

Marks, Ulf G.; Albers, Sönke

Working Paper — Digitized Version

Experiments in competitive product positioning: An equilibrium analysis

Manuskripte aus den Instituten für Betriebswirtschaftslehre der Universität Kiel, No. 364

Provided in Cooperation with:

Christian-Albrechts-University of Kiel, Institute of Business Administration

Suggested Citation: Marks, Ulf G.; Albers, Sönke (1995) : Experiments in competitive product positioning: An equilibrium analysis, Manuskripte aus den Instituten für Betriebswirtschaftslehre der Universität Kiel, No. 364, Universität Kiel, Institut für Betriebswirtschaftslehre, Kiel

This Version is available at:

<https://hdl.handle.net/10419/149830>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Nr. 364

Ulf G. Marks und Sönke Albers

Experiments in Competitive Product Positioning

– An Equilibrium Analysis –

January 1995

Ulf G. Marks

Sönke Albers
Professor of Marketing and
Management Science

University of Kiel

Olshausenstr. 40

D-24098 Kiel

Germany

Tel.: +49-431-880-1541

Fax: +49-431-880-1166

E-mail: www27@rz.uni-kiel.d400.de

Abstract

Almost all of the results on competitive product positioning derived in respective literature so far are based fundamentally on the hypothesis that Nash-equilibria are "accurate predictions" of final market configurations. If the positioning behavior of firms differs from this assumed Nash-behavior, the corresponding propositions can no longer be used for optimal product positioning. In order to test the Nash-reaction hypothesis we used a newly developed marketing simulation game PRODSTRAT to observe decisions of 240 advanced marketing students on product position, price and marketing budget under market conditions varied experimentally.

Our results show that pricing and budgeting decisions are very well described by Nash-equilibria in the case of fixed product positions, while decisions on product positioning are significantly more competitive. The experiments have led to less differentiated market configurations with the consequence of increasing pricing as well as budgeting competition and significantly reduced profits. The rather more aggressive product positioning observed here seems to stem from attempts to reduce profit differences relative to the market leader and from strategies to lower the risk of possible profit losses in case of competitors' attacks. Aggressive positioning behavior compared to corresponding Nash-behavior was particularly observed in duopolistic markets, in markets with unimodal ideal point distributions and under market conditions with a low quality effect on consumers' preferences. However, deviations from Nash-behavior can only partly be explained by market conditions and seem to depend substantially on the personality of the respective competitors.

1. Introduction

Competitive product positioning has a long research tradition and goes back to the classical paper of Hotelling (1929). He found that competition with product positions in a joint attribute and preference space could lead to a clustering of product positions in the market center. In the following decades the question of the market conditions under which this so-called "principle of minimum differentiation" holds has been addressed. Many papers derive relationships between the outcome of positioning competition, mostly modelled as Nash-equilibrium, and market conditions [see Gabszewicz, Thisse (1992), Eiselt, Laporte (1989) and Graitson (1982) for a survey, and in marketing literature especially Ansari, Economides, Ghosh (1994), Carpenter (1989), Hauser (1988), Kumar, Sudharshan (1988) and Moorthy (1988)]. Meanwhile, optimization approaches for competitive product positioning have been proposed: Horsky, Nelson (1992), Choi, DeSarbo, Harker (1992, 1990) and Choi (1988) utilize a joint space map obtained from a preference MDS procedure such as GENFOLD2 [DeSarbo, Rao (1986)] or LINMAP as input and provide an optimization program for determining an optimal entry position subject to competitive pricing and/or positioning reactions, again assuming (mostly) Nash-behavior.

The fundamental assumption of the research directions outlined is that Nash-behavior is a good approximation of real competitors' behavior. If this assumption is not valid, all of the deduced relationships between market conditions and the outcome of positioning competition could be brought into question. In addition, entry positions proposed by optimization approaches might be suboptimal. Therefore, the validity of this key assumption must be carefully tested in order to prevent new product failure.

The adequacy of modeling real competitors' decisions by means of Nash-equilibria has already been analyzed in many oligopoly experiments, covering a variety of completely different decision variables [for surveys see Holt (1989), Roth (1988), Plott (1982), Selten (1979) and Friedman (1969)]. Although the behavior observed has sometimes been found to be more cooperative [Beil (1988)] or more aggressive [O'Neil (1991), Grether, Plott

(1984)] than Nash-behavior, most papers conclude that Nash-equilibria are good approximations of real competitors' decisions [Cooper et al. (1990), Isaac, Reynolds (1988), Domowitz, Hubbard, Petersen (1987) and Alberts (1984)]. However, none of these experiments are concerned with positioning behavior and it remains unclear whether the results can be generalized, since the positioning instrument differs considerably with respect to its influence on competitors. For most of the instruments examined in previous experiments (e.g. price, marketing budget, R&D budget etc.), it is profitable for competitors to follow one player's increased or decreased effort. In contrast, one player's repositioning towards the market's ideal point makes it less attractive for others to do the same because it raises the degree of competitiveness due to a higher similarity of products. On the other hand, leaving the market's ideal point to competitors might lead to a higher profit but weakens one's own relative market position. This conflict calls for taking great care regarding generalization of findings from the experiment literature.

Experiments in the field of positioning competition have so far only been conducted by Schenk (1991) and Brown-Kruse, Cronshaw, Schenk (1993). They observe competitive behavior close to Nash-results as long as no communication between participants of the game is possible. Unfortunately, the authors based their experiments on a market model where Nash- and MaxMin-strategies are nearly identical. Hence, the experiments' results offer conclusions only on the cooperativeness but not on the competitiveness of the behavior. Moreover, their research is limited to duopolistic experiments in only two different market settings, with the product position in a one-dimensional space being the only instrument.

In summation, previous research either cannot be generalized a priori or suffers from shortcomings making it currently impossible to conclude, whether – and under what conditions – Nash-behavior is an appropriate model of real positioning behavior. In order to test the Nash-hypothesis for positioning behavior, we developed the new marketing game PRODSTRAT to obtain data on the experiment's competitors' marketing decisions in

varying oligopolistic market settings. In this game participants compete with the full marketing mix: they decide upon the product's position in a two-dimensional attribute space, as well as on the price and marketing budget - the latter being a composite of all other instruments, the use of which incurs initial costs before hopefully increasing sales. Due to the inclusion of the whole marketing mix the experiment is relatively realistic, allowing for the interaction of product positioning decisions on competition with other marketing instruments.

This article is organized as follows. The research method is introduced in chapter 2. The marketing game PRODSTRAT and its core element, the market model, are characterized, followed by a discussion of the experimental variation of market conditions. Chapter 3 gives a presentation of the results. First, the method of analysis and interpretation of the data is introduced. Afterwards, deviations between actual competitive behavior in our experiments and Nash-equilibria are described and explained by experimental factors. Then, in order to arrive at a clear picture of the isolated competitive pricing and budgeting behavior, prices and budgets are also analyzed in the final product positioning configurations. Conclusions are drawn in chapter 4.

2. Research Method

2.1. Need for Experiments

The question of whether Nash-behavior is a good approximation of human behavior can only be answered with results of empirical research. One approach might be to calibrate a market model based on the marketing behavior and market outcome over time in real world markets. The Nash-solution of the calibrated model could then be computed and compared to the actual behavior. However, such empirical field research entails the significant disadvantage of substantial noise in the data. Even more limiting is the fact that manipulations of market conditions are impossible, the consequence being that empirical findings hardly ever generalize beyond the individual case examined.

Control over the influencing variables as well as manipulation of the market setting can only be achieved in laboratory experiments, this was therefore the technique of empirical research chosen for this project. The Marketing behavior of experiment subjects was obtained by means of the new marketing game PRODSTRAT. PRODSTRAT was developed specifically for this purpose, as there was no marketing game available which would have served our needs.

2.2. Development of the Marketing Game PRODSTRAT

PRODSTRAT is an interactive computer game focussing on positioning in a two-dimensional attribute space, pricing, and budgeting decisions in an oligopolistic market. The game's participants are responsible for single brands which compete against each other. They can perform market research and plan their marketing mix directly on the computer screen. After each player has input his decisions, PRODSTRAT simulates the corresponding market results. The game is played over several periods. In total, data from 96 different games has been observed under experimentally altered market conditions. The experiments were conducted as follows:

Step 1: The experiment subjects were randomly assigned to experimental treatments. Altogether 240 advanced marketing students from two German Business Schools were selected for 48 duopolistic and 48 tripolistic games. Before starting with the game, they were given instruction and asked to type in demographical data such as age, sex, university performance, practical experience and computer knowledge. The participants remained anonymous.

Step 2: Marketing mix and market results before market entry of a new competitor were displayed to create a reference situation. The situation before market entry in duopolistic games was constituted by the monopolistically optimal marketing mix for the established brand, while the (duopolistic) Nash-equilibrium was chosen for the two established brands in the tripolistic games.

Step 3: Market entry was simulated. Entry prices and budgets were fixed according to the market average or the market pioneer's monopolistically optimal values, while the entry distance of the new product's position to established products was altered experimentally.

Step 4: Each experiment subject had to independently fix the next period's position, price and budget for his/her product. This decision could be supported by two market research opportunities. First, a vector of market results for all competitors could be requested for hypothetical market configurations (vectors of marketing mix decisions). Second, an archive of past decisions and results could be called up, sorted either by competitors or by periods. As soon as all competitors entered their final marketing mix decisions, the market results of this period were simulated and sent back to each computer terminal.

Step 5: Step 4 had to be repeated until a stable equilibrium (price, budget and position changes between the last two periods had to be smaller than prespecified tolerances for all competitors) or the upper limit of 13 periods had been reached.

Step 6: Finally, the participants were paid according to their "success", measured by cumulative profits over all periods. It was left open to the participants whether payments were linked to their absolute cumulative profit or to their relative profit share.

