How Judo Economics can help small firms to survive Bertrand competition: evidence from the lab

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Abstract

The theory of "judo Economics" describes an optimal strategy for small enterprises to enter a market. By limiting its capacity, the entrant forces a dominant enterprise to accommodate entry. In our paper we find experimental evidence supporting this theory. Collusive behavior, which can be observed in the basic model, is destroyed when price competition among multiple dominant firms is introduced. In contrast, a cost advantage strengthens the small enterprise in a competitive environment while it hurts collusive interaction with one single dominant enterprise. Using these results, we are able to derive strategies for entrants as well as incumbents in different market environments.

Keywords: market entry; price competition; capacity limitation; second mover advantage; experimental economics; management strategies
JEL: D43; L11

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"To capture the image of a small firm using its rival's large size to its own advantage, we call this a strategy of *judo economics*." [Gelman and Salop (1983), p. 315.]

1 Introduction

The term *judo economics* was originally coined by Gelman and Salop (1983). They adapt the idea of a martial arts technique and transfer it to an economic setting. In their study, a market entry game is analyzed where a single entrant faces a monopolistic incumbent. As the incumbent obtains some customer loyalty if products are not differentiated, he always has the possibility to match the entrant's price. The entry of a firm which targets on serving all customers is thus always deterred. In case of a credible capacity limitation, however, accommodation can be the optimal strategy for the incumbent. If the entrant commits itself to serve only a part of the customers, the incumbent is better off relinquishing those customers than serving all customers at a low price. The small firm therefore uses the fact that the incumbent has to serve the whole market at a single price to force accommodation.
What seems to be the result of specific assumptions in a game theoretic model, can be also observed in real market interactions. Small firms limit their sales to avoid competition with strong incumbents. Several examples can be found in various sectors around the world. Sørgard (1995) reports judo competition in the breakfast cereals sector in the United Kingdom (Viota vs. Kellogg) and in the cement industry in Norway (Viking Cement vs. Norcem). The prime example for the application of judo economics can, however, be found in the airline industry. Wilson (1996) reports that Kiwi Airlines entered business in 1992 with only two leased airplanes. The airline exclusively served the route Chicago-Newark-Orlando-Chicago. As this limitation of size was credible, Kiwi airline was not seen as a threat by the market incumbents and was thus able to gain positive profits in the highly competitive flight market.
In this work, we consider the basic model of Gelman and Salop (1983) and modify their assumptions to create a more realistic picture of market entry situations. Within our analysis, we address the following main questions:

1. Are incumbents' responds related to the entrants' scale of entry? In particular, do higher capacities induce more aggressive price responses?

2. Is the judo limitation applicable in an environment with multiple incumbents?

3. How does a cost advantage influence entry decisions and incumbents' responses?

Combining a game theoretic model with an experimental approach, we are able to provide insights on advantages and disadvantages of the judo limitation in different environments. Our results show that in its origin framework with equal cost and one dominant incumbent, judo limitation helps the entrant to make accommodation attractive for the dominant incumbent. Cooperation between firms, however, improves both firms' situation up to a level above the judo outcome. When we introduce competition between two incumbents, we find that entry is much more likely to be deterred, even in case of a judo limitation. In contrast, the introduction of a cost advantage strengthens the entrant in this competitive environment. When the entrant obtains a cost advantage, but faces only one incumbent, we observe entrants performing worse than in the basic judo setting. We discuss these findings with respect to game theoretic and behavioral approaches.

2 Related literature

Market entry phenomena have been well studied. Mostly, incumbents' strategies to deter entry are in the focus of the literature. In the early work of Dixit (1979), competition between an established firm and a potential market entrant is analyzed. The game is modeled as a sequential quantity competition, where the established firm acts as a leader. In this quantity game, leadership is comparable to the second mover position as obtained by the incumbent in the model of Gelman and Salop (1983). This is due to quantities being strategic substitutes while prices being strategic complements. Although Dixit (1979) focuses on the effect of product differentiation, his findings can be related to our study. He shows that holding an excess capacity can be an optimal strategy for the incumbent to deter entry. This finding is somewhat inverse to the judo effect, where the entrant's commitment to a limited capacity results in accommodating being the optimal strategy for the incumbent. In an extension of his basic model, Dixit (1980) pointed out that the incumbent's investment decision on capacity has a significant impact on

entry deterrence, even under more general assumptions on post-entry competition.
Fudenberg and Tirole (1984) study the effect of incumbent's advertising on accommodation. Their model predicts that the level of advertising is low, if the incumbent chooses to deter entry. As this keeps his own and the entrants' products similar in the customers' perception, it makes a price war more credible in case of market entry. However, if the incumbent uses advertising to increase its stock of goodwill, it softens price competition and thus makes entry easier.
In Srinivasan (1991), it is shown that a low cost incumbent uses price limiting as an entry deterrence strategy. If the incumbent is active in multiple markets, he coordinates his pricing to signal potential entrants that he is at a cost advantage.
The majority of experiments on market entry focuses on the coordination between potential entrants in simultaneous move games, see for example Rapoport (1995), Camerer and Lovallo (1999), Zwick and Rapoport (2002) and Duffy and Hopkins (2005). In one of the rare experimental studies on a sequential market entry game, Jung et al. (1994) analyze an experimental chain store game. In each market there is either a strong or weak monopolist who faces random entrants. In each period, an entrant chooses whether to enter a market. For strong monopolists, it is a dominant strategy to fight entry while for weak monopolists, accommodating is more beneficial. As the history of monopolists' responses is observable, the entrants' decision is based on the monopolists' reputation. Experimental results show that weak monopolists use predatory pricing to imitate stronger ones and deter entry in later periods.

From the viewpoint of a potential entrant, capacity limitation is a feasible entry strategy to avoid an aggressive response by the incumbent. Thomas (1999) analyzes empirical data to compare incumbents' observed behavior with theoretical predictions. Besides new products and advertising, incumbents mainly use an aggressive price response to compete with new entrants. Moreover, he finds empirical evidence for less aggressive responses towards judo like entrants.
The core idea of judo is, however, not only important in its origin framework but has been discussed and further elaborated. The judo outcome in competitive as well as cooperative settings has been acknowledged. For example, Sørgard (1995) analyzes the basic model of Gelman and Salop (1983), but assumes a repeated pricing game. Due to this repetition, he considers

collusion to arise after market entry. If the entrant expects the incumbent's response to be collusive, he will not limit his capacity voluntarily. The explanation is that a higher capacity of the entrant makes the non-collusive outcome less attractive for the incumbent. In their modification of the basic judo model, Allen et al. (2000) analyze sequential capacity installing before a simultaneous price competition. They derive that the incumbent installs a capacity to induce the judo equilibrium, if he faces a cost advantage. Díaz et al. (2009) study a two-stage price competition with exogenous capacity constraints. First, firms announce a list price and in the second stage, firms are able to offer discounts. They show that in some cases the low-capacity firm follows a low pricing strategy, which is in turn a judo strategy. Recently, Dechenaux and Kovenock (2011) have proved the judo outcome to be part of collusive interaction. They study a simultaneous price and quantity competition and show that limitations in prices as well as quantities are used to avoid a non-collusive respond from a dominant firm.

3 Four simple Market Entry Games

3.1 Monopoly with Entry and Symmetric Cost

This is the original setting studied by Gelman and Salop (1983).
A dominant firm is assumed to serve a market as a monopolistic incumbent. Additionally, there is a small rival who would like to enter the market with a homogeneous good. We assume that the marginal cost c is the same for both firms and w.l.o.g. we set $c = 0$. Consumers' preferences are assumed to be lexicographical which means that the low price product is preferred but when prices are equal the dominant firm's product is preferred. The small firm has to decide simultaneously on a price and a capacity and then the dominant firm chooses its price.

