

## **Multiplayer Coordination and Competition in a Vertically Differentiated Market**

Klaus Burgmeier  
*WHU – Otto Beisheim School of Management, Germany*

### **Abstract**

In a vertically differentiated market, the producer of an established brand can leverage its reputational advantage by offering an inferior product beside its premium brand. The so-called fighter brand competes directly with the newcomers in the market. Based on the vertical differentiation model in Jost (2010), we use laboratory experiments to examine the effect of increasing the number of players in a market. In a two-player market, subjects coordinate so that the relative profits are balanced. In the treatment with three players, the incumbents deviate from the equilibrium to drive the two entrants' profits to the minimum. The reason for this change in behavior seems to be the increased difficulty to reciprocate when more than two players are involved.

JEL Codes: C91, D21, L22, L25

### **Acknowledgements**

This work has been funded by the Roechling Foundation. I would like to thank Fan Wu and Peter-J. Jost for useful discussions and valuable comments.

## Introduction

Launching fighter brands is a widespread marketing strategy. Fighter brand as defined by Ritson is “[...] designed to combat, and ideally eliminate, low-price competitors while protecting an organization’s premium price offerings.”<sup>1</sup> Two commonly known marketing strategies, namely *brand extension* and *multibranding*, are both variations of fighter brands. *Brand extension* is the term for a modified product in an existing product category using an existing name; examples for modifications include new flavors, pack sizes, colors, etc. *Multibranding*, in contrast, applies to an existing product under a new brand name; GM, for example, sold slightly reshaped automobiles under the different brand names of Pontiac, Cadillac, Opel, Oldsmobile, and others.<sup>2</sup> It is worth noticing that a product is qualified as a fighter brand only if the new product is priced below the original offer.

Fighter brands offer the launching firm a number of advantages such as access to new market segments, reinforcement of an existing brand name or a premium product, protection against expiring patent rights, generation of economies of scale, better use of established competencies such as logistics and marketing, and reduction of the entrepreneurial risk through a diversified product portfolio.<sup>3</sup> However, there are also potential downsides. If the fighter brand is too similar with the original premium product with respect to its quality and price, competition on the same market (cannibalization) may occur; whereas if the fighter brand is too different from the original product, it may miss the point of protecting the original brand by leaving too much room for other brands to enter the profitable premium market. In this paper we discuss a model that predicts the theoretically optimal positioning of the fighter brands. We further show experimentally that the number of the entrants has an influence on the positioning decisions of the players.

## Theoretical Literature and Fighter Brand Model

As the key issue with fighter brands relates to optimal product design and positioning, two streams of theoretical literature are relevant for this analysis. One stream of literature regards goods as horizontally differentiated, i.e. they are equal in all characteristics except a taste parameter. It originated in Hotelling’s model (1929), which perceives consumers as differing in their tastes, which are uniformly distributed between 0 and 1. In a market with two firms, Hotelling finds that minimal differentiation is optimal.<sup>4</sup> Salop (1979) modifies Hotelling’s basic assumptions by employing a circle-shaped market with uniformly distributed consumer preferences.<sup>5</sup> In his analysis, Salop concludes that maximum differentiation is optimal for the competing firms.<sup>6</sup>

A second stream of literature approaches goods as differing in their qualities, i.e. they are vertically differentiated. The standard model is that of Shaked and Sutton (1982), in which the authors assume that consumers differ in their incomes and quality valuation. As a result, they find

---

<sup>1</sup> Ritson, M., 2009, 87.

<sup>2</sup> See Kotler, P. and G. Armstrong, 2010, 266-269.

<sup>3</sup> See Ritson, M., 2009, 88-93.

<sup>4</sup> See Hotelling, H., 1929, 41-57.

<sup>5</sup> Through shaping the market as a circle, Salop avoids the so-called *hinterland* problem. This problem assures that in a duopolistic market with relatively similar prices, a firm will always occupy the part of the market that is located “behind” the other firm. See Salop, S.C., 1979.

<sup>6</sup> See Salop, S. C., 1979, 141-156.

that profits can be maximized with quality differentiation.<sup>7</sup> Based on this model, Choi and Shin (1992) add an Entrant, a firm entering the market and choosing its quality while an Incumbent is already offering a product in the market. In this model, the Entrant will generate the maximum profits if he selects a quality of  $\frac{4}{7}$  and price of  $\frac{2}{7}$  of the Incumbent's product.

In the model introduced by Jost (2010), the Incumbent is allowed to launch a fighter brand before the potential competitor enters the market. The fighter brand has a quality and price below the original premium product, and the launch does not incur any cost. The Entrant also has full and free access to the production technology and offers a product that has at most the same quality as the premium brand.<sup>8</sup>

At the beginning of the game, the Incumbent offers a premium product, the quality of which is denoted by  $q_{IH}$ . The game comprises of four stages. In the first stage, the Incumbent sets the quality of the fighter brand  $q_{IL}$ . In the second stage, the Entrant chooses the quality  $q_2$  of his product. In the third stage, the Incumbent and the Entrant simultaneously set the prices of their products,  $p_{IH}$ ,  $p_{IL}$  and  $p_2$ . In the last stage, the consumers decide which product to purchase based on their own utility function and the price/quality ratio of the products. A consumer may also decide not to purchase any product if the price/quality ratio does not meet up with her utility function.

The utility function of the consumers is

$$u_i(p, q) = \begin{cases} \theta_i q - p, & \text{if consumer buys} \\ 0 & \text{otherwise} \end{cases}$$

where  $\theta_i$  denotes a consumer's preference for quality which is uniformly distributed between 0 and  $\bar{q}$ , with  $\bar{q}$  being the maximum quality. For a certain product, the quality is  $q$  and the price is  $p$ .

The profit-maximizing solution is solved using backward induction. The profit from each product is calculated by multiplying the price with the quantity of that product. The Incumbent receives the profit from the premium product and the fighter brand product. The Entrant receives the profit from the only product he has.<sup>9</sup>

The premium brand always has the highest level of quality. Depending on the quality ranking of the fighter brand product and the competing product, two scenarios may occur, namely the firewall scenario and the sandwich scenario (see Figure 1).

**[Insert Figure 1 here]**

Denoting the quality and price of the premium product as  $q_{IH}$  and  $p_{IH}$ , the fighter brand's quality and price as  $q_{IL}$  and  $p_{IL}$ , and the Entrant's as  $q_2$  and  $p_2$ , respectively, we solve for the demands in the last stage.

In the **firewall scenario**, demands compute as

<sup>7</sup> See Jost, P.-J., 2010.

<sup>8</sup> See Choi, C. J. and H. S. Shin, 1992, 229-231.