2.3. Market Model

The core element of PRODSTRAT is its market model. To keep up as close as possible with the positioning research tradition, a disaggregated, static and deterministic model with stochastic error term has been chosen for this project. A sketch of the model is presented in Figure 1. In the following description, period indices are dropped for the convenience of the reader and β 's denote various parameters.

Insert Figure 1 about here

Consumer's utility. Similar to the model of DePalma et al. (1985, 1987), utility u_{ki} of the k -th consumer buying the i -th product decreases linearly with price P_i and Euclidean distance D_{ki} between product position and the consumer's ideal point in a two-dimensional

joint space. Random influences on consumer utility are represented in an additional Weibull-distributed error term ε . In line with Carpenter (1989) it is further assumed that consumers only tolerate a certain discrepancy D_{max} between ideal point and product position. Formally:

$$u_{ki} = \begin{cases} \beta_0 - \beta_1 D_{ki} - \beta_2 P_i + \varepsilon_{ki} & \text{if } D_{ki} < D_{max} \\ 0 & \text{otherwise} \end{cases} \quad [k \in K, i \in I] \quad (1)$$

where:

$$D_{ki} = \sqrt{\sum_{d \in \{1,2\}} (q_{dk} - Q_{di})^2} \quad [k \in K, i \in I]$$

- I : set of products (competitors),
- K : set of consumers,
- u_{ki} : utility of the k -th consumer [$k \in K$] buying the i -th product [$i \in I$],
- D_{ki} : distance of the k -th consumer's ideal point [$k \in K$] to the i -th product position [$i \in I$],
- P_i : price of the i -th product [$i \in I$],
- Q_{di} : i -th product's coordinate [$i \in I$] in d -th dimension of the joint space [$d \in \{1,2\}$],
- q_{dk} : coordinate of the k -th consumer's ideal point [$k \in K$] in d -th dimension of the joint space [$d \in \{1,2\}$],
- D_{max} : maximum quality tolerance of consumers,
- ε_{ki} : Weibull-distributed stochastic error term of the k -th consumer's utility [$k \in K$] for the i -th product [$i \in I$].

Choice probability in the case of awareness and availability of all products. Assuming utility maximizing behavior of consumers in connection with a Weibull-distributed error term ε in the utility function, the choice probability in the case of awareness and availability of all products is given by the Multinomial Logit Model [McFadden (1974)]:

$$Pr(Ch|A\&A)_{ki} = \begin{cases} \frac{\exp[u_{ki}]}{\sum_{j \in J_k} \exp[u_{kj}]} & \text{if } u_{ki} > 0 \\ 0 & \text{otherwise} \end{cases} \quad [k \in K, i \in I] \quad (2)$$

- J_k : $J_k \subset I$; set of products offering positive utility to the k -th consumer [$k \in K$],
- $Pr(Ch|A\&A)_{ki}$: probability that the i -th product is bought by the k -th consumer [$k \in K$] in the case of awareness and availability of all products.

Unconditional choice probability. Full awareness and availability of all products is generally not possible in the market place. Rather, it can be assumed that i -th product's probability of

awareness and availability $Pr(a\&a)_i$ increases with its marketing budget B_i and decreases with the amount of competitor's budgets B_j . Conditional choice probability $Pr(Ch|A\&A)_{ki}$ and probability of awareness and availability $Pr(a\&a)_i$ are then merged into the unconditional choice probability $Pr(Ch)_{ki}$ (similar to the popular MARKSTRAT-game [Larréché, Gatignon (1990)]).

$$Pr(A\&A)_i = 1 - \exp[-\beta_3 B_i + \beta_4 \sum_{j \in W} B_j] \quad [i \in I] \quad (3)$$

$$Pr(Ch)_{ki} = \begin{cases} \frac{\exp[u_{ki}] Pr(A\&A)_i}{\sum_{j \in J_k} \exp[u_{kj}] Pr(A\&A)_j} & \text{if } u_{ki} > 0 \\ 0 & \text{otherwise} \end{cases} \quad [k \in K, i \in I] \quad (4)$$

W : $W \subset I$, set of competitors' products,

B_i : marketing budget of the i -th product [$i \in I$],

$Pr(a\&a)_i$: probability of awareness and availability of the i -th product [$i \in I$],

$Pr(Ch)_{ki}$: probability that the i -th product is bought by the k -th consumer [$k \in K$].

Consumers' consumption and aggregated market results. Based on individual choice probabilities, aggregated market results for all products $i \in I$ – number of buyers S_i , sales X_i , revenue U_i , and profit π_i – may easily be computed. Two aspects of the chosen model need to be pointed out. First, as can be seen from equation (7), it is assumed that consumption volumes of consumers v_{ki} depend on products' utilities and that these volumes are affected by the industry's total amount of marketing budget. Hence, primary demand is variable. Second, in equation (10) it is assumed that marginal production costs vary across the joint space. This assumption is more technical in nature and shapes the profit (objective) function across the joint space, thereby increasing the chance that a single optimum exists. Mathematically, the model is given as follows:

$$S_i = \sum_{k \in K} Pr(Ch)_{ki} \quad [i \in I] \quad (5)$$

$$X_i = \sum_{k \in K} Pr(Ch)_{ki} v_{ki} \quad [i \in I] \quad (6)$$

where:

$$v_{ki} = \beta_5 (1 - \exp[-\beta_6 u_{ki} - \beta_7 \sum_{j \in I} B_j]) \quad [k \in K, i \in I] \quad (7)$$

$$U_i = X_i P_i \quad [i \in I] \quad (8)$$

$$\pi_i = U_i - B_i - \kappa_i X_i - K_{fix} \quad [i \in I] \quad (9)$$

where:

$$\kappa_i = \beta_8 + \sum_{d \in \{1,2\}} \frac{\beta_9}{1 + \exp[-\beta_{10} - \beta_{11} Q_{di}]} \quad (10)$$

- S_i : i -th product's number of buyers [$i \in I$],
- X_i : i -th product's sales [$i \in I$],
- v_{ki} : k -th consumer's consumption volume [$k \in K$] of the i -th product [$i \in I$],
- U_i : i -th product's revenue [$i \in I$],
- π_i : i -th product's profit [$i \in I$],
- κ_i : i -th product's marginal production costs [$i \in I$].
- K_{fix} : fixed costs.

2.4. Experimental Design

The market situation created by the market model depends on the chosen parameter values. An experimental variation of these parameters (market conditions) is worthwhile for two reasons. First, it is possible to investigate whether results hold for more than one data set, and second, experimental variations allow for the discovery of relationships between market conditions and game playing behavior.

Our market model contains 16 parameters to be specified: β_0 - β_{11} , D_{max} , K_{fix} , the number of competitors \hat{I} , and the type of the ideal point distribution IPD . Because a full factorial design with such a large number of parameters is impracticable, a fractional factorial design was applied. Alternative designs exist which differ with respect to the number of included experimental factors, the number of factor levels, the number of replications, and the extent to which interaction effects may be present. Because of the explorative character of this

project, a broad design with a larger number of experimental variables - each at only two levels, however - has been chosen. The selected experimental factors and their levels are documented in Table 1.

Insert Table 1 about here

Combinations of factor levels were chosen according to an orthogonal main effects plan which guarantees that all experimental variables are uncorrelated [Addelman (1962), p. 21] but does not allow for the estimation of interaction effects. The fractional factorial design is shown in Table 2.

Insert Table 2 about here

The design leads to 12 completely different market conditions. Each of the market conditions was implemented in PRODSTRAT with a close and a far entry distance (*ED*) of the new product's position to the established competitors' product position(s), such that $12 \times 2 = 24$ different treatments were created. With 4 replications each, we thus arrive at 96 experiments to be conducted. We worked with parameter values as given in Table 3 which led to plausible market conditions.

Insert Table 3 about here

Based on the final outcome of the 96 experiments with $48 \times 2 + 48 \times 3 = 240$ players, profit/revenue-ratios, budget/revenue-ratios, price-, budget-, crossprice- and crossbudget-elasticities were computed and are displayed in Figure 2. In addition to the distribution of profit/revenue-ratios reflecting a broad spectrum of possible gross margins, the computed budget/revenue-ratios are not unusual for consumer products. Furthermore, realistic ranges of price-elasticities between -0.5 and -5.0 [Bolton (1989), p. 162, Russell, Bolton (1988), p. 237, Tellis (1988), p. 337], budget-elasticities between 0.0 and 0.5 [Hagerty, Carman,

Russel (1988), p. 5, Assmus, Farley, Lehmann (1984), p. 66] and small positive crossprice-elasticities [Hanssens, Parsons, Schultz (1992), pp. 194 ff.] characterize most experimental settings. Crossbudget-elasticities can be either positive, which would imply that primary demand effects are stronger than market share effects of the marketing budget [Meridith, Maki (1991), p. 1133, Roberts, Samuelson (1989), p. 214], or negative [Hanssens, Parsons, Schultz (1992), pp. 194 ff.].

Insert Figure 2 about here

3. Results

3.1. Methodological Remarks

Analysis of final configurations. PRODSTRAT is quite complex in comparison to oligopoly experiments with a single instrument and limited choice set - where the structure of the game can easily be described by a payoff matrix. The participants of PRODSTRAT are not explicitly given a transparent payoff matrix but must form an idea about the payoff function during the game. Hence, one can expect that a learning process occurs over time, so that observations for different periods should be treated separately. We will here concentrate on the analysis of final configurations, while a process analysis of the development of configurations over periods is given elsewhere [Marks, Albers (1995)].