Proposition 1. *In the non-cooperative equilibrium with one entrant and one incumbent with symmetric cost, entry is always accommodated.*

Proof. Proof. The proof follows Gelman and Salop (1983).
If the capacity is not limited, the dominant firm matches the small firm's price, leaving the small firm with zero profits. Therefore, the small firm

does not enter without limiting its capacity.[3] If capacity is limited, the small firm chooses a price and capacity combination that is small enough so that the dominant firm is better off accommodating entry by serving the residual demand at a high price, instead of deterring the small firm's entry by matching its price.

Knowing the small firm's price $\bar{p}_s$ and capacity $\bar{k}$, the dominant firm may either match the small firm's price ($p_d = \bar{p}_s$) or accommodate ($p_d > \bar{p}_s$). In the first case, the dominant firm serves the entire market at the price $\bar{p}_s$ and has a profit of $\pi_d^{match}(p_d) = p_d D(p_d) = \bar{p}_s D(\bar{p}_s)$. In the second case, the dominant firm serves only the residual demand and therefore maximizes its profit $\pi_d^{accom}(p_d) = p_d \left(D(p_d) - \bar{k}\right)$ with $p_d > \bar{p}_s$.[4] As the small firm has to ensure that entry is accommodated, the small firm must choose a pair (p_s, k) that fulfills the condition $\pi_d^{match} \leq \pi_d^{accom}$, i.e. the dominant firm's profit from accommodation is not smaller than its profit from deterrence. Let $\phi(k)$ denote the function that maps the greatest p_s that fulfills the condition for each k. Thus, the small firm's optimization calculus can be written as:

$$\begin{array}{rcccl} \pi_s(p_s, k) & = & p_s k & \rightarrow & max! \\ w.r.t. \quad p_s & \leq & \phi(k) & & \end{array} \tag{1}$$

As Gelman and Salop (1983) derived that the constraint holds with equality in equilibrium, one can derive the condition for the optimal capacity k^* as $0 = \phi(k^*) + k^* \phi'(k^*)$. This determines equilibrium prices $p_s^* = \phi(k^*)$ and also $p_d^* = argmax\ \pi_d^{accom}(k^*)$. □

3.2 Duopoly with Entry and Symmetric Cost

The duopoly setting is modeled by introducing a second large firm. After the small firm's decision on a price-capacity pair, the two large firms decide simultaneously on their prices. Consumers again prefer the lowest price products, but given equal prices they choose the large firms' products.

[3] Theoretically, any positive entry cost ϵ would be sufficient to guarantee that entry is ruled out in this case.

[4] We follow Gelman and Salop (1983) and assume reservation price rationing for calculating the residual demand. This means that the consumers are served by the firms in the order of their willingness-to-pay, with the highest being served first. The assumption is not crucial for the existence of the equilibria, but determines the distribution of profits between the small and the dominant firm.

Proposition 2. *In the non-cooperative equilibrium with one entrant and two incumbents with symmetric cost, entry is always deterred.*

Proof. Proof. The two large firms ($D = d1, d2$) face a Bertrand competition without capacity constraints. As we assume zero marginal cost for all firms, in any equilibrium $p_{d1} = p_{d2} = 0$. Because $0 > p_s$ is not feasible, the large firms do not accommodate entry. Hence, all firms have zero profits in equilibrium. □

3.3 Monopoly with Entry and Asymmetric Cost

This setting corresponds to the case of the monopoly with entry and symmetric cost (see Subsection 3.1), except that the dominant firm faces a cost disadvantage $c_d > c_s = 0$.

Proposition 3. *In the non-cooperative equilibrium with one entrant and one cost-disadvantaged incumbent, entry is always accommodated.*

Proof. Proof. The decisive difference to the case with symmetric cost is, that the small firm can set a price below the dominant firm's marginal cost ($p_s < c_d$), forcing accommodation. This leaves us with two candidates for equilibrium in this game. One possibility is that the small firm chooses the corner solution in which it sets a price just below the marginal cost of the large firm ($p_s = c_d - \epsilon$), serving the entire market up to its maximum capacity, i.e. $k \leq \min[k^{max}; D(c_d)]$ where k^{max} is an exogenously given maximum capacity. The other possibility is that the small firm uses an optimization as in Subsection 3.1, limiting its capacity and choosing a price that is greater than the marginal cost of the large firm ($p_s > c_d$) but will not be undercut in equilibrium. The small firm chooses the more profitable of the two options, i.e. the corner solution arises if and only if $(c_d - \epsilon) \min[k^{max}; D(c_d)] > p_s^* k^*$. In either case, the large firm accommodates entry and maximizes its profit as a monopolist for the residual demand. □

3.4 Duopoly with Entry and Asymmetric cost

This setting corresponds to the case of the duopoly with entry and symmetric cost (see Subsection 3.2), except that the dominant firms face a cost disadvantage $c_{d1} = c_{d2} = c_D > 0$.

Proposition 4. *In the non-cooperative equilibrium with one entrant and two symmetrically cost-disadvantaged incumbents, entry is always accommodated.*

Proof. Proof.The decisive difference to the case with symmetric cost is, that the small firm can set a price below the large firms' marginal cost, forcing accommodation. In contrast to the previous case, the only option the small firm has in equilibrium is to undercut the large firms by choosing a price $p_s = c_D - \epsilon$ and serving the entire market up to its maximum capacity, i.e. $k \leq \min[k^{max}; D(c_D)]$ where k^{max} is an exogenously given maximum capacity. Entry and accommodation at a higher price is not an option, due to the tough competition between the large firms just as in Subsection 3.2. In equilibrium, the large firms set their Bertrand price $p_{d1} = p_{d2} = c_D$ and share the residual demand. Thus, the large firms' equilibrium profits are zero. □

4 Experimental Design

4.1 Treatment parameters

Our experiment included 4 treatments in a 2x2-factorial design, corresponding to the four models that we analyzed in the previous section. We vary the number of large firms in the market on the one hand and the marginal cost of the large firms on the other hand. The first treatment *SYM1* tests the original model of Gelman and Salop (1983). In the second treatment $SYM2$ we study an analogous situation with competition among two large firms. In the third treatment $ADV1$ we introduce a cost disadvantage for the monopolist in the framework of the original model. Finally, in the fourth treatment $ADV2$, we combine both variations, introducing a cost disadvantage for the two large firms.

We used a linear demand function $D(p) = 100 - p$ and allowed for integer prices in the range $[0; 100]$. We allowed for integer capacity decisions of the small firm in the range $[0; 50]$, i.e. $k^{max} = 50$. Table 1 summarizes the treatments and the corresponding equilibrium predictions.[5]

[5]Due to player's discrete strategy spaces, predictions slightly differ from the equilibria described in Section 3. We do not expect firms to choose prices or capacities equal to zero, as this would lead to zero profits in any case.

Table 1: Overview of treatment parameters

Treatment	SYM1	SYM2	ADV1	ADV2
Incumbents	1	2	1	2
Cost structure	c=0	c=0	c_d=10, c_s=0	c_d=10, c_s=0
p_s	14	[1;100]	16	10
k	30	[1;50]	45	50
p_d	35	1	23	11
π_s	370	0	720	500
π_d	1225	50	506	220
independ. obs.	7	6	7	7

4.2 Experimental Procedure

For each treatment we collected 6 or 7 independent observations (see table 1). In each session, the game was played 20 rounds in fixed matchings of two or three participants. Instructions were read aloud and questions were answered individually. Communication between the participants was prohibited. Subjects were recruited on campus using ORSEE of Greiner (2004) and randomly assigned to their roles and their matching partners. They were mainly students of economics and management.