<sup>9</sup> For simplicity reason, the production cost is set to be zero.

$$x_{1H} = \bar{\theta} - \frac{p_{1H} - p_{1L}}{q_{1H} - q_{1L}} \quad (1)$$

$$x_{1L} = \frac{p_{1H} - p_{1L}}{q_{1H} - q_{1L}} - \frac{p_{1L} - p_2}{q_{1L} - q_2} \quad (2)$$

$$x_2 = \frac{p_{1L} - p_2}{q_{1L} - q_2} - \frac{p_2}{q_2} \quad (3)$$

While in the **sandwich scenario**, demands compute as

$$x_{1H} = \bar{\theta} - \frac{p_{1H} - p_2}{q_{1H} - q_2} \quad (4)$$

$$x_{1L} = \frac{p_{1H} - p_2}{q_{1H} - q_2} - \frac{p_2 - p_{1L}}{q_2 - q_{1L}} \quad (5)$$

$$x_2 = \frac{p_2 - p_{1L}}{q_2 - q_{1L}} - \frac{p_{1L}}{q_{1L}} \quad (6)$$

Using backward induction to calculate the prices in stage 3, equilibrium prices in the **firewall scenario** are

$$p_{1H}^* = \frac{1}{2} \frac{\bar{\theta}(q_{1H}(q_{1L} - q_2) + 3q_{1L}(q_{1H} - q_2))}{4q_{1L} - q_2} \quad (7)$$

$$p_{1L}^* = \frac{2\bar{\theta}q_{1L}(q_{1L} - q_2)}{4q_{1L} - q_2} \quad (8)$$

$$p_2^* = \frac{\bar{\theta}q_2(q_{1L} - q_2)}{4q_{1L} - q_2} \quad (9)$$

In the **sandwich scenario**, correspondingly,

$$p_{1H}^* = \frac{\bar{\theta}(q_{1H} - q_2)(q_{1H}(q_2 - q_{1L}) + 3q_2(q_{1H} - q_{1L}))}{2(q_2(q_{1H} - q_2) + q_{1H}(q_2 - q_{1L}) + 2q_2(q_{1H} - q_{1L}))} \quad (10)$$

$$p_{1L}^* = \frac{\bar{\theta}q_{1L}(q_2 - q_{1L})(q_{1H} - q_2)}{2(q_2(q_{1H} - q_2) + q_{1H}(q_2 - q_{1L}) + 2q_2(q_{1H} - q_{1L}))} \quad (11)$$

$$p_2^* = \frac{\bar{\theta}q_2(q_2 - q_{1L})(q_{1H} - q_2)}{q_2(q_{1H} - q_2) + q_{1H}(q_2 - q_{1L}) + 2q_2(q_{1H} - q_{1L})} \quad (12)$$

Solving for the profit-maximizing qualities of the Entrant and the Incumbent in the case where the Incumbent makes his choice first, *IncFirst*, Jost finds that the Incumbent will always launch a fighter brand with a quality of  $q_{1L}^* = 0.54806 q_{1H}$  and the Entrant will always enter the market with a quality of  $q_2^* = \frac{4}{7}(0.54806) q_{1H}$ , resulting in a firewall scenario.

If the game sequence is reversed so that the Entrant enters the market before the Incumbent launches the fighter brand, it is optimal for the Entrant to set a quality of  $q_2^* = \frac{4}{7}q_{1H}$ , which is consistent with the solution of Choi and Shin (1992). In this situation, the Incumbent should not launch a fighter brand.

In both sequences, if the Incumbent's fighter brand shares the same quality with the Entrant product, severe price competition emerges. This drives the prices for both products down to the production cost, which is zero. Such an outcome is especially harmful for the Entrant, since his only product does not generate any profits while the Incumbent still makes profits with his unmatched premium product.

In order to examine the effect of number of entrants in the experiment, we introduce a second Entrant in the model. Both Entrants act simultaneously in all their decisions. There are in total 10 possible scenarios, depending on where the Entrants' products and the fighter brand are positioned. The profit-maximizing equilibria, however, are the same as in the 2-player game, with the two Entrants setting exactly the same quality for their own product. In this case, the two Entrants equally split the demand that one Entrant at that location would have obtained; prices remain unaffected by competition between Entrants. As in the 2-player game, the price of the fighter brand product and the Entrant's product will be driven to zero if the fighter brand has the same quality as one or both Entrant goods.

## Experimental Literature

The existing experimental literature mostly focuses on models with horizontal differentiation, especially Hotelling's model. Brown Kruse et al. (1993) conduct an experiment with markets consisting of two identical firms to test where the firms would locate on a given spectrum of consumer preferences. The communication between the firms are either allowed or forbidden. Employing a scale between 0 and 100, they find that without communication subjects prefer the suboptimal middle position,  $x=50$ , while they coordinate much better with communication, leading them to much more frequently select the theoretically predicted values of  $x_1=25$  and  $x_2=75$ .<sup>10</sup>

Analogously, in a market with three firms and no communication, Collins and Sherstyuk (2000) analyze where firms locate and find that no equilibrium emerges, but that the preferred locations are the inner quartiles and the middle position. As explanations they offer inexperience, approximate equilibrium behavior as well as risk aversion.<sup>11</sup>

Huck, Müller and Vriend (2002) research a market with four identical firms, fixed groups, and no communication. The theoretical equilibrium is  $x_1=x_2=25$  and  $x_3=x_4=75$ . The data leads to a W-shaped distribution with 19.2% on the left equilibrium point, 13.5% on the right equilibrium point and 9.7% in the center. In the course of the game, subjects increasingly choose the center location; stepwise approximation to the theoretical equilibrium does not occur.<sup>12</sup>

There are very few experiments with vertically differentiated markets. The only two studies to our knowledge are those from Mangani and Luini (2000) and Mangani (2002). Researching into information asymmetry, Mangani and Luini (2000) create a market of lemons in a classroom setting, testing three treatments that differ in information symmetry and quality choice, i.e. exogenous vs. endogenous. Their aim is to generate a separating equilibrium in the case of information symmetry; they are also interested whether or not firms also offer high qualities in the case of information asymmetry with endogenous qualities. They restrict the number of possible qualities to two, the high-quality but costly to produce SUPERS and the inferior but inexpensive REGULARS. They find that more REGULARS than SUPERS are traded and that asymmetry lowers prices of both products, forcing them toward production cost.<sup>13</sup> Mangani (2002) tests the vertical differentiation model of Shaked and Sutton (1982) in a laboratory setting. He focuses on price-setting behavior in a vertically differentiated market of two firms with exogenously given qualities. He finds that high differentiation leads to high but suboptimal prices, while low differentiation leads to prices above the optimum, probably due to tacit collusion.<sup>14</sup>

The existing literature indicates that there can be behavioral reasons that drive the participants' decisions away from the theoretical equilibrium. Therefore we would like to test how the fighter brand model holds in laboratory experiments. Further, we enquire the underlying reasons behind the decisions made in the experiments.

---

<sup>10</sup> See Brown-Kruse, J., Cronshaw, M. B. and D. J. Schenk, 1993. 139-165.

<sup>11</sup> See Collins, R. and K. Sherstyuk, 2000,

<sup>12</sup> See Huck, S., Müller, W. and N. Vriend, 2002, 231-240.

<sup>13</sup> See Luini, L. und A. Mangani, 2000.

<sup>14</sup> See Mangani, A., 2002.

## Experimental Design

Based on Jost's model (2010), we developed two experiments to test whether the participants position their products as predicted by the equilibrium. Further, we test how the number of players affects the decisions. The formulas of the models by Jost (2010) as well as Choi and Shin (1992) are the underlying theoretical foundation of the experiments.