Stability of final configurations. The final configurations arrived at in each game are considered to be equilibria. Although not more than 19 of the 96 experiments were terminated because of stable equilibrium configurations (identified as negligible price, budget and position changes over the last two periods), the final configurations are nevertheless good approximations of equilibria once competitive processes converge. Convergence of a time series can be tested econometrically [Mason, Phillips, Nowell (1992), p. 666]. The development of time series towards a stable equilibrium is captured by a steady state Ω_{ir}^* , and the first (ρ_{ir1}) as well as the second order autocorrelation (ρ_{ir2})

such that for the t -th period, the i -th product and the r -th characteristic of interest Ω_{irt} can be written:

$$\Omega_{irt} = \Omega_{ir}^* + \varepsilon_{irt} \quad [i \in I, r \in C, t \in T] \quad (11)$$

where:

$$\varepsilon_{irt} = \rho_{ir1}\varepsilon_{ir,t-1} + \rho_{ir2}\varepsilon_{ir,t-2} + \mu_{irt}$$

μ_{irt} : remaining residual representing white noise ($i \in I, r \in C, t \in T$),

C : set of characteristics $C = \{ P_{it}, B_{it}, DMC_{it}, \pi_{it}, \pi_{it-K_{it}}, \sum_{k \in K} u_{kit} \mid i \in I, t \in T \}$,

DMC_{it} : i -th product's Euclidean distance to the market center (profit maximizing position of a monopolist) in the t -th period.

If $|\rho_{ir1}| < 1$, $|\rho_{ir2}| < 1$ and $|\rho_{ir1} + \rho_{ir2}| < 1$ are holding, convergence of the time series of the r -th characteristic and the i -th product is given. In this sense, positioning behavior over time – measured as Euclidean distance to the market center (DMC), which represents the profit maximizing position for a monopolist – converges for 96.6% of all competitors. Price time series converge in 96.3%, budget time series in 97.5% and profit time series in 97.1% of the cases. These numbers demonstrate the appropriateness of the final configurations' interpretation as equilibria.

Relative Approach. This paper sets out to test the adequacy of the Nash-hypothesis' ability to forecast real competitors' behavior. Hence, rather than examining absolute values of final configurations' Ω_{ir} for the r -th characteristic and the i -th product, we compare them with Nash-equilibria. The results of this comparison are examined in chapter 3.2. Nash-equilibria were numerically computed, using the variational inequality approach [Harker (1984). Computational details are presented by Marks (1994)].

Extracting Pricing and Budgeting Behavior. It is well known that positioning decisions exert strong influence on pricing and budgeting. The more homogeneous the products (the closer the product positions), the lower the Nash-prices are [e.g. d'Aspremont et al. (1979)]

and Hauser (1988)]. Carpenter (1989) found a decrease of marketing budgets with a stronger homogeneity of the products, but budgeting wars might occur under different conditions. In order to arrive at a clear picture of the isolated competitive pricing and budgeting behavior, it is necessary to analyze prices and budgets in the final product positioning configurations. This analysis is carried out in chapter 3.5.

3.2. Descriptive Analysis of Final Configurations in Relation to Nash-Equilibria

For the i -th product, relative deviations A_{ir} between the r -th characteristic of interest in the final configuration Ω_{ir}^{Real} and the r -th characteristic of interest in the corresponding Nash-equilibrium Ω_{ir}^{Nash} are defined in equation (12). Note that the absolute deviation is not related to Ω_{ir}^{Nash} but to an average score in order to avoid missing cases (e. g. if DMC s of single products are zero). The distribution of relative deviations A_{ir} will be described and explained by experimental variables in the following.

$$A_{ir} = \frac{\Omega_{ir}^{Real} - \Omega_{ir}^{Nash}}{(\sum_{j=1}^I \Omega_{jr}^{Nash})/I} \quad [r \in C, i \in I] \quad (12)$$

If Nash-behavior is a good approximation of real competitors' interactions (see references in chapter 1), then the A_{ir} are close to zero. Distributions and statistics of relative deviations of the characteristics $[r \in C] - DMC, price, budget, profit, profit contribution$ and aggregated consumer utility – are presented in Figure 3 and Table 4. They show profound variation and overall a significantly more aggressive competitive behavior than under the Nash-hypothesis, as will be explained in the following discussion.

Insert Figure 3 and Table 4 about here

67.1% of the experiment's 240 competitors choose a DMC smaller than theoretical Nash-positions would predict. On average, the relative deviation amounts to -27.7%, which

differs significantly from zero although an extremely high standard error of 57.4% is observed.

83.3% of the participants set prices lower than their theoretical (Nash-)counterparts. Nevertheless, the average relative deviation is only -7.1%. Taking profit contribution as another indicator for price competitiveness, it is seen that the number and amount of negative deviations increases relative to the distribution of price deviations, implying an even greater rivalry among competitors.

78.6% of the competitors chose lower budgets than expected. The average relative deviation amounts to -6.5%. The question arises of whether this result should be interpreted as an increase or decrease in competitiveness. In simple models, which only include market share effects of the budget, lowering the budget would clearly be understood as a cooperative signal. But in the PRODSTRAT model, decreasing the budget also implies a reduction of the industry's total amount of marketing budgets with the consequence of reduced consumption volumes. If this primary demand effect is stronger than the market share effect (e. g. if monopolistic attribute positions dominate) and if positive crossbudget elasticities occur, decreasing the budget rather means an uncooperative free rider behavior. Another aspect should be taken into consideration: lowering the budget is neither competitive nor cooperative when it is initiated simply to adapt to lower profitability of the market.

The experiment's competitors' marketing mix decisions as compared to Nash-decisions led to reduced profits for 94.0% of the participants and to an alarmingly high average relative deviation of -39.9%. Such a planning error could have serious financial consequences for a new product concept being introduced with the confidence that Nash-behavior leads to a valid forecast of competitive reactions. Surprisingly, consumers do not profit by the intense competition. Aggregated consumer utility is slightly decreased by the experiment's competitors' activities. Obviously, the increase of consumer utility due to fierce price

competition is more than offset by the, on average, larger distance between ideal points and product positions due to a suboptimal location of product positions in the perceptual space.

3.3. Explanations for the More Aggressive Competitive Behavior in our Experiment

The previous chapter has revealed the extremely competitive behavior of PRODSTRAT players in contrast to the experiences gathered in other oligopoly games. What could the reasons for such an extraordinary competitiveness be? Five reasons enter consideration. (1) Many oligopoly experiments were designed to detect the extent to which cooperation is practiced and do not allow for outcomes more competitive than Nash-equilibria. This means that previous results might be biased. (2) PRODSTRAT, with its three instrumental variables and its primary demand variability, is more complex than games applied so far. The coordination of cooperation is thus more difficult. (3) In many oligopoly experiments the experiment subjects are paid explicitly according to their profit, while in this research project payment was announced to be dependent upon the "success" of the product manager, leaving open by intention whether this should be measured in absolute or relative terms. (4) Actual persons as competitors could, in contrast to the theoretical Nash-competitors, realize tradeoffs between profit and risk of profit losses in cases of misanticipation of competitors' behavior. It is well known that such tradeoffs exist [VanHuyck, Battalio, Beil (1991, 1990), Beckman (1989)]. (5) Finally, intensive competition may occur due to the game's asymmetry. A game is asymmetric if the participants are "unequal" – e. g. because of different pre-experience – or if the game is "unfair". A game is unfair if rules offer a specific advantage for one participant [Weigelt, Dukerich, Schotter (1989), p. 28]. Experiment evidence supports the expectation that experiment subjects aspire to equal payoffs [Keser (1991), p. 118, and Selten (1988), p. 269 ff.] and that asymmetry intensifies competition [Mason, Phillips, Nowell (1992), Prasnikar, Roth (1992), Weigelt, Dukerich, Schotter (1989), Friedman, Hogatt (1980), p. 11, and Selten (1979), p. 51]. Although formal asymmetry is not present in this experiment – all participants face exactly the same rules and chances – our equilibria are often characterized

by one brand being positioned near the market center while the other brands follow a less profitable niche strategy. In this sense substantial asymmetry does occur, such that experiment subjects might have tried to reduce asymmetry at the expense of profit. Note, that this kind of equilibrium is not specific to our market model, but seems to be typical for markets with unimodal and sufficiently concentrated distributions of preferences [Ansari, Economides, Ghosh (1994)].

If explanations (4) and (5) are valid, PRODSTRAT-equilibria should be characterized by lower risk and asymmetry in comparison to Nash-equilibria. In Table 5 different operationalizations of risk and asymmetry and pairwise t-tests of differences are presented. Asymmetry is reduced only in absolute terms, while relative differences between competitors' profits actually slightly increase in our experiment. Also not in the same direction are the conclusions concerning risk reduction behavior. As seen in Table 5, positioning risk is reduced at the expense of price and budget risks. Risk shifting behavior appears plausible, taking into account that the degree of positioning risk is severe, while price risk is low and budget risk actually does not exist.

Insert Table 5 about here

3.4. Influence of Experimental Conditions on the Deviations of Final Configurations in Relation to Nash-Equilibria

After having diagnosed an overall aggressive game playing behavior, the question arises as to whether this also holds for different subgroups. This question is answered with the help of t-tests. Three subgroups are examined in greater detail. First, behavioral differences might occur between the group of competitors with the established products and the one with newly introduced products (order to entry). Second, differences in behavior might also exist between markets with high or low distances of the newly introduced to the established products' positions (market entry distance). Third, it might make a difference whether a

product is closest to the market center or differentiated (product position's centralization). The t-tests in Table 6 show no influence of order of entry or market entry distance on relative deviations between game playing behavior and Nash-behavior. They indicate, however, a significant influence of a product position's centralization. It is the group of differentiated products which is responsible for the observed aggressive positioning strategies. Evidently, this group tries to achieve gains by moving its products' positions towards the market center. Centrally positioned products – those closest to market center – defend themselves by cutting prices more strongly than is efficient for Nash-solutions. Altogether, no one benefits from this behavior. Especially the central products are faced with sharp profit cuts as compared to associated Nash-profits, which in turn also implies lower optimal budgets.