The experimental software was programmed in z-Tree of Fischbacher (1999). We implemented a sequence of decisions that is perfectly in line with the theoretical models described above. Before typing their price and capacity decision, the participant playing the small firm had access to a what-if-calculator that displayed the outcomes for any hypothetical constellation of decisions. Once the small firm's decision was completed, the large firms had the opportunity also to use the what-if-calculator, which in this case, however, started up with the decision variables of the small firm already given. Then, the dominant firm entered its priced decision. Afterwards, sales quantities and profits were calculated and reported together with the prices to all subjects in the matching group.

Preceding the game, subjects participated in a first set of 10 practice rounds, in which only the dominant firm(s) made decisions in a market without competition by the small firm. Monetary incentives were introduced by randomly choosing one of these 10 rounds to be paid at the end of the experiment. In these rounds, the small firm only observed the market and received a small lump-sum payment. In the SYM1 and the ADV1 treatment the dominant

firm has to decide on its price and serves the market as a monopolist. The monopoly price $p^M = 50$ is therefore the profit maximizing prediction in these treatments. In SYM2 and ADV2 the small firm had to observe a price competition among both dominant firms. The corresponding benchmark is $p_{d1} = p_{d2} = 1 \approx p^B$ or $p_{d1} = p_{d2} = 11 \approx p^B$, respectively.
In a second set of 20 practice rounds, a fixed capacity randomly drawn from $[1; 50]$ was assigned to the small firm, which was then left with a price decision only. Other than this, the game played in the second set of practice rounds was described above.
After the experiment, the subjects were paid anonymously. Their total payoffs consisted of a show-up fee plus the earnings plus the cumulated profits from the 20 game rounds. Subjects were paid anonymously according to their total profit in the fictitious currency ECU earned in the 20 game periods plus their earnings from a randomly drawn round of each of the two sets of practice rounds plus a small show-up fee. Average earnings were from 10 to 12 €for a 1.5-hour session.[6]

5 Results

We use the first set of practice rounds to check the consistency of the behavior with the results of previous experiments reported in the literature. In the monopoly treatments the dominant firm chooses the optimal price in 93% of the cases. This is well in line with the very high percentage of optimal choices in earlier reported work (Potters et al., 2004). In the duopoly setting, we did not expect to find equilibrium behavior because the literature on behavior in Bertrand competition generally shows that there is some degree of cooperation, see for example Dufwenberg and Gneezy (2000) and Huck et al. (2004). Given that our results from the practice rounds are so similar to earlier findings, it seems that we do not need to worry about any location specific biases.

5.1 Baseline

Figure 1 displays the decisions of the small firms in the capacity-price space. To organize the data, we have added a curve depicting the *judo frontier*,

[6]At the time of the experiment the exchange rate between USD and EURO was approximately 1 : 0.71.

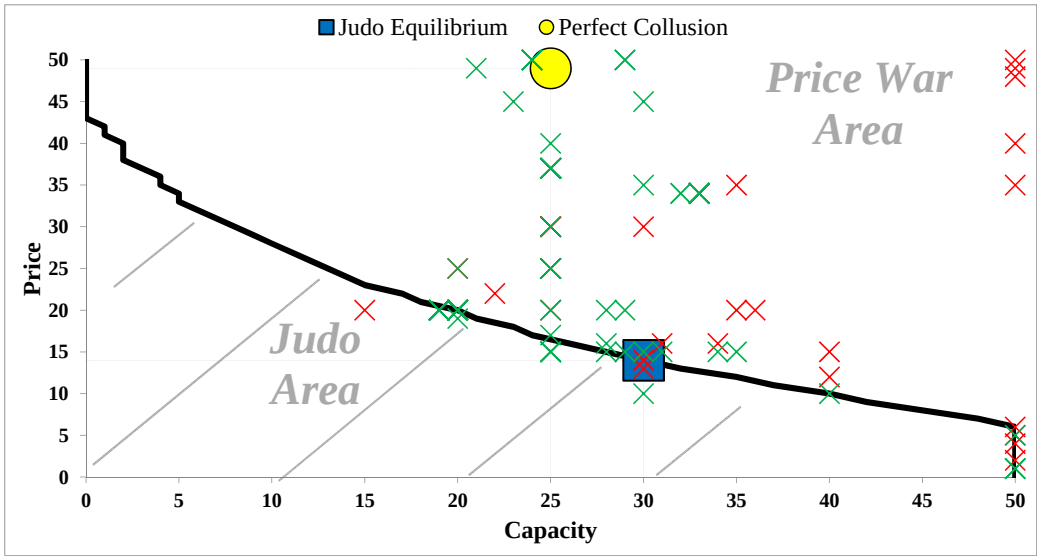

Figure 1: SYM1: Entry decisions of the small firm - accommodation (green crosses) vs. entry deterrence (red crosses)

that maps all capacity-price combinations that fulfill the constraint in the optimization problem (1), i.e. that are candidates for the small firm's judo equilibrium strategy. The judo area that consists of all capacity-price combinations on or below the judo frontier contains the strategy choices by the small firm that should be accommodated by a profit maximizing dominant firm. In contrast, the best response to any combinations above the judo frontier is to undercut the price of the entrant.

One can clearly see that the majority of the decisions can be found between the Judo prediction and the perfect collusion outcome. In 31.4% of the cases, the small firm limited its capacity as well as its price in a way, that accomodation should be favored by the second moving dominant firm. In total, accomodations were observed in 74.3% of the global firms' decisions. Table 2 shows that entrants with lower capacity choices are significantly more likely to be accommodated. Note, that Table 2 also shows that the global firms' profits are significantly greater accommodating the entrants that have been accommodated than accommodating those that have not been.

When analyzing the dominant firm's price responses, we find imperfect collusive behavior in nearly 50% of the observations. We call a response *imperfect* collusive when the dominant firm accomodated entry, even if this

Table 2: SYM1: average entry decisions - successful entry vs. price war

	Successful entry	Price war
k^{**}	27	34
π_l (assuming accommodation)	739	807
π_g (assuming accommodation)**	1333	1055
$\pi_g - \pi_l$ (assuming accommodation)	594	248
π_g (assuming price match)*	1881	1649
opportunity cost of accommodation	548	594

$^{*}p < 0.1$, $^{**}p < 0.01$ (one-sided MWU)

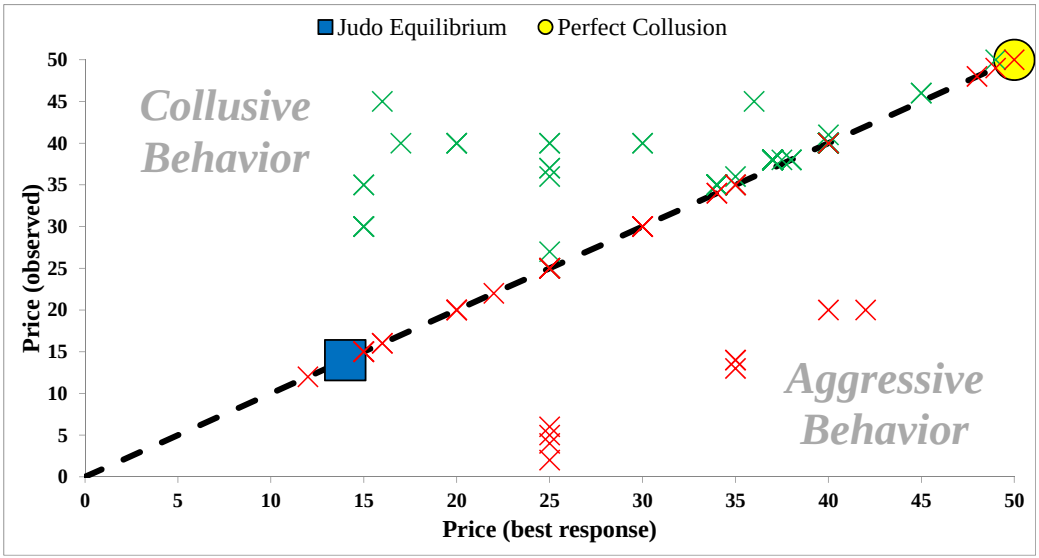

Figure 2: SYM1: Price choice of the dominant firm - accommodations (green crosses) and entry deterrences (red crosses)

reduced its own profit in comparison to matching the small firm's price. Figure 2 illustrates the global firms' price decisions. The 45-line indicates best responses. Price decisions above the best response are denoted as being collusive while prices below best response are denoted as being aggressive. An overview about the global firms' decisions is additionally presented in Table 3. It reveals that entrants outside the Judo area are significantly more likely to be accommodated, if their capacity is smaller than the capacity in the Judo equilibrium. Global firms thus seem to respond friendly towards a capacity limitation, even if a price match would be optimal.