In the experiments, the subjects only had to decide on the quality of the products. The price-setting, which occurs in the third stage of the game, was performed by the computer, as was done in Brown-Kruse et al. (1993), Collin and Sherstyuk (2000), Huck, Müller and Vriend (2002). Similarly, the consumers were simulated by the computer, as in Kübler and Müller (2002), Huck, Müller and Vriend (2002), Selten and Apesteguia (2005), Orzen and Sefton (2008), or Barreda-Tarrazona et al. (2010).

The setting is identical for both kinds of experiments: in the first stage, the Incumbent acts as a monopolist in a market with the premium brand as the only offering. In the second stage, he is faced with entry from one (or two) new competitor(s). In order to prevent or reduce the competition from the Entrant(s) with the premium product, he can launch a fighter brand with a quality and price below the premium product. In order to obtain comparable data, the Entrant(s) in the experiments will always enter and that the Incumbent will always launch a fighter brand. Thereby, the decision-making is simplified such that each player only chooses the quality of his new product; the Incumbent's premium quality cannot be altered.

Each experiment was performed under two treatments, one where the Incumbent chooses before the Entrant(s), *IncFirst*, and one where the Entrant(s) choose(s) before the Incumbent, *EntFirst*. In the experiment with three players, the two Entrants choose simultaneously. The second mover(s) are provided with information about the first mover(s)'s quality choice, so they can base their decision on this information, optimizing their own payoff or reducing the payoff of the first-mover. After all players in the market have made their choices, the computer calculates the profit-maximizing prices as well as the resulting demands and profits. Finally, the players receive feedback on all chosen qualities and profits within the market. At the end of each session, a post-experimental questionnaire with an open question was started, asking the subjects for the reasons behind their choices.

Specifically, the decision situation was such that the players who decided first were only given the information that the quality of the premium product is 100%. Since the premium product's quality could not be altered in the game, the Incumbent players only had to focus on the quality of the fighter brand. The second movers were then informed about the preceding quality choice and the information about the premium product, so that they could form their decision based on this information. For both players, the choice sets were {5%, 10%, ..., 90%, 95%}. We set  $\bar{\theta}$  equal to 100, which does not change the optimal strategy choice but facilitates profit calculation. Theoretically, the Entrant always receives significantly lower profits than the Incumbent. In order to avoid large discrepancies between the incomes of participants with different roles, we implemented different exchange rates for converting the profits from the experimental currency *Taler* to Euro, so that the average incomes of all participants in the different roles are roughly the same.

From the theoretical models, it can be deduced that the optimal strategies of the players in the experiment are

**[Insert Table 1 here]**

Plugging in the parameters implemented in the experiments in the model, the theoretical equilibria can be denoted numerically. In both *IncFirst* treatments, the Incumbents select a fighter brand quality of 55% while each of the Entrants choose 30%. In both *EntFirst* treatments, the Incumbents choose the minimal fighter brand quality of 5%, while the Entrants choose 60%. We test the following hypotheses:

**Hypothesis 1:** Subjects' quality decisions possibly deviate from the theoretical equilibrium, indicating preferences other than profit maximization.

**Hypothesis 2:** The number of subjects has an influence on the decisions of the Incumbent as well as on the Entrants.

As there are two roles in the markets, namely Incumbents and Entrants, the role of each subject was randomly assigned and remained the same throughout the experiment. The groups were randomly composed and remained unchanged throughout the experiment, as in Huck, Müller and Vriend (2002), Selten and Apesteguia (2005), Orzen and Sefton (2008), and Barreda-Tarrazona et al. (2010). Along with the instructions, we handed out a printed payoff-matrix to the subjects, as did Kübler and Müller (2002), as well as qualitative instructions, as did Selten und Apesteguia (2005).

The final payoffs to the subjects were calculated by summing up each subject's profits throughout the experiment and transferring from the experimental currency *Taler* to Euro; there was no show-up fee. The experimental program *z-Tree*<sup>15</sup> was implemented for the experiments. We conducted the experiments in MaXLab at the University of Magdeburg, Germany, in December 2010 and January 2011 with 100 students of various study fields. The amount of subjects allowed us to generate 10 independent observations for each treatment.

## Experimental Results

### Quality Choices

Since the underlying model is rather complicated, we do not expect the equilibrium qualities will be played in the first couple of rounds. Through trial-and-error, the subjects should, however, be able to identify the equilibrium in subsequent rounds.

#### 2-Player Game

Analyzing the chosen qualities in the 2-player experiment, we find proof of the expected delay in playing the equilibrium behavior in that in *IncFirst* the Incumbents start with 20% in round 1 and reaches 50% in round 4 and 40% in round 6. These qualities, however, remain at a level of 10% or below in the subsequent rounds. Overall, Incumbents hardly play the equilibrium and quasi-equilibrium qualities of 55% and 60%. Likewise, 20% or fewer of the Entrants in the *EntFirst* treatment play the equilibrium or quasi-equilibrium qualities.

Analyzing whether the strategies predicted by Jost's model are played, firewall in *IncFirst* and sandwich in *EntFirst*, we find that in *IncFirst* after round 12, all Incumbents pursue the

---

<sup>15</sup> See Fischbacher, U., 2007.

optimal firewall-strategy and that in more than 80% they are successful with this strategy. As has also been predicted, the number of Entrants trying to impose a sandwich-strategy on the Incumbents in *EntFirst* rises significantly after the first rounds and averages more than 80% throughout the experiment.

While there are practically no identical qualities of Incumbent and Entrant products in the *IncFirst* treatment, there are some in *EntFirst*. The main difference between the treatments is that in *IncFirst*, the Incumbents can observe the Entrants' choices and set their profits to zero by selecting the same quality value. However, although the Incumbents could employ this strategy as a means of punishment, they do so in only a few cases, averaging less than 10%.

**[Insert Figures 2 and 3 here]**

### **3-Player Game**

As in the 2-player game, the Incumbents almost never play the equilibrium qualities in the *IncFirst* treatment of the 3-player experiment. Equilibrium values can only be observed in 4 out of 30 rounds, accounting for no more than 20% of decisions in any round. The major percentage of choices, especially in later rounds, is the maximum possible value of 95%. In *EntFirst*, no tendency towards a specific value can be perceived, most choices are scattered over the middle range between 30% and 80%, and practically none are the minimum values of 5%.

In *IncFirst*, the Entrants try to obtain very high values, so that on average more than 80% of decisions are qualities of 90% or above. In *EntFirst*, equilibrium qualities are played in all rounds, but only in 20% of the markets at the same time. In later rounds, the 5%-option is increasingly frequently played. On average, the selected qualities are as follows:

-----

**[Insert Table 2 here]**

Statistically, we find that subjects significantly deviate in their quality setting from the equilibrium behavior. Comparing the theoretical values with the played qualities, we obtain the following significance levels:

**[Insert Table 3 here]**

### **Spiteful behavior**

Statistically comparing the played quality values of the 2-player game with the 3-player game, which should theoretically be at the same level, we find significant differences only for the Incumbent in the *EntFirst* treatment ( $p=0.000^{***}$ ), while in *IncFirst* the level is at  $p=0.353$  for the Entrant, the level in *EntFirst* is  $p=0.853$ , and for *IncFirst* it is  $p=0.393$  (Wilcoxon ranked-sign test). This means that only in the *EntFirst* treatment, values differ to a significant amount.