Insert Table 6 about here

The influences of order of entry, centralization of product positions and market entry distances have been examined on the basis of t-tests, as all subgroups embrace experiments with identical market conditions. However, such a technique is not adequate for analyzing the simultaneous influence of the experimental variables on relative deviations between experimental behavior and Nash-behavior. Therefore, regression analysis has been applied to explain relative deviations. The results are documented in Table 7.

Insert Table 7 about here

In order to view possible intervening influences of order of entry, centralization of product positions, and market entry distances, subgroup regression analyses have been performed. These regression results are presented in Tables 8-10. Although the assumptions underlying the regressions are mostly met (tests for heteroscedasticity and normality of residual distribution are presented in the tables and absence of multicollinearity is assured by design) and, furthermore, equations are generally significant, the portion of explained variance is not

very high. This indicates an importance of other variables like personal characteristics regarding competitive behavior.

Insert Tables 8 to 10 about here¹

In order to offer a condensed presentation of the regression results we do not formulate complete hypotheses as in Marks (1994), but focus on the principal idea of hypothesis generation. It is built on the observation that experiment subjects tried to reduce (absolute) asymmetry and (positioning) risk in comparison to Nash-competitors. It is then reasonable to assume that the thus motivated experiment subjects would use an instrument intensively, if it has a strong effect on asymmetry and risk reduction under specific market conditions. We operationalize and numerically compute this instrument-strength as the reduction of asymmetry and risk per unit of an instrumental variation, asymmetry and risk being measured as defined in Table 5. Applying OLS-regressions, the influences of parameter variation on the instrument's strength to reduce asymmetry and risk are determined. The directions of regression parameters are shown in Table 11 and will be the guideline for explaining relationships between experimental variables and relative deviations between final configurations and Nash-equilibria.

Before discussing regression results of the Tables 7-10 separately for experimental factors, one common result should be mentioned: aggregated consumer utility turned out to be independent of market conditions. Obviously, market conditions favoring aggressive (utility increasing) pricing in turn also favor aggressive positioning, leading to a suboptimal, utility decreasing homogeneity of supplied products and vice versa.

Insert Table 11 about here

¹ Note to the reviewers: Tables 8-10 might also be printed in the appendix. If the reviewers prefer an even more condensed documentation of regression results, these tables could also be removed. The text should then be modified by simply skipping the final sentences of each of the next paragraphs.

Number of competitors. As seen in Table 11, repositioning towards market center is less suitable if one faces many competitors. In tripolistic markets, for example, a competitor has to give up a monopolistic market area to come closer to the market center, which increases the overlap of market areas with two competitors. In contrast, duopolistic suppliers trade off differentiated monopolistic market areas for the central overlapping market area with only one competitor. This background may explain the large positive effect of the number of competitors on relative *DMC*-deviations between final configurations and Nash-equilibria in Table 7. The greater distances between product positions in tripolistic as opposed to duopolistic markets seem to relax price competition, because relative price-deviations increase with the number of competitors. Table 7 also shows a significant increase in relative budget-deviations which might be caused by attempts to raise profits, lower consumer volumes due to utility-reductions because of price increases, and the budget's potential to reduce asymmetry. Looking at the subgroup regression results of Tables 8 to 10, the responsibility of the differentiated product's positioning behavior for the observed significant positive effect on relative *DMC*-deviations is conspicuous and fits the explanation. Competitors with differentiated (mostly new) products are less motivated to attack the market center in tripolistic markets.

Type of ideal point distribution. In markets with a unimodal ideal point distribution, repositioning towards market center is especially useful for lowering the positioning risk. In such markets confidence in competitors' cooperativeness must be strong when relinquishing a position near the market center in hopes of competitors following. According to Table 7 we can assume that confidence of PRODSTRAT-players was not high enough, as relative *DMC*-deviations increase significantly in markets with uniform ideal point distributions. If we examine the ability of price and budget to reduce asymmetry and risk, we might expect that the more uniform markets are with respect to their ideal point distributions, the more strongly experiment subjects would reduce prices and increase budgets in comparison to their theoretical Nash-counterparts. This expectations is, however, not confirmed in Table 7, probably as a consequence of the large positive *DMC*-deviations in these markets,

making aggressive pricing and budgeting strategies less attractive. This interpretation is also supported by regression results differentiated by market entry distance, as in Table 10. For close market entry distances a significant negative effect on budget-deviations is registered, indicating that the experiment competitors spontaneously increase the budget in markets with unimodal ideal point distribution when product market configurations become too homogeneous. Regression results for subgroups with different degrees of centralization in Table 9 exhibit an interesting structural shift: centrally positioned competitors move relatively out of the center, while differentiatedly positioned competitors in turn increase relative prices. Although these cooperative tendencies in markets with uniform ideal point distributions do not lead to higher relative profits, a substantial reduction of interdependencies among competitors is achieved.

Maximum quality tolerance of consumers. The higher the maximum quality tolerance of consumers, the larger is the extent of overlapping market areas such that an increase of competitiveness could be expected. In addition, also supporting this hypothesis is the fact that *DMC* decreases, price reductions and budget increases seem to be effective in lowering asymmetry and risk. In contrast to these expectations, the experiment's competitors in comparison to their Nash-counterparts tended to relax competitiveness by increasing prices and budgets (see Table 7). Profit-deviations are significantly increased, while maximum quality tolerance has no influence on *DMC*-deviations. Subgroup regression results show that cooperative pricing and positioning occur especially in markets with wide entry distance (see Table 10). A wide entry distance may well help prevent spontaneous price reductions and the rise of rivalry at the beginning of the game.

Quality effect on consumer utility. A high quality effect on consumer utility corresponds with small overlapping market areas and increases the strategic importance of consumers with ideal points close to the respective product positions. While a Nash-competitor reacts to these less competitive conditions with considerable repositioning towards market center, and price and budget reductions, the experiment's competitors preferred monopolistic

positions with higher prices and budgets. Note that this strategy only leads to a reduction of interdependencies among competitors - as can be seen from lower positioning and pricing risks (see Table 11) - and not to profit advantages. These findings need not be revisited in the light of subgroup regression results.

Price effect on consumer utility. The influence of this experimental variable on relative deviations between final configurations and Nash-equilibria cannot be explained by the marketing instruments' efficiency in reducing asymmetry and risk (see Table 11). Although consumer utilities are already low in markets with a high price effect, PRODSTRAT-players, in comparison with a Nash-competitor, arrive at higher prices. But this cooperative behavior is then destroyed by noteworthy (though not statistically significant) *DMC*-reductions and higher budgets, in such a way that profit-deviations do not occur (see Table 7). Subgroup regression results demonstrate that especially differentiated new products with close entry strategy are responsible for aggressive positioning and budgeting behavior (see Table 9).

Budget effect on awareness and availability. Although the increasing of budgets might lower asymmetry and budgeting risks, the experiment's competitors (in contrast to Nash-counterparts) did not fall into the trap of budgeting races. This cooperative behavior is rewarded with significantly increased profits. The budget effect has no remarkable influence on relative *DMC* and price deviations (see Table 7). Relatively low budgets are set for differentiated products, while centrally positioned products are relatively high priced (see Table 9). By foregoing attacking the high-price products and thus leaving these businesses profitable, differentiated products can benefit from the higher level of budgets for centrally positioned products.

Competitive budget effect on awareness and availability. The higher the competitive budget effect is, the more strength price and marketing budget provide for asymmetry and risk reduction (see Table 11). The experiment's competitors apparently made use of this

effect at the expense of significantly lower profits, compared to Nash-profits (see Table 7). No influence of the competitive budget effect on positioning behavior can be seen. Interestingly, aggressive pricing behavior and unsatisfactory profits may be associated with the markets with a close market entry distance (see Table 10). It is probably that low entry distances provoke spontaneous pricing aggressions in early stages of the marketing game, increasing the competitiveness for the rest of the game.

Utility elasticity of consumption volume. Results of Table 7 show that neither relative budget increases nor relative *DMC*-decreases are used to lower asymmetry and risk. At first glance, the utility elasticity of consumption volume has no influence on relative deviations between final configurations and Nash-equilibria. But looking into subgroup regression results, it is seen that differentiated competitors more frequently attack centrally positioned products with lower relative *DMC* and price deviations with higher budget-deviations, while centrally positioned products reply with relative movement out of the center.

Industry budget elasticity of consumption volume. Especially in markets with a low budget elasticity of the consumption volume, decreases in *DMC* and price are efficient for lowering asymmetry and risk (see Table 11). Nevertheless, the budget elasticity does not have a significant influence on *DMC* and price deviations. Table 7 also shows that the experiment's competitors' budgets are lower (in comparison to Nash-budgets) if the industry budget elasticity is high. This indicates a free rider behavior in budgeting, where the experiment's subjects wait for the budget increases of competitors. Markets with high industry budget elasticity are mainly driven by the group of differentiated products (see Table 9): these competitors, in particular, lower relative budgets, but because of relatively higher *DMC*'s and prices they can, overall, realize a positive relative profit-deviation between final configuration and Nash equilibrium.