Figure 3 illustrates the development of accommodations and price war over

Table 3: SYM1: Global firm's price choices

	In Judo area	Outside Judo area $\left(k \leq k^{Judo}\right)$	Outside Judo area $\left(k > k^{Judo}\right)$	Total
Accommodation	25.0%	34.3%	15.0%	74.3%
Price war	6.4%	9.3%	10.0%	25.7%
Total	31.4%	47.6%	25.0%	100%

the 20 rounds. The increase in Judo outcomes as well as total accommodations is significant. The drop in accomodations in the last two rounds can be explained by end game effects.

We conclude that in the original setting, a Judo-like limitation can be fre-

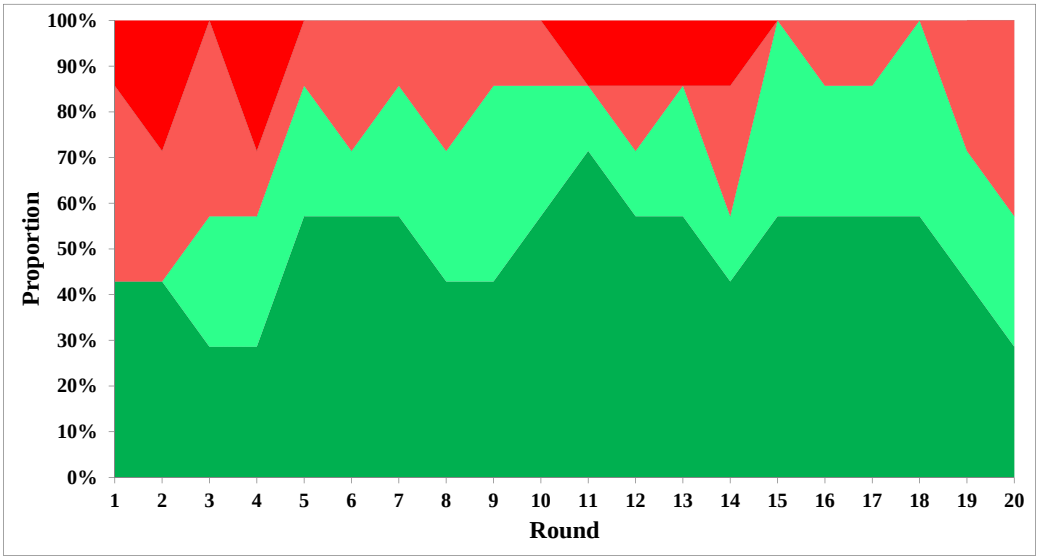

Figure 3: SYM1: Development of market outcomes - accommodations (green) vs. entry deterrences (red), transparent areas indicate best responses

quently observed. The ruinous Bertrand competition as it would appear in a pure price competition can be avoided in the majority of the interactions. Moreover, partly collusive behavior even improves the local firms' situation compared to what the non-cooperative Judo equilibrium predicts.

5.2 The competitive treatment SYM2

When a second dominant firm is introduced, the results change dramatically. In this competitive environment no niche for the small firm is left. The price-capacity decisions of the local firms are shown in Figure 4. One can see

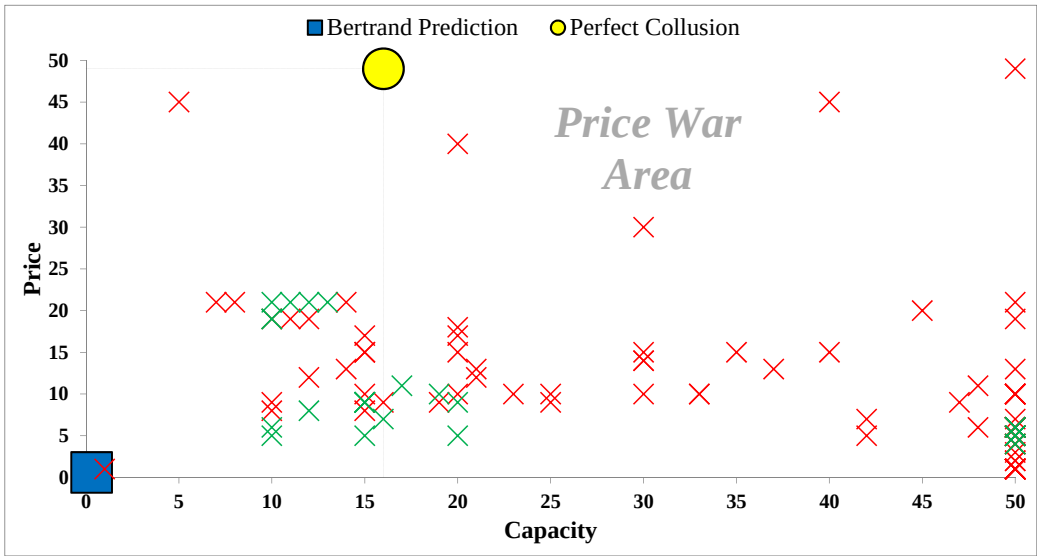

Figure 4: SYM2:Price-capacity pairs of the small firm - accommodations (green crosses) and entry deterrences (red crosses)

that the small firm is only accommodated if it limits its price and capacity quite strong. Accommodations with no capacity limitation are only observed when the corresponding price is close to zero. In total, a price war is seen in 76% of all observations. Correspondingly, we find only 7% responses that can be called imperfect collusive. Comparing accommodations and imperfect collusive behavior between the *SYM1* and the *SYM2* setting, significant differences can be proved. Table 4 illustrates the comparison. This differences

Table 4: SYM1 vs. SYM2 - comparison ($^{*}p < 0.1$, $^{**}p < 0.01$, one-sided MWU)

	SYM1	SYM2
Accommodations**	74.3%	24.2%
Collusive behavior*	50.0%	6.7%

can be explained by considering the global firms' risk of one-sided accommodation. This fits with the previous experimental finding of Huck et al. (2004) that collusion breaks down when interaction among more than two parties is analyzed. We also conclude that the Judo-type limitation of the small firm is strategic. It anticipates the collusive interaction in the monopoly setting but stays close to a strict self-limitation in the competitive duopoly.
The proportion of accomodation shows no significant trend over time, see Figure 5. Note, that in the *SYM2* treatment, accommodation is never a best response. End game effects account for the slight drop in accommodations in the last rounds.