This finding hints at an underlying systematic deviation that does not relate to the transfer of the model into the laboratory. Careful analysis of the data reveals that the deviation stems from spiteful behavior of the Incumbent players aimed at lowering the Entrants' payoffs. In the model, spiteful behavior can be exercised if two or more products share the same quality so that competition becomes so fierce that prices are driven down to zero for these goods. Since the second-mover(s) know the first-mover(s) decision(s), this situation can be created deliberately.

This harms the Entrant(s) much more than the Incumbent who then still receives profits from the premium product.

We analyze spiteful behavior by introducing a binary variable that takes a value of 1 when an Incumbent's and at least one corresponding Entrant's qualities are equal. Employing the Fisher-exact-test, we then compare the 2-player with the 3-player data. Obtaining a significance level of  $p=0.739$ , we cannot find deviating spiteful behavior for the *IncFirst* treatments, but receive a level of  $p=0.005***$  for *EntFirst*. This clearly proves that spiteful behavior occurs much more frequently in the 3-player game.

In addition, none of the two Entrants is systematically disadvantaged: the comparison between *IncFirst* and *EntFirst* on the individual level shows that quality matching differs significantly for both Entrant players, generating values of 0.000 in either case (Fisher-exact test). Equally well, the Fisher-exact test produces a value of 0.310 (*IncFirst*) and 0.180 (*EntFirst*), respectively, for the comparison whether spite is more aimed against one player type.

### Coordination and Collaboration

Extending Jost's model with a second Entrant and searching the theoretical equilibrium, we find that the Entrants' profits are highest when both Entrants select the same quality. Even though this is unlikely to occur in the first round, feedback should ensure that the outcome is possible in the subsequent rounds.

However, the data reveals that while in the *IncFirst* treatment matching qualities occur relatively frequently, it is seldom the case in *EntFirst*. Numerically, quality matching occurs in 190 out of 300 interactions in *IncFirst*, sharply contrasting with only 61 out of 300 in *EntFirst*. Introducing a binary variable that takes a value of 1 when the Entrants select the same quality and statistically testing it with the Fisher-exact-text, we find that collaboration between the Entrants in *IncFirst* and *EntFirst* differs at a highly significant level of 0.000\*\*\*.

This has consequences on the equilibrium behavior. In *IncFirst*, about 80% of the Incumbents play the equilibrium firewall strategy and the Entrants often achieve to collude with matching qualities to ensure high profits for both of them. However, in *EntFirst*, equilibrium behavior is rarely found and even further decreasing in the course of the game, as the number of Entrants pursuing the predicted profit-maximizing sandwich strategy plummets and eventually reaches zero in the final rounds.

### [Insert Figures 4 and 5 here]

The reasons become more obvious when looking at the outcomes of the games. While punishment occurs very infrequently in the *IncFirst* treatment due to the Entrants acceptance of the Incumbents' offering the highest quality, there is severe punishment in *EntFirst*. After round 4, there is punishment in almost all markets. Incumbents employ their fighter brands to set at least one of the Entrant's profits to zero.

The Incumbents exercise a *Divide-and-Conquer*<sup>16</sup> strategy to keep the Entrants from colluding. Such a strategy occurs when "(1) a unitary actor bargains with or competes against a set of multiple actors. (2) The unitary actor follows an intentional strategy of exploiting problems of coordination or collective action among the multiple actors."<sup>17</sup> The Entrants react to the

---

<sup>16</sup> See Posner, E. A., Spier, K. E. and A. Vermeule, 2009, 1-45.

<sup>17</sup> Posner, E. A., Spier, K. E. and A. Vermeule, 2009, 2.

punishment by not colluding such that the Incumbent can only set one player's profits to zero. The analysis further shows that Entrants do not employ a strategy of "taking turns in being punished" but rather pursue a strategy of underbidding the other in quality, expecting the other Entrant to select a higher value and be subsequently punished by the Incumbent. Entrants thereby sacrifice their joint power and succumb to the Incumbent, leaving themselves with suboptimal profits.

A reason that can explain this behavior is that with three players subjects are less certain to have fair behavior reciprocated by the adversary. With two Entrants, reciprocal behavior can occur between the two Entrants as well as between Entrants and Incumbents. The data show that the breakdown of collusion in *EntFirst* occurs for both types of interaction. Yet, the extent of Entrant collusion prevails at a higher level.

**[Insert Figures 6 and 7 here]**

As a result of the Divide-and-Conquer strategy, the Incumbent receives much higher payoffs in *EntFirst* than in *IncFirst*, which contradicts the model predictions. Specifically, the profits are shown in the graphs below:

**[Insert Figures 8 and 9 here]**

The analysis of the post-experimental open question "What were the main reasons behind your decision-making?" underpins these findings from the data:

**[Insert Table 4 here]**

In contrast to the 2-player experiment, the data show, as in the played data, that fewer Incumbents and Entrants attempt to maximize own profits and play best-responses. Yet, not significantly fewer subjects claim to aim at maximizing aggregate profits. Most striking is, however, that fairness concerns are completely eradicated since no player regardless of his role mentions fairness behind his behavior. Nevertheless, the data is all but unanimous with respect to whether behavior is more aggressive in the 3-player experiment. What emerges from the data is that coordination and reputation-building gains importance in the *IncFirst* treatment of 3-player game compared to the 2-player game, and that aggression increases considerably in importance in the 3-player *EntFirst* game. To summarize, the post-experimental self-stated data is in congruence with the quality data obtained during the experiment.

The results show that the actual decisions in the experiments are different from those predicted by the theoretical model. Comparing the comments given by the participants in the 2-player and 3-player games, we find that fairness concerns are significantly stronger in the 2-player game than in the 3-player game, giving support to our first hypothesis. Analyzing the collaboration levels of the 3-player experiment, we find that the *IncFirst* treatment is highly characterized by collusion between Entrants while collaboration breaks down in *EntFirst* due to the Incumbents' *Divide-and-Conquer* strategy. The number of players has shown to have an influence on the players' decisions.