3.5. Descriptive Analysis of Final Configurations in Relation to Nash-Equilibria

Under the Condition of Realized Product Positions

As we have seen in the last chapters, positioning decisions exert strong influences on pricing and budgeting. We discovered that the experiment's competitors tended to position closer to the market center and set lower prices as well as lower budgets than their Nash-counterparts. But given the aggressive positioning decisions of competitors in the experiment, pricing and budgeting behavior need not be interpreted as more competitive than Nash-behavior. In order to examine this question, relative deviations of characteristics $[r \in C]$ between final configurations and Nash-equilibria under the condition of realized product positions A_{ir}^* are described. Analogous to the measures used so far, relative deviations for the i -th competitor and the r -th characteristic Ω_{ir} are defined in equation (13).

$$A_{ir}^* = \frac{\Omega_{ir}^{Real} - \Omega_{ir}^{Nash^*}}{(\sum_{j=1}^I \Omega_{jr}^{Nash^*}) / \hat{I}} \quad (13)$$

Distributions and statistics of relative deviations for the characteristics price, budget, profit and aggregated consumer utility are presented in Figure 4 and Table 12. As can be seen, pricing and budgeting of the experiment's competitors is still more competitive than in Nash-equilibria for fixed product positions. For all characteristics, deviations are significantly different from zero with $p < 0.01$. But mean deviations of -1.4% for price, -1.6% for budget, -5.7% for profit and 3.4 for aggregated consumer utility are in a range which is acceptable for new product planning in the early stages. This is even more true when we take into consideration that experiment subjects – in contrast to Nash-competitors – did not have the tools for exact mathematical optimization of marketing instruments and therefore automatically face some negative profit-deviation.

Insert Figure 4 and Table 12

Our conclusion of the acceptability of Nash-equilibria in forecasting pricing and budgeting is also confirmed by Table 13. Its results demonstrate that asymmetry and risk reduction were apparently not intended by the experiment subjects.

Insert Table 13 about here

4. Conclusions

This research project was designed to test the Nash-reaction hypothesis inherent in a long research tradition of competitive product positioning. With the marketing game PRODSTRAT, the positioning, pricing and budgeting decisions of 240 advanced marketing students in experimentally varied market situations were observed and compared to corresponding Nash-equilibria. Interestingly, our results are rather mixed: while pricing and budgeting decisions (once product positions are fixed) are very well in line with the expected Nash-equilibria, positioning decisions proved to be significantly more competitive than corresponding Nash-behavior.

Aggressive positioning behavior was observed particularly in duopolistic markets, in markets with unimodal ideal point distributions and under market conditions with a low quality effect on consumers' utilities. This obviously stems from the experiment subjects' attempts to reduce asymmetry in the sense of absolute profit differences and to avoid the risk of profit reductions due to competitive attacks. Under these market conditions, and if substantial asymmetry and risk do occur, product managers would be better off not fully relying on Nash-behavior to predict competitive positioning reactions.

Inevitably, this research project has its limitations. Three major problems of external validity must be mentioned. First, generalization of the results is limited by the mathematical market model. Although our model is already comparatively complex and many different market conditions have been investigated, dynamic components like repositioning costs and carry-

over have not been considered. Product line decisions are not included and simultaneous competition in several markets is also not examined. Second, the experiments were conducted with advanced marketing students as the experiment subjects. Although we can expect that their behavior comes close to that of product managers' behavior, we cannot prove it. Third, we must be aware that positioning decisions in a marketing game are different from decisions in business concerning time horizon, marketing research methods and the people involved.

These limitations might be taken as starting points for further research. Considering the relevance of our findings to the validity of the propositions of a long research tradition, more research with alternative market models is needed. It would also be productive to analyze the influence of psychological aspects on competitive positioning behavior. Such an analysis could also lead to new insights on the degree to which students' behavior can be generalized. Dissimilarities to real problems in practice can only be bypassed by way of large-scale and innovative field research. Nevertheless, we are convinced that this paper has opened the discussion on how to model competitive behavior in product positioning problems.

References

- Assmus, G., U.J. Farley and D.R. Lehmann, "How Advertising Affects Sales: A Meta-Analysis of Econometric Results," *Journal of Marketing Research*, 21 (1984), 65-74.
- Addelman, S., "Orthogonal Main-Effect Plans for Asymmetrical Factorial Experiments," *Technometrics*, 4 (1962), 21-46.
- Alberts, W.W., "Do Oligopolists Earn "Noncompetitive" Rates of Return?," *The American Economic Review*, 74, 4 (1984), 624-632.
- Ansari, A., N. Economides and A. Ghosh, "Competitive Positioning in Markets with Nonuniform Preferences," *Marketing Science*, 13, 3 (1994), 248-273.
- Beckman, S., "Producer's Dilemma Experiments," *Journal of Economic Behaviour and Organization*, 11 (1989), 27-46.

- Beil, R.O., *Collusive Behavior in Experimental Oligopoly Markets*, Dissertation, Texas A&M University, 1988.
- Bolton, R.N., "The Relationship between Market Characteristics and Promotional Price Elasticities," *Marketing Science*, 8, 2 (1989), 153-169.
- Brown-Kruse, J., M.B. Cronshaw and D.J. Schenk, "Theory and Experiments on Spatial Competition," *Economic Inquiry*, 31 (1993), 139-165.
- Carpenter, G.S., "Perceptual Position and Competitive Brand Strategy in a Two-Dimensional, Two-Brand Market," *Management Science*, 35, 9 (1989), 1029-1044.
- Choi, S.C., *Optimal Product Positioning in a Competitive Environment*, Dissertation, University of Pennsylvania, 1988.
- Choi, S.C., W.S. DeSarbo and P.T. Harker, "Product Positioning Under Price Competition," *Management Science*, 36, 2 (1990), 175-199.
- Choi, S.C., W.S. DeSarbo and P.T. Harker, "A Numerical Approach to Deriving Long-Run Equilibrium Solutions in Spatial Positioning Models," *Management Science*, 38, 1 (1992), 75-86.
- Cooper, R.G., D.V. DeJong, R. Forsythe and T.W. Ross, "Selection Criteria in Coordination Games: some Experimental Results," *The American Economic Review*, 80, 1 (1990), 218-233.
- d'Aspremont, C., J.J. Gabszewicz and J.F. Thisse, "On Hotelling's 'Stability in Competition'," *Econometrica*, 47, 5 (1979), 1145-1150.
- DePalma, A., V. Ginsburgh, Y.Y. Papageorgiou and J.F. Thisse, "The Principle of Minimum Differentiation Holds Under Sufficient Heterogeneity," *Econometrica*, 53, 4 (1985), 767-781.
- DePalma, A., V. Ginsburgh and J.F. Thisse, "On the Existence of Location Equilibria in the 3 Firm Hotelling Problem," *The Journal of Industrial Economics*, 36, 2 (1987), 245-252.
- DeSarbo, W.S. and V. Rao, "A Constrained Unfolding Methodology for Product Positioning," *Marketing Science*, 5 (1986), 1-19.
- Domowitz, I., R.G. Hubbard and B.C. Petersen, "Oligopoly Supergames: Some Empirical Evidence on Prices and Margins," *Journal of Industrial Economics*, 35, 4 (1987), 379-398.
- Eiselt, H.A. and G. Laporte, "Competitive Spatial Models," *European Journal of Operational Research*, 39 (1989), 231-242.
- Friedman, J.W., "On Experimental Research in Oligopoly," *Review of Economic Studies*, 36 (1969), 399-414.
- Friedman, J.W. and A.C. Hoggatt, *An Experiment in Noncooperative Oligopoly*, Greenwich, 1980.
- Gabszewicz, J.J. and J.F. Thisse, "Location," in R.J. Aumann and S. Hart, Eds., *Handbook of Game Theory*, 1, Amsterdam, 1992, 281-304.
- Graitson, D., "Spatial Competition à la Hotelling: A Selective Survey," *The Journal of Industrial Economics*, 31, 1/2 (1982), 13-25.
- Grether, D.M. and C.R. Plott, "The Effects of Market Practices in Oligopolistic Markets: an Experimental Examination of the Ethyl Case," *Economic Inquiry*, 22 (1984), 479-507.

- Hagerty, M.R., J.M. Carman and G.J. Russel, "Estimating Elasticities with PIMS Data: Methodological Issues and Substantive Implications," *Journal of Marketing Research*, 25 (1988), 1-9.
- Hanssens, D.M., L.J. Parsons and Schultz, R.L.: *Market Response Models: Econometric and Time Series Analysis*, Kluwer Academic Publishers: Boston/Dordrecht/London, 1992.
- Harker, P.T., "A Variational Inequality Approach for the Determination of Oligopolistic Market Equilibrium," *Mathematical Programming*, 30 (1984), 105-111.
- Hauser, J.R., "Competitive Price and Positioning Strategies," *Marketing Science*, 7, 1 (1988), 76-91.
- Holt, C.A.: "The Exercise of Market Power in Laboratory Experiments," *Journal of Law and Economics*, 32 (1989), S107-S130.
- Horsky, D. and P. Nelson, "New Brand Positioning and Pricing in an Oligopolistic Market," *Marketing Science*, 11, 2 (1992), 133-153.
- Hotelling, H., "Stability in Competition," *Economic Journal*, 39 (1929), 41-57.
- Isaac, R.M. and S.S. Reynolds, "Appropriability and Market Structure in a Stochastic Invention Model," *The Quarterly Journal of Economics*, 103 (1988), 647-671.
- Keser, C., *Experimental Duopoly Markets with Demand Inertia, Game-playing Experiments and Strategy Method*, Dissertation, University of Bonn, 1991.
- Kumar, K.R. and D. Sudharshan, "Defensive Marketing Strategies: An Equilibrium Analysis Based on Decoupled Response Function Models," *Management Science*, 34, 7 (1988), 805-815.
- Larréché, J.L. and H. Gatignon, *Markstrat 2: A Marketing Strategy Simulation, Instructor's Manual*, Redwood City, 1990.
- Marks, U.G., *Neuproduktpositionierung in Wettbewerbsmärkten*, Deutscher Universitäts-Verlag: Wiesbaden, 1994.
- Marks, U.G. and S. Albers, "Experiments in Competitive Product Positioning - A Process Analysis," *Working Paper*, University of Kiel, 1995.
- Mason, C.F., O.R. Phillips and C. Nowell, "Duopoly Behaviour in Asymmetric Markets: an Experimental Evaluation," *The Review of Economics and Statistics*, 74, 4 (1992), 662-670.
- McFadden, D., "Conditional Logit Analysis of Qualitative Choice Behavior," in P. Zarembka, Ed., *Frontiers in Econometrics*, Academic Press: New York, 1974, 105-142.
- Meredith, L. and D. Maki, "Asymmetric Promotion and Strice Effects in an Oligopolistic Service Industry," *Applied Economics*, 23 (1991), 1123-1134.
- Moorthy, K.S., "Product and Price Competition," *Marketing Science*, 7, 2 (1988), 141-168.
- O'Neil, B., "Comments on Brown and Rosenthal's Reexamination," *Econometrica*, 59, 2 (1991), 503-507.
- Plott, C.R., "Industrial Organization Theory and Experimental Economics," *Journal of Economic Literature*, 20 (1982), 1485-1527.
- Prasnikar, V. and Roth, A.E., "Considerations of Fairness and Strategy: Experimental Data from Sequential Games," *Quarterly Journal of Economics*, 107 (1992), 867-888.