Overall, the symmetric treatments yielded results that fit with game theo-

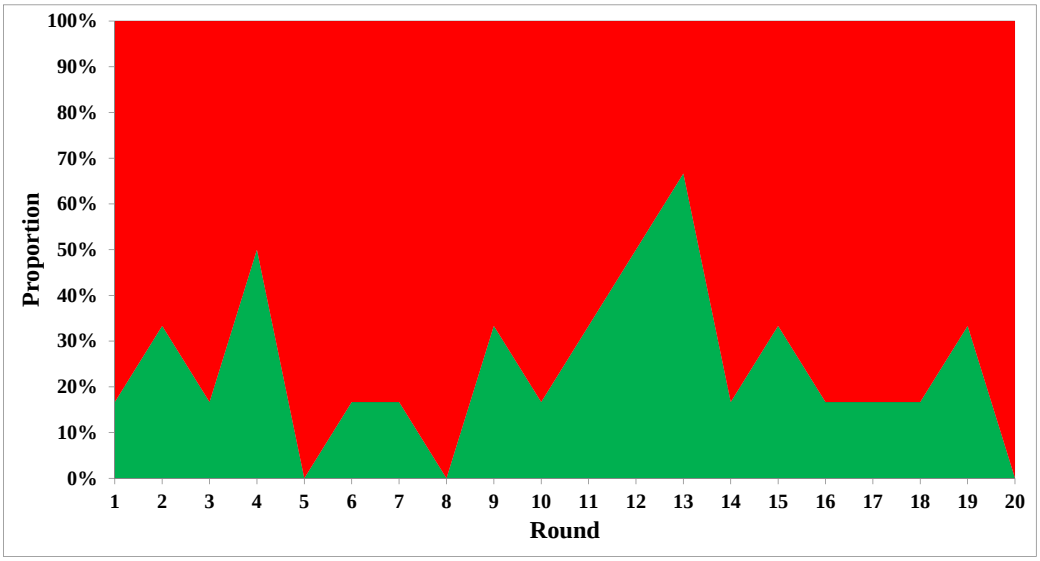

Figure 5: SYM2: Development of market outcomes - accommodations (green) vs. entry deterrences (red)

retic benchmarks as well as behavioral predictions.

5.3 The asymmetric treatments ADV1 and ADV2

Introducing a cost disadvantage for the global firms offers a new entry strategy for the small firm. Besides the Judo limitation observed in the symmetric settings, the small firm may now also decide to set a price equal to or below the marginal cost of the global firms. In this situation, capacity limitation

becomes obsolete. In the *ADV1* setting we actually observed heterogeneous price-capacity combinations which are displayed in Figure 6. As described

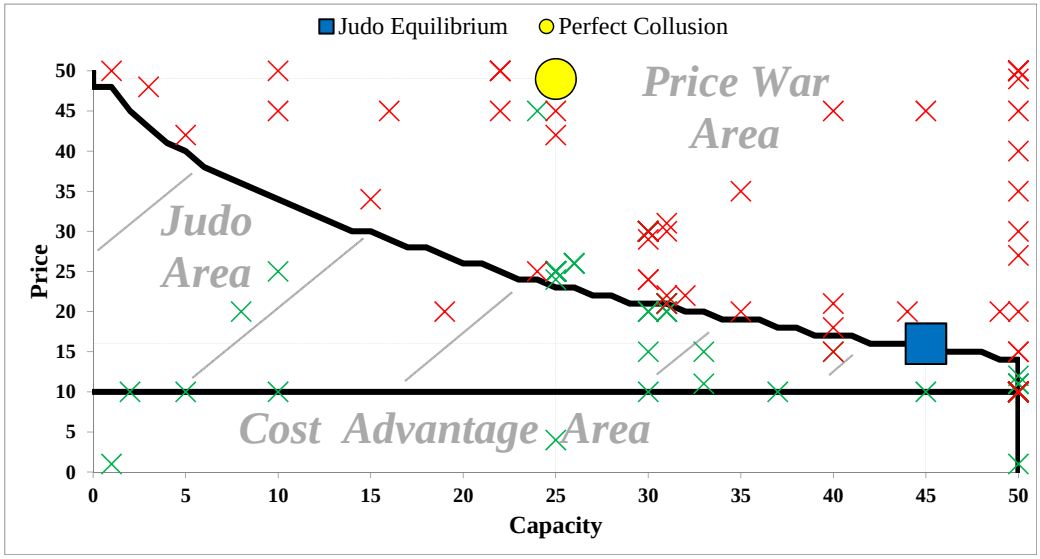

Figure 6: ADV1: Price-capacity pairs of the small firm - accommodations (green crosses) and entry deterrences (red crosses)

above, some observations yield a maximum capacity decision combined with a price slightly below the dominant firm's marginal cost. Anyway, we find many observations with high price and capacity decisions. It seems that the small firm tries to use its strengthened situation to enter the market as a *big player*. The dominant firm therefore refuses collusion and matches the small firm's price in most of the cases. According to Table 5, the entrant's capacity decision is not decisive for the incumbent's response. It is rather the incumbent's profit compared to the entrant's profit that is significantly related to a successful entry. If the dominant firm finds itself performing worse than the entrant in case of accommodation, it is much more likely to deter entry. Thus, the cost asymmetry which is to the advantage of the small firm from a game theoretic point of view, behaviorally goes against it. The responses of the dominant firm are illustrated in Figure 7. The summary of the global firms' responses in Table 6 shows a similarityto the results in the *SYM1* treatment. An entrant which is outside the Judo area, is more likely to be accommodated if his capacity choice is below that of the Judo equilibrium.

Table 5: ADV1: average entry decisions - successful entries vs. price wars

	Successful entry	Price war
k	33	35
π_l (assuming accommodation)**	598	1053
π_g (assuming accommodation)*	1142	999
$\pi_g - \pi_l$ (assuming accommodation)**	238	−366
π_g (assuming price match)**	656	1313
opportunity cost of accommodation **	−282	568

$^*p < 0.1$, $^{**}p < 0.01$ (one-sided MWU)

Figure 8 displays the development of accommodations and price war over

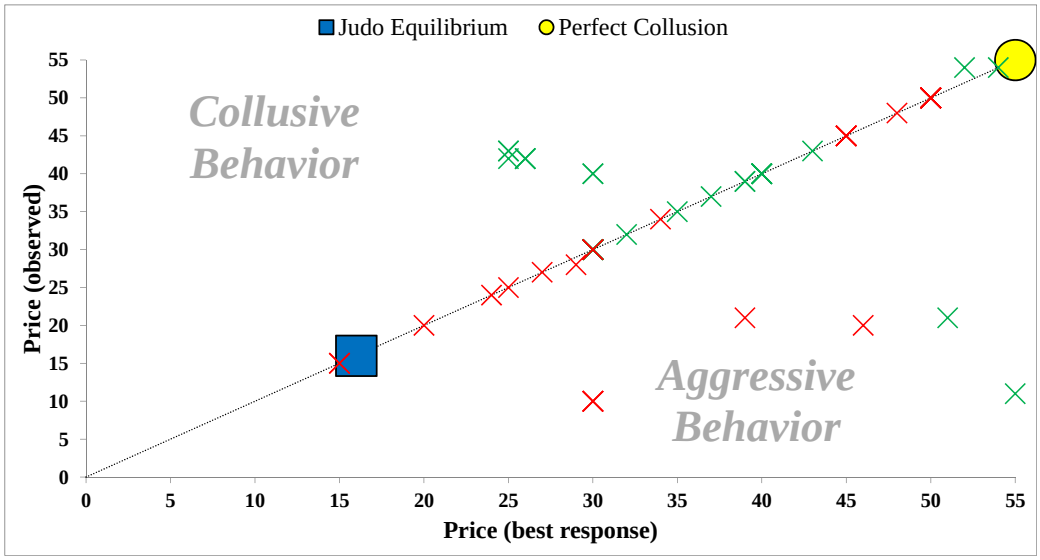

Figure 7: ADV1: Price choice of the dominant firm - accommodations (green crosses) and entry deterrences (red crosses)

time. The proportion of accommodations which are forced by local firms using their cost advantage as well as the proportion of total accommodations increases significantly. As in the *SYM1* treatment, the drop in accomodations in the last rounds can be explained by end game effects.