## Conclusion

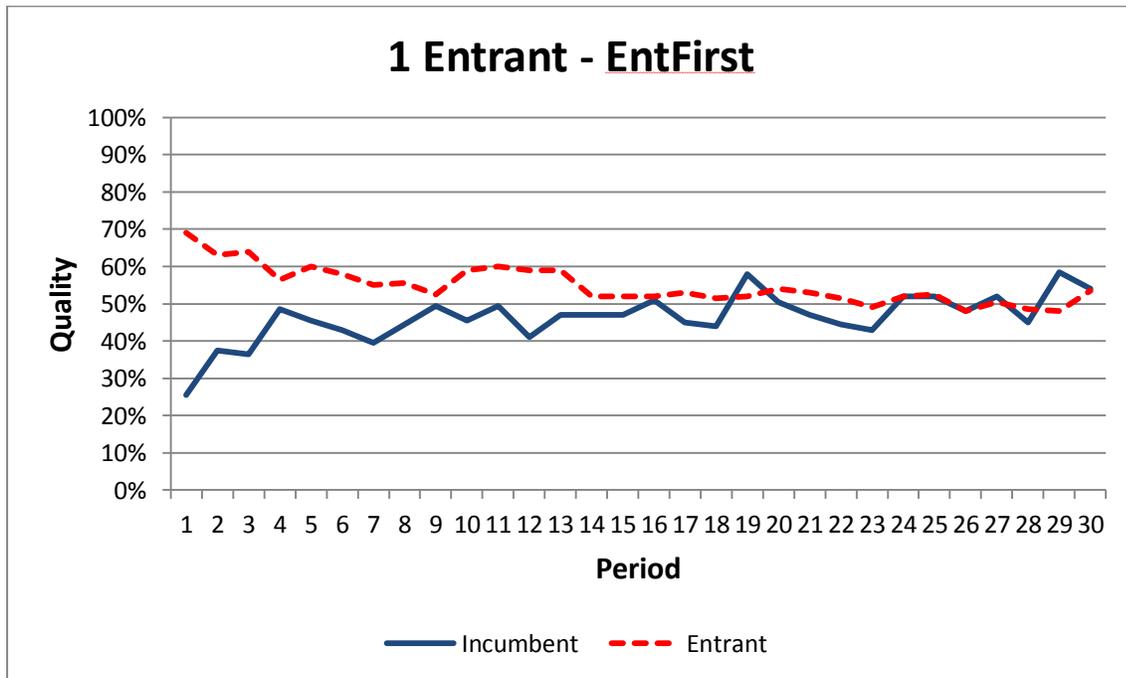
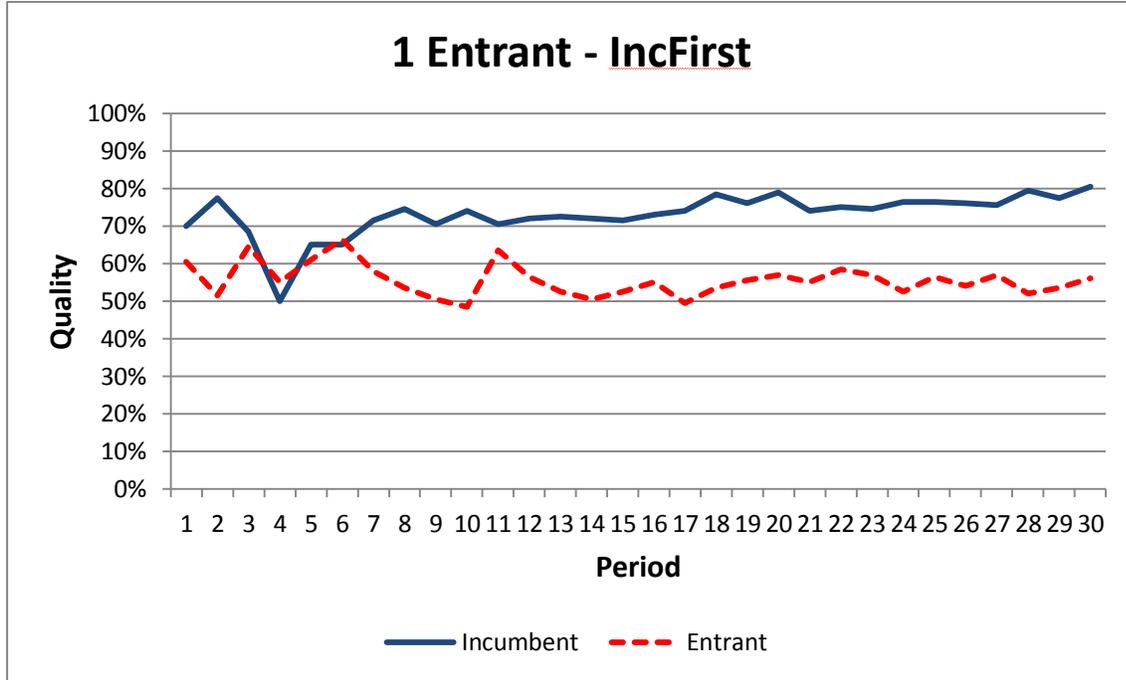
In conclusion, the experiment illustrates that in a vertically differentiated market with one Incumbent and newly entering competitors, the competitive situation has an enormous impact on the behavior of the Incumbent player. While with only one competitor Incumbents avoid cut-throat competition and include fairness concerns in their decision-making process, these feelings are overcome if there are two Entrants coming into the market. When the Entrants move first, Incumbents deviate from the equilibrium so as to drive the entrants' profits to the minimum, even though the deviation also results in lower profits for themselves.