- Roberts, M.J. and L. Samuelson, "An Empirical Analysis of Dynamic, Nonprice Competition in an Oligopolistic Industry," *Rand Journal of Economics*, 19, 2 (1988), 200-220.
- Roth, A.E., "Laboratory Experimentation in Economics: a Methodological Overview," *The Economic Journal*, 98 (1988), 974-1031.
- Russell, G.J. and R.N. Bolton, "Implications of Market Structure for Elasticity Structure," *Journal of Marketing Research*, 25 (1988), 229-241.
- Schenk, D.J., *Spatial Competition and Communication: Theory and Experiments*, Dissertation, University of Colorado, 1991.
- Selten, R., "Experimentelle Wirtschaftsforschung," *Vorträge der Rheinisch-Westfälischen Akademie der Wissenschaften*, 287 (1979), 41-72.
- Selten, R., *Models of Strategic Rationality*, Dordrecht, 1988.
- Tellis, G.J., "The Price Elasticity of Selective Demand: A Meta-Analysis of Econometric Models of Sales," *Journal of Marketing Research*, 25 (1988), 331-341.
- Van Huyck, J.B., R.C. Battalio and R.O. Beil, "Tacit Coordination Games, Strategic Uncertainty, and Coordination Failure," *The American Economic Review*, 80, 1 (1990), 234-248.
- Van Huyck, J.B., R.C. Battalio and R.O. Beil, "Strategic Uncertainty, Equilibrium Selection, and Coordination Failure in Average Opinion Games," *The American Economic Review*, 106, 3 (1991), 885-910.
- Weigelt, K., J. Dukerich and A. Schotter, "Reactions to Discrimination in an Incentive Pay Compensation Scheme: A Game-Theoretic Approach," *Organizational Behaviour and Human Decision Processes*, 44 (1989), 26-44.

Table 3: Chosen Values for Factor Levels

Factor Levels	Experimental Factors							
	β_1	β_2	β_3	β_4	β_6	β_7	D_{max}	ED
↘	0.022	0.072	0.55	0.03	2.4	0.02	50.0	20.0
↗	0.028	0.085	0.75	0.07	3.6	0.04	70.0	40.0
Other, non-experimental parameters: $\beta_0=1.0$, $\beta_5=20.0$, $\beta_8=2.0$, $\beta_9=1.0$, $\beta_{10}=-4.0$, $\beta_{11}=0.08$, $K_{fix}=6$ Mio. \$								

Table 4: Statistics of Relative Deviations of Key Characteristics between Final Configurations and Nash-Equilibria

Characteristics	Mean	Std.Dev.	Cases	F-Stat.	Signif. ^a
DMC	-0.277	0.574	240	7.49	0.000
Price	-0.071	0.080	240	14.20	0.000
Profit Contrib.	-0.124	0.125	237	15.50	0.000
Budget	-0.065	0.112	238	9.29	0.000
Profit	-0.399	0.315	235	19.00	0.000
Utility	-0.045	0.221	238	3.21	0.001
a two-tailed F-test					

Table 5: Asymmetry and Risk in Nash-Equilibria and Final Configurations: Results of two-tailed t-Tests

Characteristics		Means		t-Stat.	df	Signif.
Asym_1 [%] (relative)	$\frac{\sum_{i=1}^{\hat{I}} \sum_{j=1}^{\hat{I}} \pi_i - \pi_j }{2 \sum_{i=1}^{\hat{I}} \pi_i}$	15.72	20.17	-1.96	233	0.051
	$\sqrt{\frac{1}{\hat{I}} \sum_{i=1}^{\hat{I}} (\pi_i - \pi^{\circ})^2}$	1502	1133	4.49	233	0.000
Positioning Risk	percentage of profit reduction, if competitors reduce DMC by 1%	-2.80	-1.18	-6.49	228	0.000
Pricing Risk	percentage of profit reduction, if competitors reduce price by 1%	-0.13	-0.56	4.40	229	0.000
Budgeting Risk	percentage of profit reduction, if competitors increase budget by 1%	0.21	0.15	3.05	237	0.003
π_i i -th product's profit		π° mean of products' profits				

Table 6: Influence of Product Position's Centralization on Relative Deviations

Characteristics	Mean of ... Products		t-Wert	df	Signif. ^a
	Differentiated	Central			
DMC	-0.340	-0.093	-4.67	231.25	0.000
Price	-0.057	-0.092	3.31	182.66	0.001
Profit Contrib.	-0.096	-0.167	4.33	177.16	0.000
Budget	-0.050	-0.087	2.59	212.54	0.010
Profit	-0.357	-0.463	2.45	166.08	0.015
Utility	-0.057	-0.026	-0.92	150.33	0.358
a two-tailed t-test with separate variance estimate; significance levels confirmed by nonparametric Kruskal-Wallis-Test					

Table 7: Relative Deviations of Key Characteristics between Final Configuration and Nash-Equilibrium as a Function of Experimental Factors: Results of OLS-Regressions

Experimental Factors	Characteristics of Product Market					
	DMC	Price	Profit Contribution	Budget	Profit	Utility
Constant	-0.614***	-0.119***	-0.215***	-0.148***	-0.478***	-0.005
Number of Competitors	0.226**	0.027**	0.027	0.053***	0.141***	-0.041
Type of Ideal Point Distrib.	0.265***	0.006	0.033**	-0.005	0.020	-0.033
Maximum Quality Tolerance	0.011	0.034***	0.056***	0.048***	0.098*	-0.009
Quality Effect	0.135	0.019	0.035*	0.047***	-0.055	-0.034
Price Effect	-0.070	0.029**	0.039**	0.062***	-0.064	-0.019
Budget Effect	-0.014	0.010	0.027	-0.029*	0.105**	0.030
Competitive Budget Effect	0.032	-0.036***	-0.059***	0.031*	-0.094*	0.047
Utility Elasticity	-0.038	0.001	0.005	-0.009	-0.075	-0.043
Industry Budget Elasticity	0.081	0.003	0.015	-0.042**	0.056	0.031
Number of Cases	240	240	237	238	235	238
R ²	0.114	0.186	0.211	0.263	0.171	0.056
F-Statistic	3.285***	5.840***	6.746***	9.031***	5.147***	1.490
Signif. Residual Normality ^a	0.069	0.468	0.869	0.084	0.188	0.911
Signif. Heteroscedasticity ^b	0.962	0.731	0.596	0.045	0.981	0.266
a	Kolmogorov-Smirnov-Test		*	p<0.05		
b	Goldfeld-Quandt-Test		**	p<0.01		
			***	p<0.001		

Table 8: Relative Deviations of Key Characteristics between Final Configuration and Nash-Equilibrium as a Function of Experimental Factors: Results of Subgroup OLS-Regressions for Established and New Competitors

Experimental Factors	Characteristics of Product Market											
	DMC			Profit Contribution (Price)			Budget			Profit		
	Established Competitors	New Competitors	Signif. ΔBeta^a	Established Competitors	New Competitors	Signif. ΔBeta^a	Established Competitors	New Competitors	Signif. ΔBeta^a	Established Competitors	New Competitors	Signif. ΔBeta^a
Constant	-0.329*	-0.921***	0.01	-0.196***	-0.235***	0.43	-0.153***	-0.142***	0.80	-0.523***	-0.434***	0.50
Number of Competitors	0.100	0.401***	0.04	0.007	0.065**	0.06	0.068***	0.038	0.26	0.144*	0.151*	0.93
Type of Ideal Point Distrib.	0.294**	0.223*	0.63	0.027	0.042	0.61	-0.003	-0.008	0.84	0.005	0.045	0.61
Maximum Quality Tolerance	-0.119	0.168	0.05	0.058**	0.055*	0.92	0.060***	0.028	0.23	0.112*	0.081	0.70
Quality Effect	0.042	0.264*	0.13	0.037	0.024	0.66	0.043*	0.051*	0.76	-0.039	-0.081	0.61
Price Effect	-0.025	-0.162	0.35	0.023	0.060*	0.22	0.041*	0.096***	0.04	-0.066	-0.063	0.97
Budget Effect	-0.147	0.146	0.05	0.037	0.013	0.43	-0.026	-0.028	0.93	0.126*	0.083	0.60
Competitive Budget Effect	-0.044	0.091	0.35	-0.067***	-0.047	0.50	0.031	0.027	0.88	-0.093	-0.082	0.89
Utility Elasticity	-0.090	0.009	0.50	-0.003	0.014	0.58	-0.018	0.007	0.35	-0.043	-0.122*	0.33
Industry Budget Elasticity	0.076	0.124	0.74	0.001	0.032	0.30	-0.040*	-0.055**	0.59	0.048	0.074	0.75
Number of Cases	144	96		142	95		143	95		140	95	
R ²	0.108	0.260		0.238	0.257		0.255	0.343		0.163	0.214	
F-Statistic	1.804	3.350**		4.582***	3.266**		5.065***	4.937***		2.811**	2.574*	
Signif. Residual Normality ^b	0.094	0.570		0.993	0.939		0.118	0.465		0.352	0.520	
Signif. Heteroscedasticity ^c	0.872	0.944		0.510	0.752		0.102	0.110		0.965	0.693	
a	F-test of restricted regressions					*	p<0.05					
b	Kolmogorov-Smirnov-Test					**	p<0.01					
c	Goldfeld-Quandt-Test					***	p<0.001					

