Dekimpe and Hanssens (1995) indicate that competitive reactions have intensified in recent history making it more difficult for a brand to create long-run market share gains. Also Bass and Pilon (1980) argue that competitive reactions often prevent such gains.

Therefore, we recommend that first firms should do a competitive analysis by formulating a scenario in which all firms attack each other with the same degree of aggressiveness. Based on that primary analysis, management can choose its level of competition and conduct further sensitivity analyses for that specific level. In the second step, the level chosen should be tested against optimal (non aggressive) reactions of the competitors as well as against more aggressive behavior than the one chosen.

2. Empirical analysis

2.1. Data

For the empirical study of the model a scanner database consisting of time series with 73 weekly observations each is available. The time series comprise sales values and prices collected in 4 retail stores of one chain and for 7 brands in a product category (detergents). The 7 brands here considered dominate the market comprising more than 90% of the market share. They are manufactured by 3 different firms ($f_1 = \{1,2\}, f_2 = \{3,5,7\}$ and $f_3 = \{4,6\}$). Because of the existing competitive relationships, the market response functions we use contain a rather high number of parameters, and we pool the outlets for estimation purposes. For the application of our model, one needs cost data. Cost data will typically be available for the brands of the firm under consideration but not for competitors. The missing cost data must be estimated by the management (e.g., costs of a competitor = average sales price—sales tax—estimated margin of the retailer—estimated margin of the competitor). According to information of ACNielsen and one of the manufacturers, the typical margins of the retailers are around 20% of the sales price. The average margin for the competitors were estimated to be 30% of the sales price. For reasons of confidentiality, we cannot reveal the true cost data. We determined the cost data iteratively in such a way that the optimal prices in the Nash equilibrium were as close as possible to the average observed prices.

2.2. The market response model

With respect to the specific market (detergents) that we analyze, we choose a market response model including prices ($p_{j,t}$), customer holdover effects ($S_{i,t-1}$) and reference prices ($p^r_{j,t}$) as predicting variables:

$$S_{i,t} = f\Big(a_{i,0} + \sum_j a_{i,j}\, p_{j,t} + a_{i,J+1} S_{i,t-1} + \sum_j \big(a_{i,J+1+j}\, (p^r_{j,t} - p_{j,t})^- + a_{i,2J+1+j}\, (p^r_{j,t} - p_{j,t})^+\big)\Big) + \epsilon_{i,t} \quad (3)$$

According to the results of the meta-analysis for various products and markets effected by Tellis (1988), detergents show high absolute price elasticities. Therefore, our primary focus is on price effects. Apart from (cross) price effects, we include (positive and negative) deviations of reference prices from actual prices (overviews of the relevant literature are given by, e.g., Winer (1988) or Bridges, Yim, and Briesch (1995)) to model the effects of price promotion as perceived by the customers. Using relative prices as predictive variable and market share S as dependent variable in equation 3, in order to calculate equation 1, in each period we have to multiply S and p by the average weekly market volume and average price, respectively.

Based on a more general reference price model consisting of up to 5 periods of lagged prices, lagged competitive prices and a trend variable, the following simple model—where reference prices are formed by a one-period lagged price (cf. Hardie, Johnson and Fader (1993)) and a trend variable (cf. Winer (1988))—showed an optimal compromise between the number of parameters and predictive accuracy:

$$p^r_{i,t} = \theta_{i,0} + \theta_{i,1} p_{i,(t-1)} + \theta_{i,2} t \tag{4}$$

Optimization of Strategies: In the presence of reference price effects, the profit impact of a price-promotion in the current period is affected by the future prices and costs (Greenleaf (1995)). The problem can, therefore, be solved by dynamic programming if prices are divided into discrete intervals, such as one cent. A difficulty that arises with several products and planning periods is that the problem space grows fast and optimization by dynamic programming would take too much time when using an appropriate grid and—like in our case—several optimization problems have to be solved for various degrees of aggressiveness. For this reason, we use an approximate technique, i.e., Simulated Annealing (see Kirkpatrick, Gelatt and Vecchi (1983)), to examine the issue in depth[2]. To study different degrees of aggressiveness, several scenarios with different zetas for the competitive brands are analyzed. Zetas are varied between $\zeta_{f,j} = -3$[3] (three units less profit for all competitors equals one additional unit of a firm's profits) and $\zeta_{f,j} = 1.5$ ("ultra-altruistic" scenario). The strategies adopted are determined for a duration of $T =$ 30 discrete periods.