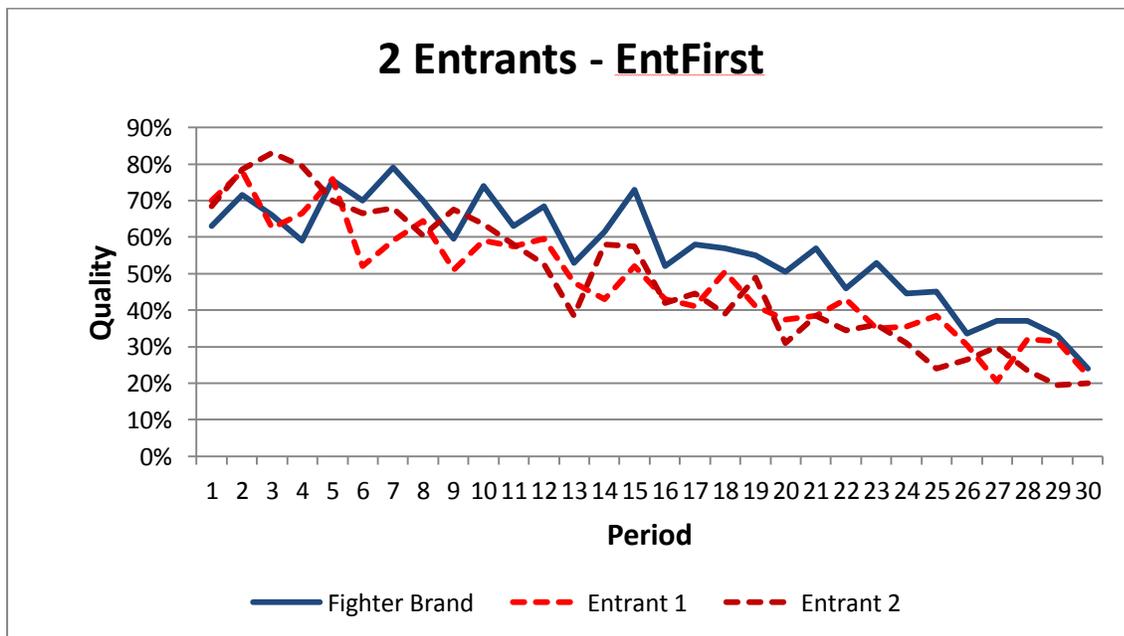
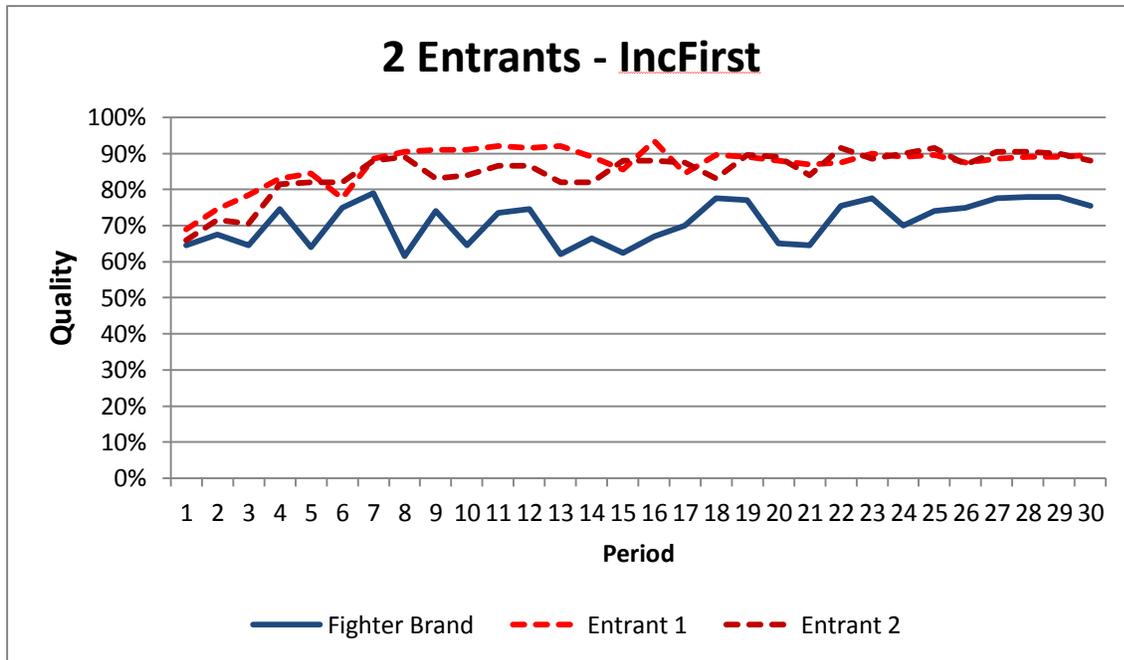
While coordination persists when the Entrants move after the Incumbent, coordination breaks down when this order is reversed. Then, the Incumbents employ a Divide-and-Conquer strategy<sup>18</sup> to punish coordination, leading to a breakdown of collusion, emergence of cut-throat competition, and vanishing of fairness concerns. The reason behind this breakdown may be that with three players subjects are less sure about the other players' behavior and are thus uncertain whether fair behavior will be reciprocated by the opponents. As a consequence, Incumbents prefer not to engage in reciprocity and keep the Entrants' profits to a minimum.

---

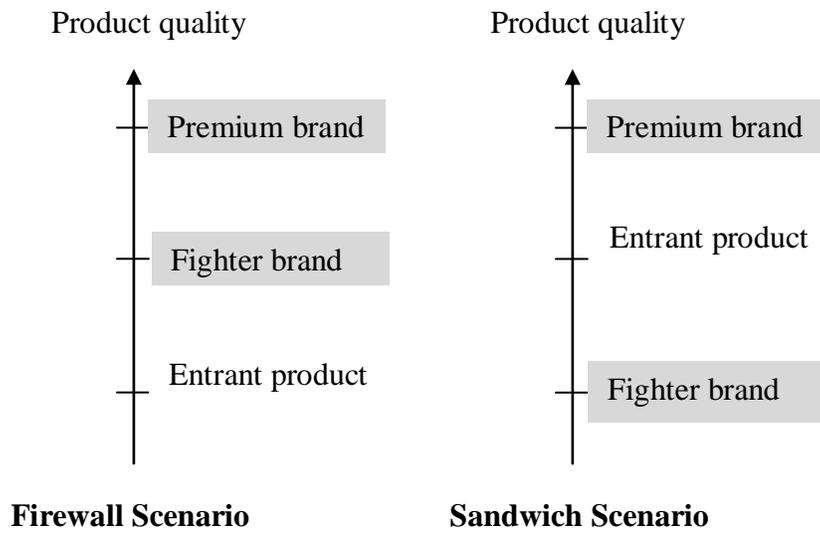
<sup>18</sup> See Posner, E. A.; Spier, K. E. and A. Vermeule, 2009, 1-45.

Appendix – Quality Choices





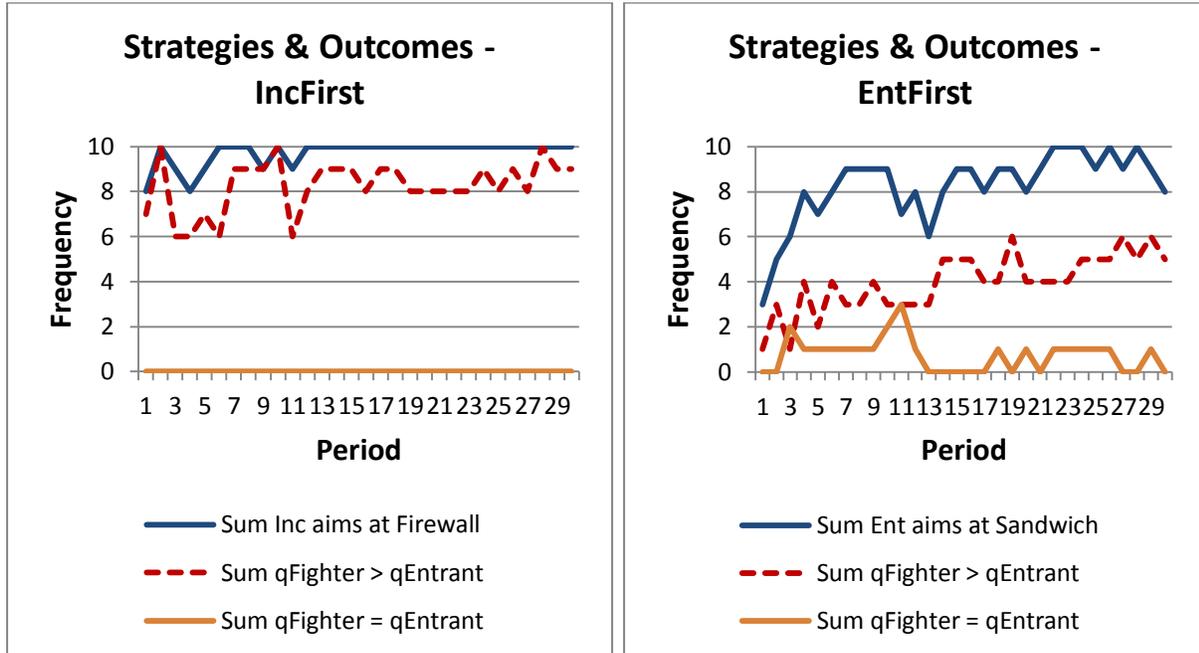
**FIGURE 1: Possible quality rankings**



**TABLE 1: Theoretical equilibrium qualities**

Experiment / Treatment	Optimal Strategy	
	Incumbent	Entrant
<b>2 Players - IncFirst</b>	$q_{1L} = 55\%$	$q_2 = 30\%$
<b>3 Players - IncFirst</b>	$q_{1L} = 55\%$	$q_2 = q_3 = 30\%$
<b>2 Players - EntFirst</b>	$q_{1L} = 5\%$	$q_2 = 60\%$
<b>3 Players - EntFirst</b>	$q_{1L} = 5\%$	$q_2 = q_3 = 60\%$