Table 9: Relative Deviations of Key Characteristics between Final Configuration and Nash-Equilibrium as a Function of Experimental Factors:
Results of Subgroup OLS-Regressions for Central and Differentiated Competitors

Experimental Factors	Characteristics of Product Market											
	DMC			Profit Contribution (Price)			Budget			Profit		
	Different. Competitors	Central Competitors	Signif. ΔBeta^a	Different. Competitors	Central Competitors	Signif. ΔBeta^a	Different. Competitors	Central Competitors	Signif. ΔBeta^a	Different. Competitors	Central Competitors	Signif. ΔBeta^a
Constant	-0.791***	-0.461***	0.12	-0.166***	-0.268***	0.03	-0.125***	-0.184***	0.16	-0.478***	-0.479***	0.99
Number of Competitors	0.573***	-0.099*	0.00	0.004	0.032	0.31	0.035*	0.066***	0.23	0.111*	0.147*	0.65
Type of Ideal Point Distrib.	0.096	0.469***	0.00	0.065***	-0.005	0.01	0.009	-0.011	0.42	0.048	-0.005	0.51
Maximum Quality Tolerance	0.033	0.007	0.84	0.036*	0.071**	0.21	0.026	0.078***	0.04	0.086	0.115	0.72
Quality Effect	0.045	0.216***	0.19	0.049**	0.024	0.38	0.063***	0.030	0.19	-0.062	-0.028	0.67
Price Effect	-0.114	0.047	0.21	0.027	0.066**	0.17	0.076***	0.035	0.11	-0.041	-0.114	0.36
Budget Effect	-0.001	-0.015	0.91	-0.018	0.080***	0.00	-0.056**	0.007	0.01	0.106*	0.115	0.91
Competitive Budget Effect	0.035	-0.054	0.49	-0.056**	-0.075**	0.51	0.028	0.040	0.65	-0.056	-0.131	0.34
Utility Elasticity	-0.207*	0.188***	0.00	-0.006	0.031	0.18	0.014	-0.044*	0.02	-0.016	-0.160*	0.07
Industry Budget Elasticity	0.131	-0.023	0.24	0.040*	-0.018	0.04	-0.057**	-0.006*	0.05	0.032	0.097	0.41
Number of Cases	144	96		143	94		143	95		141	94	
R ²	0.238	0.614		0.287	0.336		0.325	0.370		0.148	0.231	
F-Statistic	4.646***	15.206***		5.959***	4.730***		7.124***	5.553***		2.526*	2.802**	
Signif. Residual Normality ^b	0.332	0.150		0.948	0.844		0.399	0.026		0.068	0.818	
Signif. Heteroscedasticity ^c	0.599	0.024		0.654	0.140		0.332	0.004		0.953	0.684	
a	F-test of restricted regressions					*	p<0.05					
b	Kolmogorov-Smirnov-Test					**	p<0.01					
c	Goldfeld-Quandt-Test					***	p<0.001					

**Table 10: Relative Deviations of Key Characteristics between Final Configuration and Nash-Equilibrium as a Function of Experimental Factors:
Results of Subgroup OLS-Regressions for Close and Wide Market Entry Distance**

Experimental Factors	Characteristics of Product Market											
	DMC			Profit Contribution (Price)			Budget			Profit		
	Close Entry Distance	Wide Entry Distance	Signif. ΔBeta^a	Close Entry Distance	Wide Entry Distance	Signif. ΔBeta^a	Close Entry Distance	Wide Entry Distance	Signif. ΔBeta^a	Close Entry Distance	Wide Entry Distance	Signif. ΔBeta^a
Constant	-0.383*	-0.845***	0.06	-0.164***	-0.266***	0.04	-0.118***	-0.178***	0.16	-0.327***	-0.629***	0.02
Number of Competitors	0.165	0.287**	0.40	0.022	0.032	0.73	0.035*	0.072***	0.15	0.097	0.183**	0.26
Type of Ideal Point Distrib.	0.248*	0.282**	0.82	0.020	0.046*	0.37	-0.034*	0.024	0.03	0.017	0.020	0.97
Maximum Quality Tolerance	-0.113	0.135	0.09	0.038	0.074***	0.23	0.048**	0.048*	0.99	-0.028	0.225***	0.00
Quality Effect	0.084	0.186	0.48	0.031	0.040	0.77	0.027	0.067***	0.12	-0.048	-0.065	0.82
Price Effect	-0.187	0.047	0.11	0.029	0.050*	0.48	0.072***	0.052*	0.43	-0.083	-0.047	0.64
Budget Effect	0.014	-0.042	0.70	0.049*	0.005	0.14	-0.020	-0.038	0.47	0.126*	0.082	0.56
Competitive Budget Effect	-0.013	0.077	0.54	-0.101***	-0.018	0.00	0.013	0.049*	0.16	-0.169**	-0.017	0.05
Utility Elasticity	-0.070	-0.006	0.66	-0.007	0.017	0.41	-0.000	-0.017	0.52	-0.109*	-0.039	0.36
Industry Budget Elasticity	0.083	0.079	0.98	-0.012	0.042*	0.07	-0.042*	-0.043*	0.97	0.024	0.091	0.38
Number of Cases	120	120		118	119		119	119		118	117	
R ²	0.112	0.172		0.283	0.255		0.288	0.314		0.208	0.261	
F-Statistic	1.537	2.541*		4.738***	4.152***		4.888***	5.541***		3.149**	4.196***	
Signif. Residual Normality ^b	0.244	0.510		0.587	0.626		0.572	0.358		0.692	0.324	
Signif. Heteroscedasticity ^c	0.922	0.839		0.344	0.666		0.110	0.173		0.934	0.961	
a	F-test of restricted regressions					*	p<0.05					
b	Kolmogorov-Smirnov-Test					**	p<0.01					
c	Goldfeld-Quandt-Test					***	p<0.001					

Table 11: Efficiency of Instruments to Reduce Asymmetry and Risk under Different Market Conditions as given by Experimental Factors

Experimental Factors	Decreasing DMC to Reduce ...				Decreasing Price to Reduce ...				Increasing Budget to Reduce ...			
	Asymmetry	Distance Risk	Price Risk	Budget Risk	Asymmetry	Distance Risk	Price Risk	Budget Risk	Asymmetry	Distance Risk	Price Risk	Budget Risk
Number of Competitors	↓				↑	↓	↓	↓	↑	↓		↓
Type of Ideal Point Distrib.	↑	↓			↑		↑	↑	↑			↑
Maximum Quality Tolerance	↑				↑			↑	↑			↑
Quality Effect	↑	↓			↓		↑				↑	
Price Effect	↓							↓				↓
Budget Effect					↓		↑	↑	↑			↑
Competitive Budget Effect	↑						↑	↑				↑
Utility Elasticity	↑				↓			↑	↑			↑
Industry Budget Elasticity	↓					↓	↓					

Comment: Arrows indicate parameter directions of regressions between experimental factors and the amount of asymmetry- respectively risk-reduction per unit instrumental variation.

Table 12: Statistics of Relative Deviations of Key Characteristics between Final Configurations and Nash-Equilibria under the Condition of Realized Product Positions

Characteristic	Mean	Std.Dev.	Cases	F-Stat.	Signif. ^a
Price	-0.014	0.052	236	4.19	0.000
Profit Contrib.	-0.030	0.098	236	4.66	0.000
Budget	-0.016	0. 94	238	2.66	0.008
Profit	-0.057	0.115	235	7.56	0.000
Utility	-0.034	0.145	237	3.63	0.000
a two-tailed F-test					

Table 13: Asymmetry and Risk in Nash-Equilibria and Final Configurations under the Condition of Realized Positions: Results of two-tailed t-Tests

Characteristics	Means		t-Stat.	df	Signif.
	Nash*	Final			
<i>Asym_1</i> [%]	17.48	20.17	-2.50	233	0.013
<i>Asym_2</i> [1000\$]	1111	1133	-0.93	233	0.356
Distance Risk	-1.44	-1.48	0.33	235	0.741
Price Risk	-0.36	-0.64	4.18	234	0.000
Budget Risk	0.15	0.14	0.46	235	0.648