We use the following bootstrap approach (see, e.g., Efron (1982)) to calculate confidence intervals for the impact on profits due to changes in the "level of competiton": Different sets of parameters of the market response model are estimated for 1000 bootstrap samples. For each set of parameters and level of aggressiveness, we estimate the firms' profits assuming that the parameter sets from bootstrapping are the true parameters, but that the firms implement the strategy calculated from the parameters estimated on the basis of the original data set.

2.3. Estimation results

The estimation of equation 4 shows that, apart from two trend effects (brands 3 and 6), all parameters have significant ($\alpha = 0.05$) *t*-statistics (see Table 2).

The estimation of 2 different functional forms (linear, logistic) for the market response model showed that the linear variant has a significantly lower variance explanation ($\bar{R}^2 =$ 61.2%) than the logistic model ($\bar{R}^2 = 68.4\%$). Consequently, we describe in detail only the logistic model[4]. If weighted with average shares, the variance explanation of our model after elimination of insignificant parameters reaches 72.3 percent (the parameters are shown in Table 3). Customer holdover effects are insignificant for all equations. This may be explained by the fact that the interpurchase time for this product category is more than a week (here weekly data are analyzed).

Table 1. Competitive Structure

firm	with brands	is influenced by comp. brands	and influences
f_1	1,2	7	3,4,5
f_2	3,5,7	1,4	1,2,4,6
f_3	4,6	1,3,5,7	5

2.4. Competitive analysis

Once the market response model is estimated, the structure of the competition between the different brands can be studied. The market response function shows the influence of competitive brands on the product line of a firm. If the strategy adopted by a company does not have any significant effects on the market share of a competitive brand, it does not influence it (directly). Hence, in the planning stage, managers must in the first place know which competitive brands affect the brands of their firm and which rival brands can, in turn, be influenced.

The competitive structure is shown in Table 1. Coefficients are depicted in Table 3 so as to help interpreting optimization results[5]. Firm f_1, for instance, offering brands 1 and 2 is influenced by the strategy of competing brand 7 but impacts brands 3, 4, and 5. So, if firm f_2 uses brand 7 for an aggressive policy against firm f_1, f_1 cannot react directly. On the other hand, it has the option to punish f_2 by using an aggressive strategy against products 3 and 5 manufactured by f_2 whose sales depend on the strategy concerning brand 1.

Table 2. Coefficients and standard errors of estimators of the reference price equations

Brand	Intercept ($\hat{\theta}_{i,0}$)	Price ($\hat{\theta}_{i,1}$)	Trend ($\hat{\theta}_{i,2}$)
1	0.723	0.327	0.000622
	(0.0578)	(0.0539)	(0.000236)
2	0.457	0.495	0.001294
	(0.0465)	(0.0516)	(0.000219)
3	0.519	0.483	insignificant
	(0.0563)	(0.0547)	—
4	0.583	0.471	−0.000867
	(0.0591)	(0.0527)	(0.000214)
5	0.877	0.206	−0.000835
	(0.0648)	(0.0580)	(0.000186)
6	0.713	0.330	insignificant
	(0.0606)	(0.0558)	—
7	0.656	0.110	−0.000193
	(0.0374)	(0.0500)	(0.000089)

Table 3. Coefficients and one-tailed asymptotic *t*-statistics of the reduced model. *a* denotes parameters significant at $\alpha = 1\%$

prod.	variable	coeff.	std.dev.coeff.	*t*-value
1	p_1	−2.25	0.125	-17.9^a
1	p_7	1.61	0.153	10.5^a
1	p_1^r-	−1.18	0.080	-14.7^a
1	p_1^r+	3.42	0.169	20.1^a
2	p_2	−4.09	0.089	-45.6^a
2	p_2^r+	2.58	0.174	14.7^a
2	p_7^r+	−1.86	0.170	-10.9^a
3	p_1	0.96	0.098	9.8^a
3	p_3	−5.83	0.194	-29.9^a
3	p_5	1.20	0.096	12.4^a
3	p_3^r+	3.02	0.253	11.9^a
4	const	−2.88	0.143	-20.0^a
4	p_3	1.65	0.136	12.1^a
4	p_4	−5.27	0.208	-25.2^a
4	p_5	1.05	0.116	9.0^a
4	p_7	1.22	0.131	9.3^a
4	p_1^r-	1.40	0.116	12.0^a
4	p_1^r+	−1.07	0.164	-6.5^a
4	p_4^r+	3.29	0.126	25.9^a
5	const	−3.42	0.271	-12.5^a
5	p_1	1.57	0.314	5.0^a
5	p_4	2.80	0.249	11.2^a
5	p_5	−3.68	0.203	-18.1^a
5	p_4^r-	1.90	0.204	9.3^a
5	p_5^r+	2.00	0.159	12.6^a
6	p_6	−5.69	0.216	-26.3^a
6	p_5^r+	−1.29	0.132	-9.7^a
6	p_6^r+	1.63	0.402	4.0^a
7	p_3	2.45	0.187	13.0^a
7	p_7	−6.19	0.250	-24.7^a
7	p_3^r-	1.75	0.128	13.6^a