In the *ADV2* setting, it can be observed that many local firms set prices at the marginal cost level of the global firms. Therefore, the accommodation rate is significantly increased. Nevertheless, if the small firm tries to enter

Table 6: ADV1: Global firm's price choices

	In Judo area	Outside Judo area $\left(k \leq k^{Judo}\right)$	Outside Judo area $\left(k > k^{Judo}\right)$
Accommodation	15.7%	22.1%	0.7%
Price war	2.1%	4.3%	32.2%
Total	17.8%	26.4%	32.9%

	In costadvantage area	Total
Accommodation	18.6%	57.1%
Price war	4.3%	42.9%
Total	22.9%	100%

the market with a higher price, it is matched by either of the global firms. A summary of the local firms' price-capacity decisions is visualized in Figure 9.

The development of accommodations and price war over the 20 rounds is shown in Figure 10. We calculate two siginificant trends with respect to the accommodations. On the one hand, the proportion of accommodations where a price match would have been optimal decreases. On the other hand, the proportion of accomodations due to the small firm using its cost advantage increases.

In conclusion, the asymmetric treatments yielded mixed results. In the *ADV2* treatment, we find the small firm using its cost advantage and therefore improving its situation significantly. In contrast, within the interaction with one dominant firm, the small firm seems to be too greedy and therefore is unable to ask for an accommodating reaction of the dominant firm. In both settings the collusion seems to decrease compared to the symmetric treatments *SYM1* and *SYM2*. A comparison is presented in Table 7.

Table 7: SYM1/SYM2 vs. ADV1/ADV2 comparison ($^*p < 0.1$, one-sided MWU)

	SYM1 $\rightarrow$ ADV1	SYM2 $\rightarrow$ ADV2
Accommodations*	-17.2%	$+23.5\%$
Collusive behavior	-23.5%	-3.1%

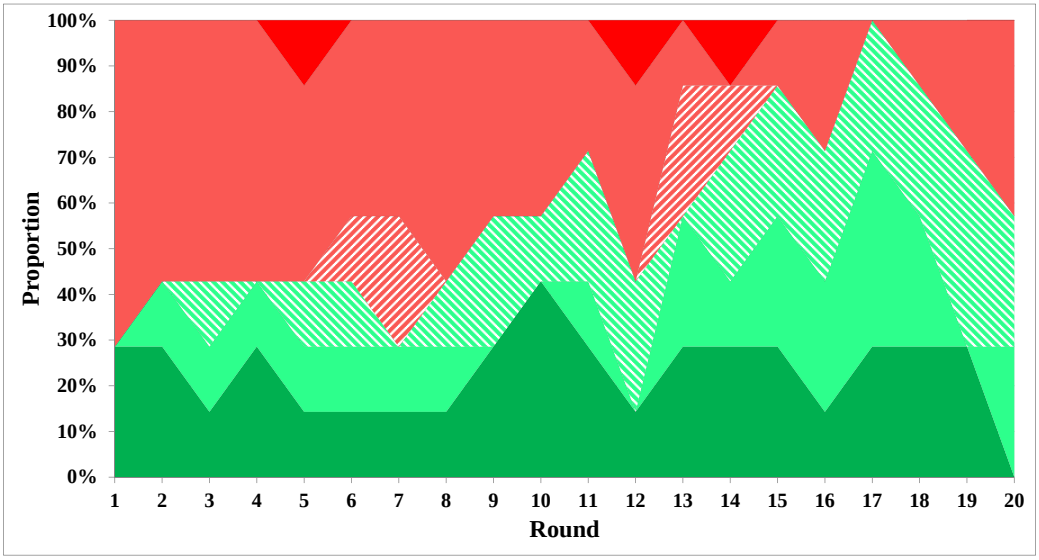

Figure 8: ADV1: Development of market outcomes - accommodations (green) vs. entry deterrences (red), transparent areas indicate best responses, shaded areas indicate the usage of the cost advantage

5.4 Profit and efficiency comparison

In the baseline setting, firms make profits above the non-cooperative Judo-prediction. This can be explained by collusive behavior. As it was described in the last subsection, the introduction of cost asymmetry resulted in a more competitive environment. An overview about the profits in the *SYM1* as well as in the *ADV1* treatment is presented in 11.

According to Table 8, entrants perform more often better than the Judo prediction in the *SYM1* treatment compared to the *ADV1* treatment. This finding proves to be significant.

The profits of the small firm can be ranked according to the treatments

Table 8: Percentage of profits at least at the Judo prediction (accommodations only in parentheses)

	SYM1	*ADV1*
Entrants only *	71% (95%)	9% (16%)
Global firms only	70% (67%)	76% (70%)
Both firms	49% (66%)	9% (16%)

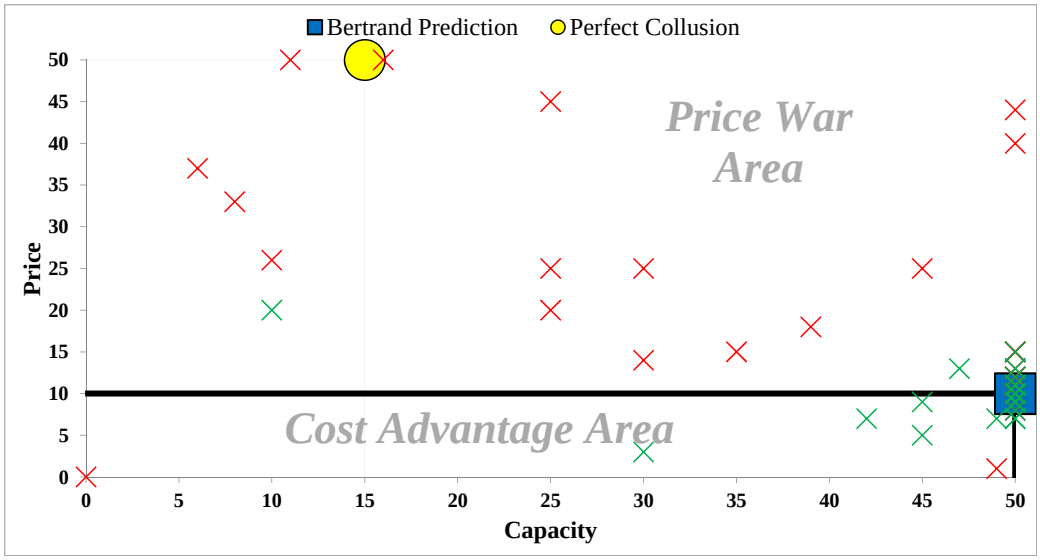

Figure 9: ADV2: Price-capacity pairs of the small firm - accommodations (green crosses) and entry deterrences (red crosses)

in the following order (Spearman Rank correlation coefficient $\rho_s = -0.7095$, $p < 0.01$, one-sided):[7]

$$\pi_l^{SYM1} \quad > \quad \pi_l^{ADV1} \quad > \quad \pi_l^{ADV2} \quad >^{**} \quad \pi_l^{SYM2} \tag{2}$$

The global firms' profits can be ranked as follows (Spearman Rank correlation coefficient $\rho_s = -0.9260$, $p < 0.01$, one-sided):[8]

$$\pi_g^{SYM1} \quad >^{*} \quad \pi_g^{ADV1} \quad >^{**} \quad \pi_g^{SYM2} \quad >^{*} \quad \pi_g^{ADV2} \tag{3}$$

It was predictable that the dominant firm prefers the monopolistic situation over competition and symmetric costs compared to a cost disadvantage. In contrast, it was not expected that the small firm suffers from its cost advantage.