**FIGURES 2 and 3: Strategies and outcomes in the *IncFirst* and *EntFirst* treatments**



**TABLE 2: Observed and predicted quality values**

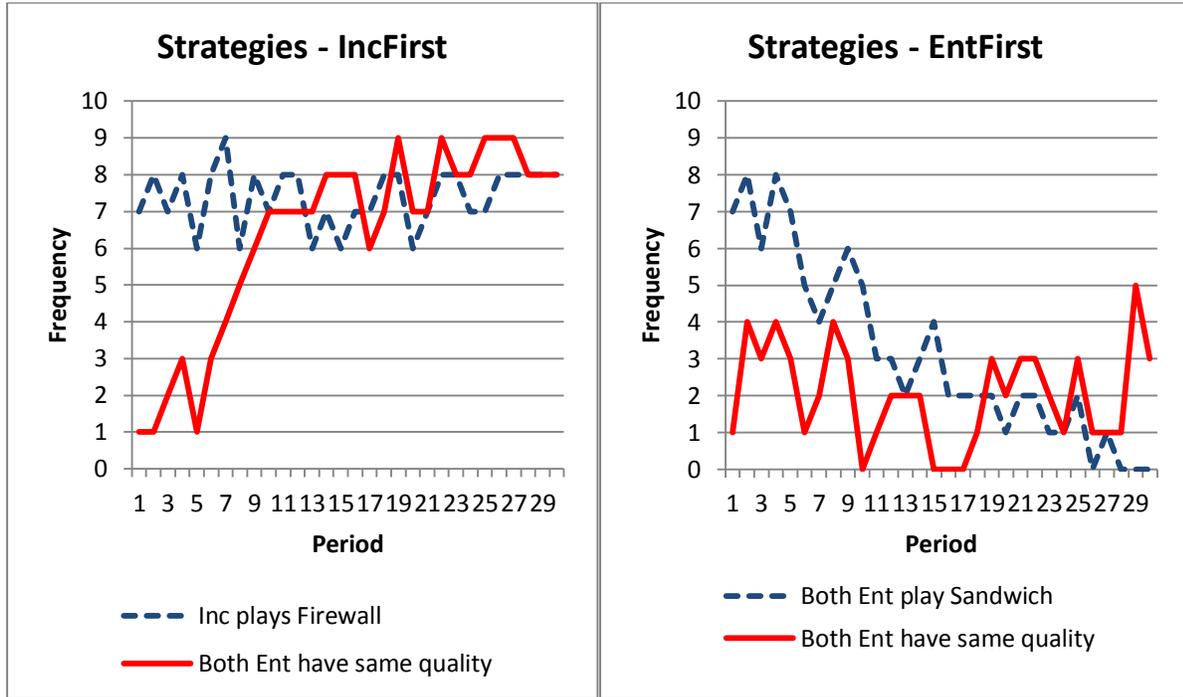
<b>Treatment</b>	<b>Player type</b>	<b>3-player game</b>	<b>2-player game</b>	<b>Model prediction</b>
<b>IncFirst</b>	Incumbent	71.0 %	73.0 %	55.0 %
<b>IncFirst</b>	Entrant 1	87.0 %	50.5 %	30.0 %
<b>IncFirst</b>	Entrant 2	85.0 %	-	30.0 %
<b>EntFirst</b>	Incumbent	56.3 %	46.4 %	5.0 %
<b>EntFirst</b>	Entrant 1	47.9 %	50.1 %	60.0 %
<b>EntFirst</b>	Entrant 2	48.6 %	-	60.0 %

**TABLE 3: Statistical deviations of observed qualities from predicted values**

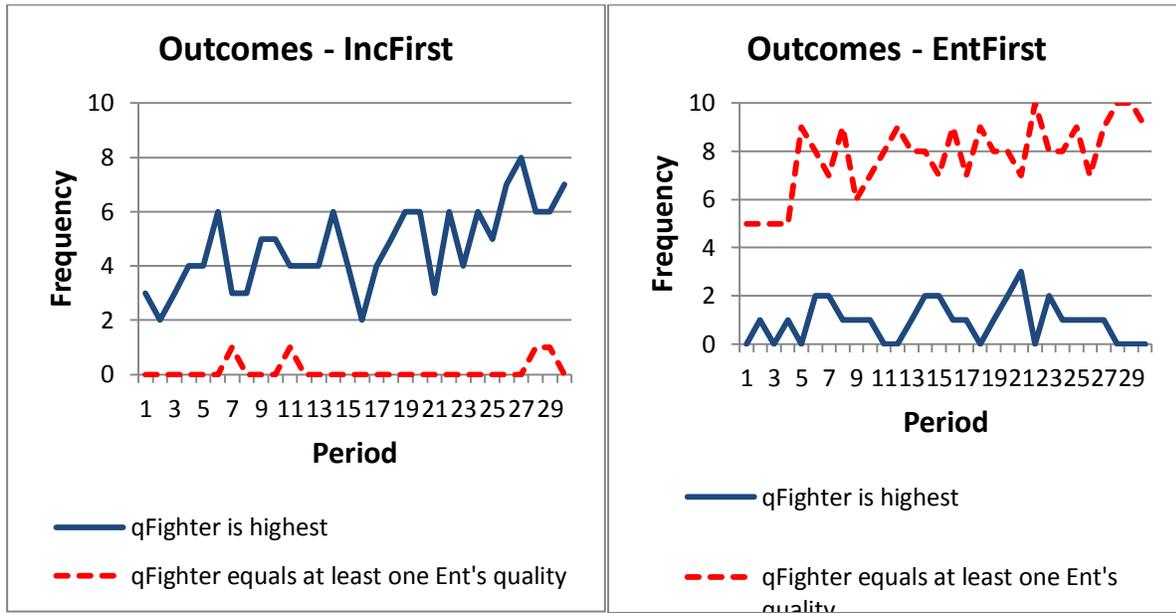
<b>Treatment</b>	<b>Player type</b>	<b>3-player game</b>	<b>2-player game</b>
<b>IncFirst</b>	Incumbent	0.059*	0.005***
<b>IncFirst</b>	Entrant 1	0.005***	0.005***
<b>IncFirst</b>	Entrant 2	0.005***	-
<b>EntFirst</b>	Incumbent	0.000***	0.008***
<b>EntFirst</b>	Entrant 1	0.093*	0.005***
<b>EntFirst</b>	Entrant 2	0.086*	-

Note: \*\*\*:  $p < 0.01$ ; \*\*:  $p < 0.05$ ; \*:  $p < 0.1$ ; Wilcoxon Ranked-sign test