2.5. *Results of the different scenarios*

The simulation results presented in Figure 1 indicate that in case of stronger competition firm f_2 has to expect the highest losses. The right-hand side of Figure 1 shows the differences between the profits of each firm and their Nash solution: $\pi_{f(\zeta f,i\,=\,1,\zeta f,j\,\neq\,0)} - \pi_{f(\zeta f,i\,=\,1,\zeta f,j\,=\,0)}$. By looking at this difference, the comparison of asymmetric effects is facilitated. Firm f_3 seems to be less vulnerable than the other two companies. f_1 improves its relative profit position as compared to f_2 but slightly loses ground with respect to f_3. The decision on the extent of an aggressive strategy in the presence of an asymmetric advantage may now be based on this primary analysis. However, the sensitivity of more interesting alternatives should be tested. Therefore, we conducted an additional sensitivity analysis which demonstrated that at $\zeta_{f,j} < -0.25$ firm f_3 can gain a significantly better relative position than the other two companies[6]. Also, f_1's losses are smaller than f_2's

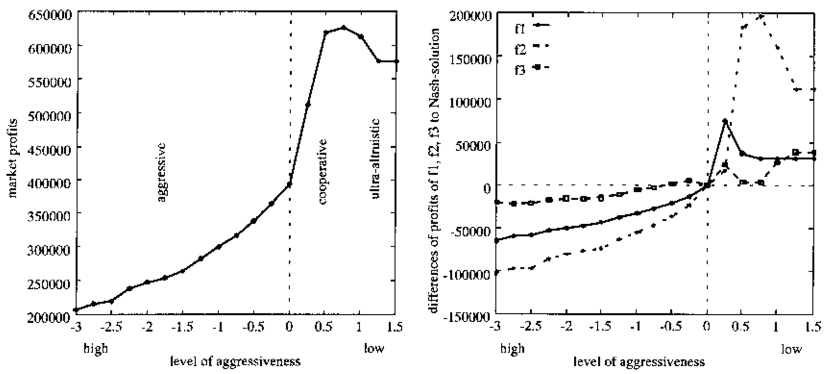

Figure 1. Market profits and profits of f1, f2, f3 minus Nash profits.

losses. The advantage becomes significant at about $\zeta_{f,j} = -0.6$, i.e., the situation where one additional unit of product line profits for a firm equals 0.6 units of losses for the other two firms together. It is surprising that f_3 realizes slightly higher profits at $\zeta_{f,j} = -0.25$ than at $\zeta_{f,j} = 0$. A look at the profits at brand level shows that this is a side-effect of the product line policy adopted by f_2 with brands 3, 5, and 7. Not only the profits of brand 4—responsible for higher profits of f_3—are increasing, but also the profits of f_2's brand 3 are growing up to a level of $\zeta_{f,j} = -0.25$ and decreasing afterwards. The total profits of f_2 are, nevertheless, decreasing because of lower profits coming from brands 5 and 7. This proves that in product line optimization the strategy regarding a single brand is only one of the means for obtaining the overall profit of the company concerned.

Our sensitivity analyses showed that the solution was robust against (a) the measurement error of the market response functions, (b) the optimal but non-aggressive response of the competitive attacks by the firm with asymmetric disadvantages, (c) the assumption of aggressive behavior of the firm with disadvantages evaluated via strategies drawn from its empirical distribution as well as (d) different starting configurations and random values of the optimization algorithm.