We introduce an efficiency criterion and define $E = \frac{CR+\pi_l+\sum \pi_g}{CR^{max}}$ as the ratio of the sum of actual consumer rent CR and all firms' profits to maximum welfare.[9] According to figure 12, the treatments can be ranked the follow-

[7] $^{**}p < 0.01$ (pairwise one-sided MWU)

[8] $^{*}p < 0.1$ (one-sided MWU), $^{**}p < 0.01$ (pairwise one-sided MWU)

[9] In the symmetric setting, consumers' rent is maximized when the dominant firm sets a price equal to its marginal cost ($p_g = 0$). In the asymmetric setting, consumers' rent is

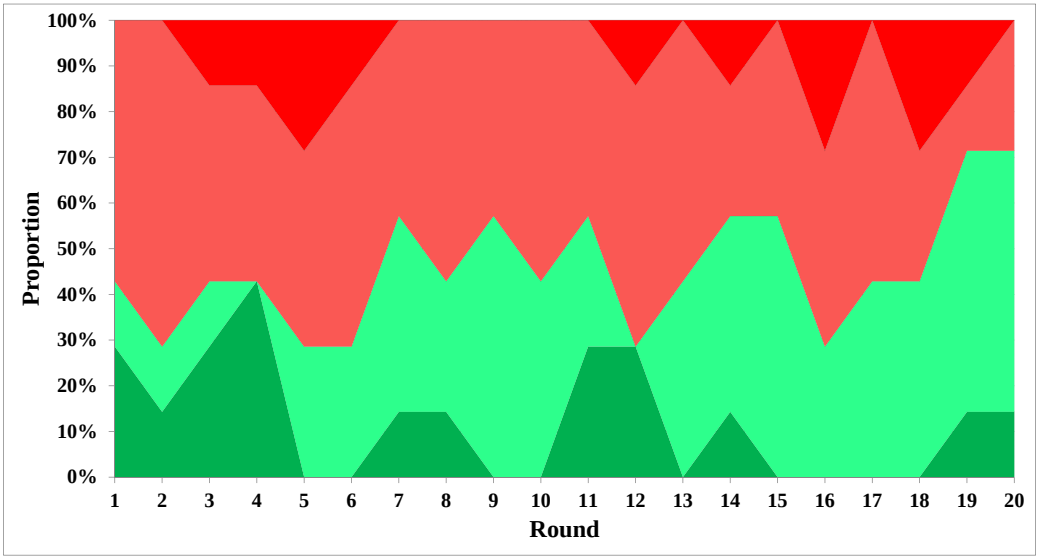

Figure 10: ADV2: Development of market outcomes - accommodations (green) vs. entry deterrences (red), transparent areas indicate best responses

ing way (Spearman Rank correlation coefficient $\rho_s = -0.8891$, ** $p < 0.01$, one-sided):[10]

$$E^{SYM2} >^{**} E^{ADV2} >^{**} E^{SYM1} > E^{ADV1} \tag{4}$$

6 Discussion

We have seen that a size limitation can be a successful strategy for firms to enter a market. Although this result is based on experimental data from student participants, we can transfer basic ideas to formulate managerial implications for entrants and incumbents. Several papers have reported no significant difference between the laboratory decisions of students and business professionals, see for example Siegel and Harnett (1964), DeJong et al. (1988), Dyer et al. (1989) and Cooper et al. (1999). As moreover our main

maximized when the small firm sells its maximum capacity ($\hat{k} = 50$) at any price and at least one dominant firm sells at its marginal cost as well ($p_g = 10$).

[10] $^{**}p < 0.01$ (pairwise one-sided MWU)

findings are in line with the theoretical and behavioral predictions, we derive the following implications.

For entrants, it is necessary to identify situations were the judo strategy is applicable. A judo-type situation is given, if (i) the market is characterized by at least one dominant firm and (ii) the small firm has the opportunity to limit its own size, i.e. by concentrating on a niche. First, the existence of a dominant firm is a basic condition because in a market of nearly perfect competition, no firm has the strategic space for accommodating a new entrant. Note, that in a judo setting, the incumbent only allows for accommodation to maintain its market power with respect to the residual market. Second, if the small firm cannot credibly limits its size, accommodation is never an optimal response for the incumbent. An entrant can credibly signal its size limitation by making its assets, contracts and targets public. Recall the example of Kiwi Airlines leasing only two airplanes to serve one exclusive route.

If these two basic conditions are not fulfilled, potential entrants have to expand their set of strategies. One possibility is obtaining a cost advantage. Our experimental results indicate that a small firm can successfully enter a market, if it focuses on exploiting a favorable cost structure. In contrast, if the small firm, however, tries to use its cost advantage to enter the market with an increased size, the incumbents response is more likely to be aggressive. A second possibility is the differentiation of products. The results of Dixit (1979) and Shaked and Sutton (1982) indicate that a higher degree of product differentiation helps entrants, as competition with an incumbent is softened. Moreover, Carpenter and Nakamoto (1990) formulate advertising strategies for entrants and conclude that a product differentiation with high advertising is optimal, if the incumbent obtains a strong competitive advantage. However, Boccard and Wauthy (2009) argue that size limitation is more effective for entrants than differentiation.

Overall, we advise entrants to focus on its core business because leaving the judo limitation may provoke an aggressive response by the incumbents. As Kiwi airline was the prime example for a successful application of the judo entry, it is, however, also a bad example for giving up this strategy. When the airline expanded their routes in 1994, it faced increasing price competition with the big airlines. Due to insufficient financial assets, the company has finally gone bankrupt in the end of 1999.

Incumbents, should anticipate judo entrants and implement precautionary measures. They can strengthen their market position by targeting on

customer loyalty. If customers do not favor the new entrants only due to an marginal price undercut, the threat of entry is weakened. Modeling several levels of customers' switching cost, Wang and Wen (1998) are able to show that incumbents can allow for entry without loosing all profits. That is due to the customers considering not only the price differential but also the costs of a new supplier.
In the basic model of Gelman and Salop (1983), the incumbent had to serve all customers at a single price. Thus, matching an entrant's price was very unprofitable. If the incumbent is, however, able to charge different prices from different segments of customers, he is not too prone to price competition with a potential entrant. Maintaining flexibility in responses towards market entries is therefore the key for a successful counter strategy to the judo approach.

7 Concluding remarks

In this paper, we studied judo (capacity) limitation as an entry strategy for small firms in the laboratory. Our experimental results indicate that judo-type outcomes are the majority in the original setting of Gelman and Salop (1983). High capacity choice indeed seem to induce very aggressive responses by the market incumbents. When the entrant faces competition between two incumbents, he has no chance to survive without cost advantage. If the small firm obtains a cost advantage, outcomes significantly change. On the one hand, the small firm is then able to enter the hostile duopoly market. On the other hand, it performs worse in the interaction with one single incumbent. We relate this finding to the incumbent responding more aggressively due to the altered distribution of profits. Besides this behavioral exception, experimental results are in line with the game theoretic predictions.
We conclude that small enterprises, for example local firms, that do not obtain a cost advantage, can use the judo (size) limitation as an entry strategy to avoid a price war. The basic necessity thereby is a credible capacity limitation by e.g. concentrating on a specific part of the market or a limited number of machines. We have also shown that the judo strategy can be applied to various problems, including competition among sales representatives or politicians.
Our study does, however, incorporate some limitations, e.g. the assumption of homogeneous products, pure price competition and quasi one-shot games.

In the discussion of our implications, we have seen that product differentiation may alter the entrant-incumbent competition. Moreover, the incumbent usually obtains a set of instruments to respond entry. Advertising is hereby the most common instrument.
Finally, to capture a more realistic picture of market situations, market dynamics or market growth as in Shen and Villas-Boas (2010) is further to be analyzed. Our one shot-game might therefore be extended to a multi-period game after entry to evaluate the entry strategies in the long run. Analyzing empirical data, Geroski (1995) for example reports that most entrants are driven out of the market again after entry. Moreover, it takes quite a lot time until a successful entrant reaches the size of an average incumbent. Our experimental design can be easily adapted to study the sustainability of a judo entry strategy.