Figure 1: Disaggregated Market Model of PRODSTRAT

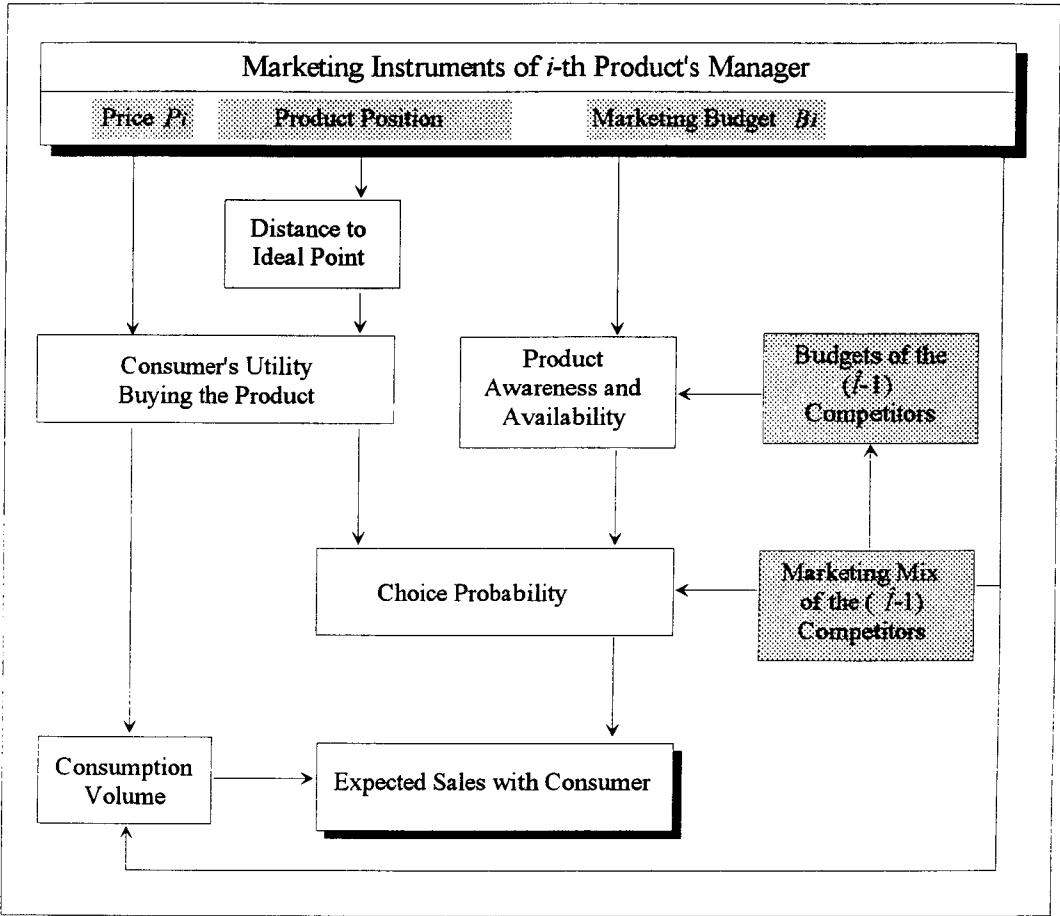


Figure 2: Characterization of Experimental Markets by Key Ratios and Elasticities

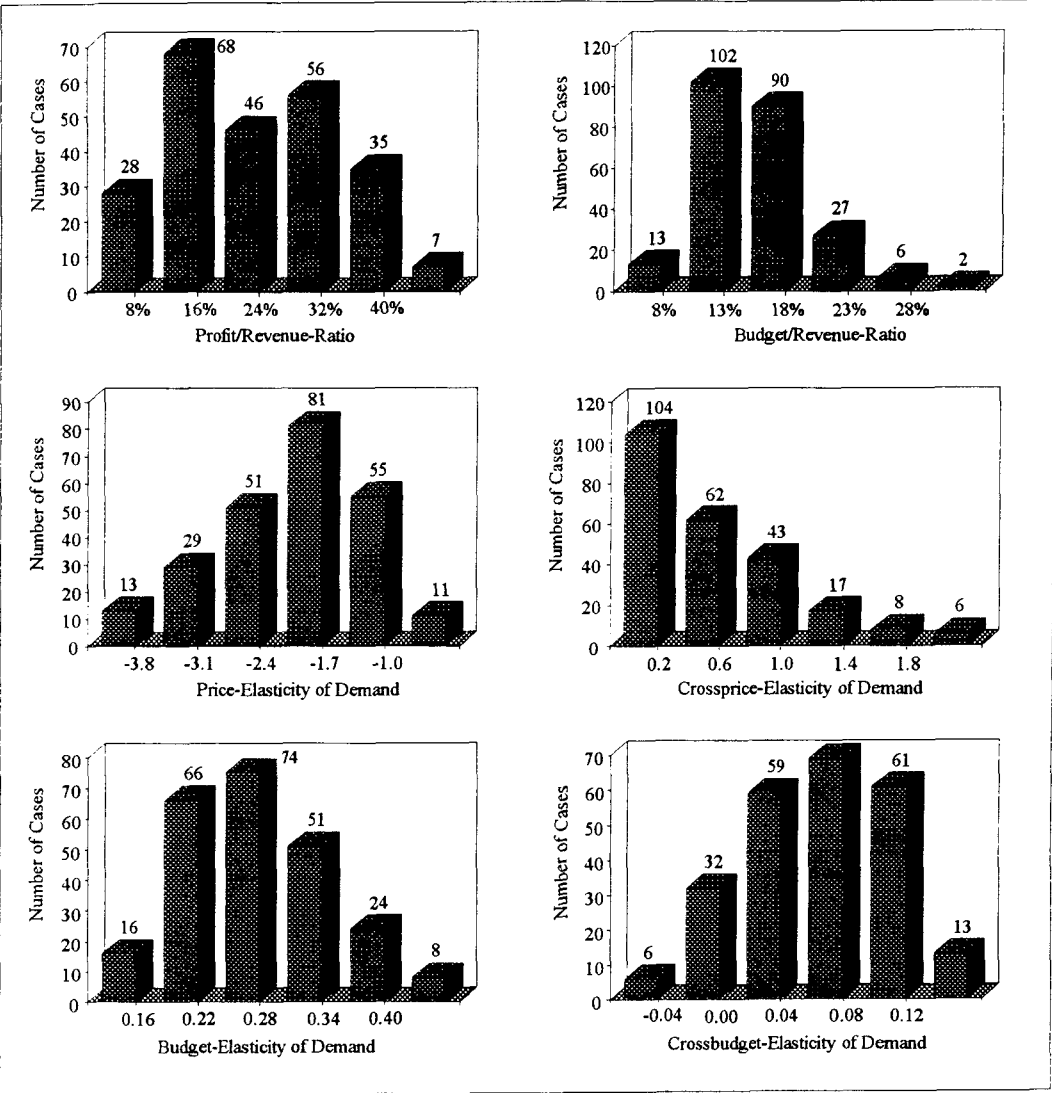


Figure 3: Distribution of Relative Deviations of Key Characteristics between Final Configurations and Nash-Equilibria

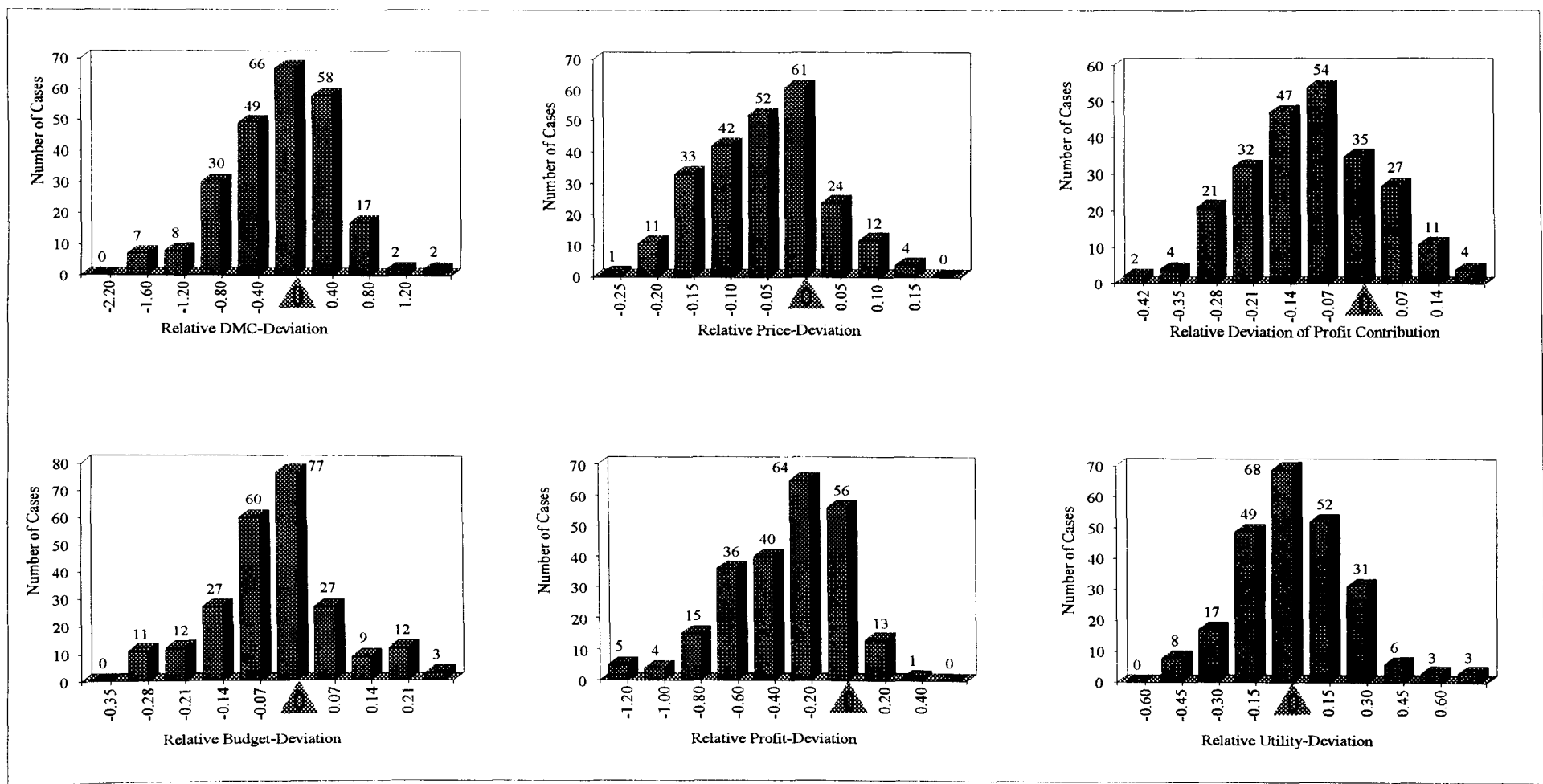


Figure 4: Distribution of Relative Deviations of Key Characteristics between Final Configurations and Nash-Equilibria Under the Condition of Realized Product Positions