The analysis of the pricing decisions at the different ζ-levels revealed the following results:

1. More aggressive strategies typically entail lower average prices than cooperative strategies (see Figure 2).
2. While for the Nash equilibrium ($\zeta_{i,j} = 0$) pulsation reaches a low level, pricing strategies are characterized by higher pulsations the more aggressive behavior is. Note, that we take the standard deviation of prices as a measure of pulsing intensity (Figure 2). It is well known that pulsing strategies may be optimal in the presence of asymmetric reference price effects (Kopalle, Rao and Assuncao (1996)).
3. Even small positive weights for the competitive firms strongly move upwards the average price and profit level.
4. For small positive weights the pulsation increases but it decreases again with larger weights where several brands reach their upper price limit[7].

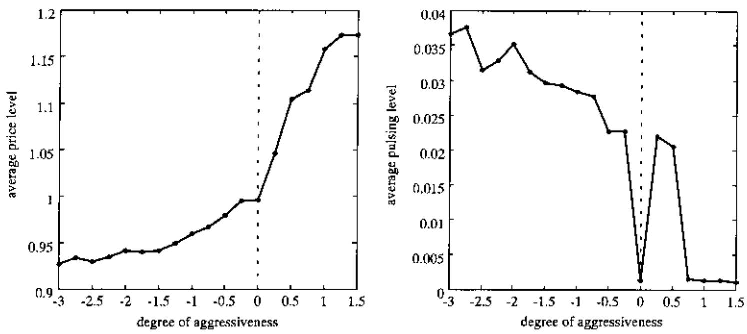

Figure 2. Average price levels and standard deviation of prices (high-low level).

5. "Ultra-altruistic" behavior leads to worse solutions in terms of market profits than cooperative behavior (see Figure 1). Overall market profits are increased only up to a point where all firms weight each profit contribution with unit weight. When all firms set higher prices than in a monopoly situation in order to favour the other firms, the overall market profits decrease again. Therefore, "ultra-altruistic" firms act "aggressively" against themselves.
6. With cooperative behavior overall profits increase although the profits of individual firms may decrease (see the differences of the profits from Nash equilibrium for different levels of competition in Figure 1). The same holds for the individual brands within each firm.

Our model indicates stronger absolute effects in terms of average prices and market profits with positive (i.e., cooperation) than with negative (i.e., aggressiveness) ζ-weights (see Figures 1 and 2). Starting with the non cooperative scenario, pricing decisions are characterized by the following changes when the degree of aggressiveness is increased: for small negative weights most brands—step by step—reduce the price and only slightly start high-low strategies; when the degree of aggressiveness is further increased, most of the brands increase their pulsing level and continue to slightly reduce the price level. We found that the high-quality brand of firm f_1 which also has the highest individual market share shows higher asymmetric power than the lower quality brands.

3. Conclusion

We have developed a model that includes weights for competitors' profits in firms' objective functions in order to be able to study a wider range of scenarios than usual within the stage of competitive analysis. We recommend that a firm considers the effects of different levels of aggressiveness and cooperation and performs further sensitivity analyses for some of the more interesting levels. We found that, once a product manager has decided on which level of aggressiveness he is going to operate, the decision on next week's price is based on the optimal strategy for this level which we obtain as a result of the analysis conducted. We have illustrated our methodology on the basis of an empirical analysis revealing that aggressive pricing decisions are characterized by high-low strategies with a higher amplitude and lower average price level. In our analysis, the high-quality brand showed higher asymmetric power than the other brands.

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Notes

1. One difficulty is that usually no exact information is available on the costs competitors have to meet. Management's subjective estimates or an average of the own costs can be used when no better information is available.
2. For a marketing application, see, e.g., DeSarbo, Oliver and Rangaswamy (1989).
3. Minus three has been selected arbitrarily. Our results show that at this level competition is really destructive.
4. The static model without reference prices was calculated for comparison purposes but showed significantly lower variance explanation ($\bar{R}^2 = 57.5\%$) than the reference price model. Another comparison was made for a response model omitting only the competitive reference prices. This model explained—on average—3.9 percentage points less variance than the more comprehensive model.
5. Price coefficients of a brand have typically positive and cross-price effects negative signs. Positive and negative deviations of prices from reference prices ($p^r - p$) typically have positive signs for the brand under consideration and negative signs for competing brands.
6. Confidence regions were calculated from the bootstrap sample.
7. During the optimization process, prices were limited by the observed maximum and minimum prices.

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