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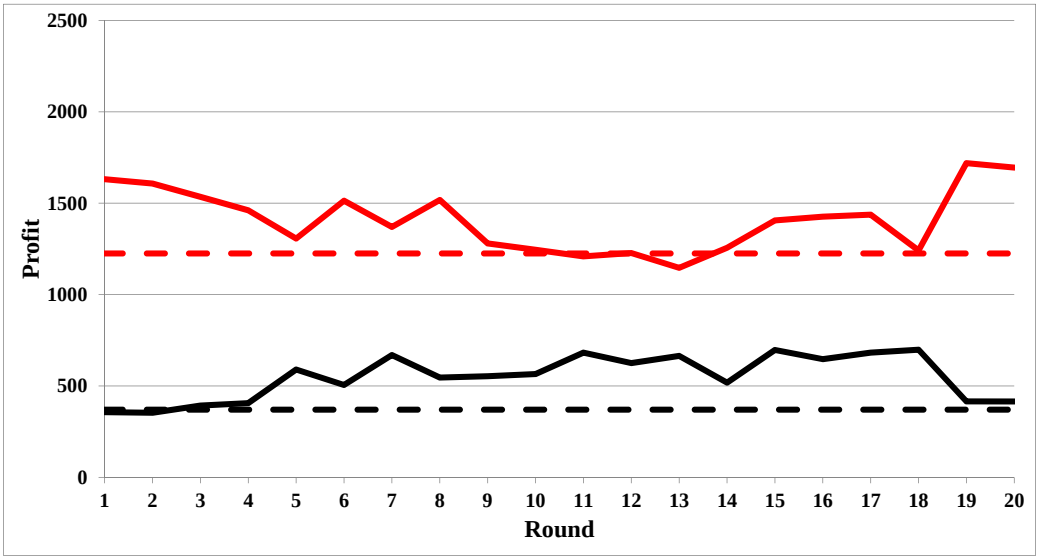
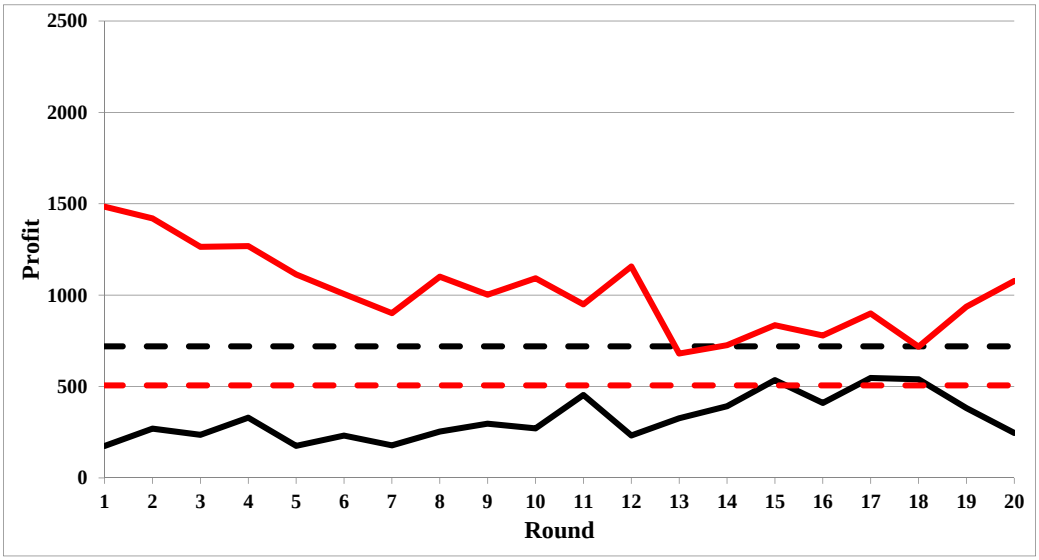
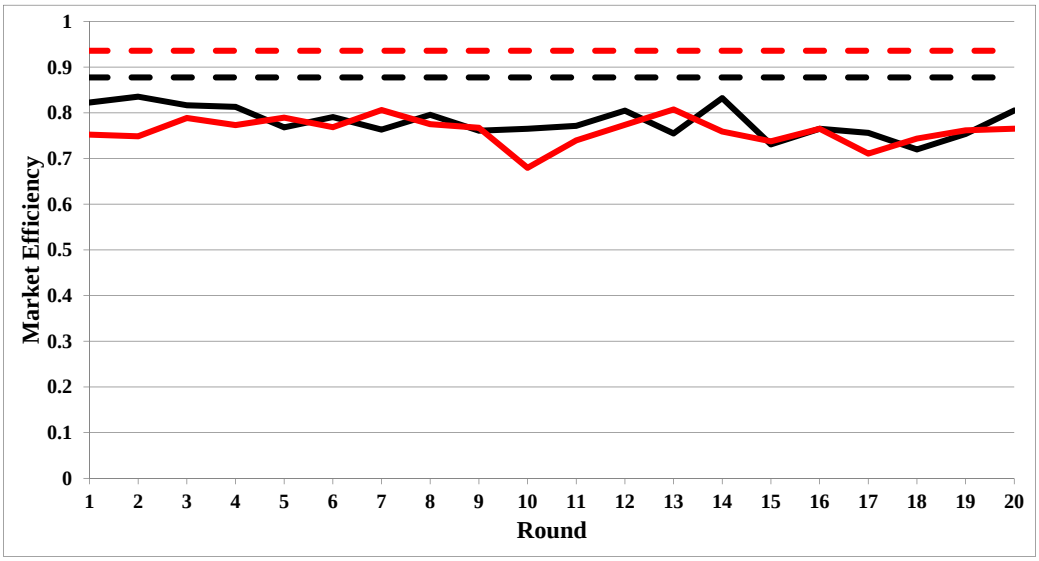


(a) SYM1

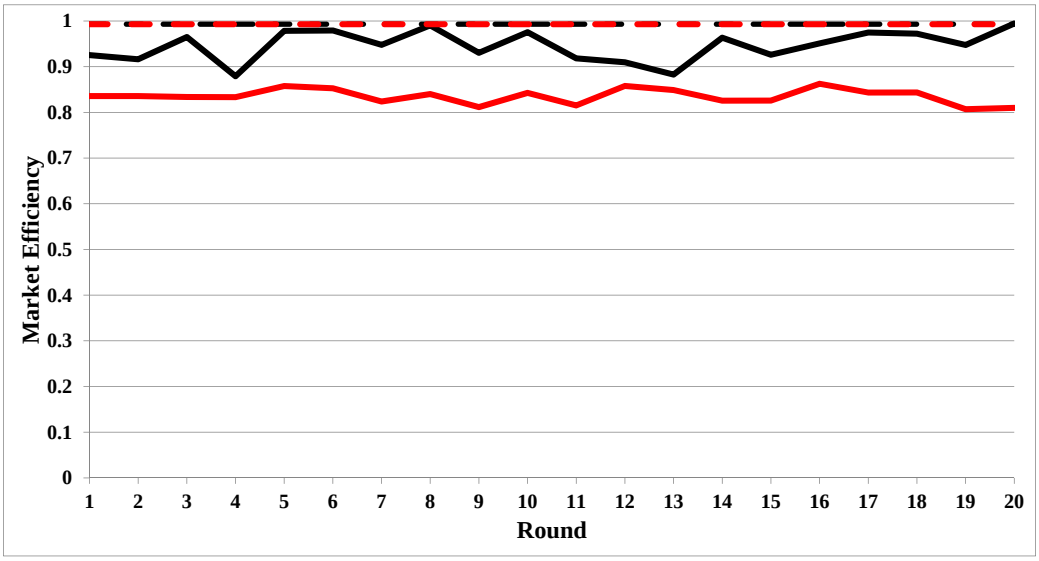


(b) ADV1

Figure 11: Average profits - small firm (black solid line) vs. dominant firm (red solid line) vs. predictions (dashed lines)



(a) SYM1 vs. ADV1



(b) SYM2 vs. ADV2

Figure 12: Average efficiency - symmetric treatments (black solid lines) vs. asymmetric treatments (red solid lines) vs. predictions (dashed lines)