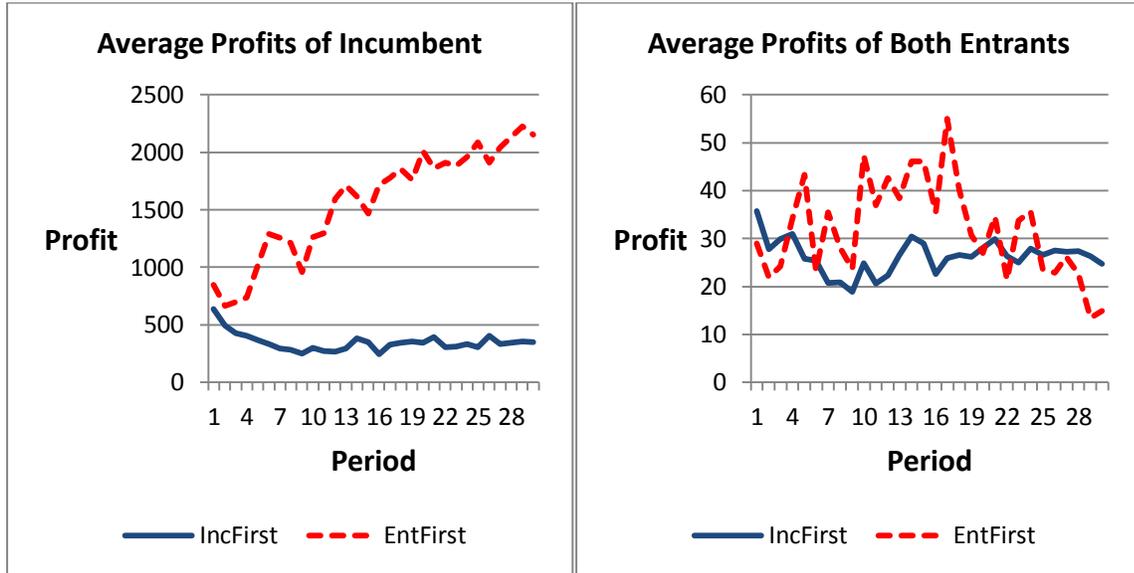
**FIGURES 4 and 5: Played strategies in *IncFirst* and *EntFirst***



**FIGURES 6 and 7: Outcomes in *IncFirst* and *EntFirst* treatments**



**FIGURES 8 and 9: Average profits of Incumbents and Entrants**



**TABLE 4: Decision reasons as provided by the subjects**

		<b>IncFirst</b>		<b>EntFirst</b>	
<b>Type</b>	<b>Reason</b>	<b>2-PI</b>	<b>3-PI</b>	<b>2-PI</b>	<b>3-PI</b>
<b>Inc</b>	Maximizing own profits, playing best response	90%	50%	70%	30%
<b>Inc</b>	Maximizing aggregated profits, finding agreement	20%	10%	10%	0%
<b>Inc</b>	Fairness, inequity aversion	30%	0%	20%	0%
<b>Inc</b>	Exercising aggression, pressuring	20%	20%	60%	50%
<b>Inc</b>	Coordination, reputation-building	10%	30%	20%	0%
<b>Ent</b>	Maximizing own profits, playing best response	90%	60%	100%	40%
<b>Ent</b>	Maximizing aggregated profits, finding agreement	20%	20%	20%	10%
<b>Ent</b>	Fairness, inequity aversion	20%	0%	0%	0%
<b>Ent</b>	Exercising aggression, pressuring	30%	0%	0%	20%
<b>Ent</b>	Coordination, reputation-building	20%	60%	60%	10%

## REFERENCES

- Barreda-Tarrazona, I., García-Gallego, A., Georgantzís, N., Andaluz-Funciac, J. and A. Gil-Sanz, 2010, "An Experiment on Spatial Competition with Endogenous Pricing" *International Journal of Industrial Organization*, 29:1, 74-83.
- Brosig, J., 2002, "Identifying Cooperative Behavior: Some Experimental Results in a Prisoner's Dilemma Game" *Journal of Economic Behavior & Organization*, 47:3, 275-290.
- Brown-Kruse, J., Cronshaw, M. B. and D. J. Schenk, 1993, "Theory and Experiments on Spatial Competition" *Economic Inquiry*, 31:1, 139-165.
- Choi, C. J. and H. S. Shin, 1992, "A Comment on a Model of Vertical Differentiation" *Journal of Industrial Economics*, 40:2, 229-231.
- Collins, R. and K. Sherstyuk, 2000, "Spatial Competition with Three Firms: An Experimental Study" *Economic Inquiry*, 38:1, 73-94.
- Fischbacher, U., 2007, "z-Tree: Zurich Toolbox for Ready-made Economic Experiments" *Experimental Economics*, 10:2, 171-178.
- García-Gallego, A., and N. Georgantzís, 2001, "Multiproduct Activity in an Experimental Differentiated Oligopoly" *International Journal of Industrial Organization*, 19, 493-518.
- Hotelling, H., 1929, "Stability in Competition" *Economic Journal*, 39, 41-57.
- Huck, S., Müller, W. and N. J. Vriend, 2002, "The East End, the West End, and King's Cross: On Clustering in the Four-player Hotelling Game" *Economic Inquiry*, 40:2, 231-240.
- Jost, P.-J., 2010, "The Use of Fighter Brands to Thwart new Entrants" GEABA Discussion Paper DP-10-03, March 2010.
- Kotler, P. and G. Armstrong, 2010, *Principles of Marketing*. 13th ed. Upper Saddle River, NJ, Pearson.
- Kübler, D. and W. Müller, 2002, "Simultaneous and Sequential Price Competition in Heterogeneous Duopoly Markets: Experimental Evidence" *International Journal of Industrial Organization*, 20, 1437-1460.
- Lehmann-Grube, U., 1997, "Strategic Choice of Quality when Quality is Costly: the Persistence of the High-quality Advantage" *RAND Journal of Economics*, 28:2, 372-284.
- Luini, L. and A. Mangani, 2000, "Vertical Product Differentiation and Adverse Selection: An Experimental Note" University of Siena Working Paper, n. 305, October 2000.
- Mangani, A., 2002, "Does Product Differentiation Relax Price Competition? An Experimental Answer" University of Siena Working Paper, n. 350, March 2002.

Pfähler, W. and H. Wiese, 2007, *Unternehmensstrategien im Wettbewerb*, Berlin et al., Springer.

Posner, E. A., Spier, K. E. and A. Vermeule, 2009, “Divide and Conquer“ Discussion Paper No. 639, Harvard Law School, November, 2009.

Ritson, M., 2009, “Should you Launch a Fighter Brand?” *Harvard Business Review*, 87:10, 86-94.

Salop, S. C., 1979, “Monopolistic Competition with Outside Goods” *Bell Journal of Economics*, 10:1, 1979, 141-156.

Selten, R. and J. Apesteguia, 2005, “Experimentally Observed Imitation and Cooperation in Price Competition on the Circle” *Games and Economic Behavior*, 51, 171-192.

Shaked, A. and J. Sutton, 1982, “Relaxing Price Differentiation Through Product Differentiation” *Review of Economic Studies*, 49, 3-13.

Shaked, A. and J. Sutton, 1982, “Natural Oligopolies” *Econometrica*, 51:5, 1469-1483.