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Coexistence of small and dominant firms in Bertrand competition: Judo economics in the lab

by Daniel Cracau* and Abdolkarim Sadrieh†

Abstract

The theory of "Judo Economics" describes an optimal entry strategy for small firms. Using a capacity limitation, small firms force dominant market incumbents to accommodate. In this article, we study the power of Judo economics as an entry strategy in different market environments. We find experimental evidence supporting the theory in the original setting with a monopolistic, dominant market incumbent. When we introduce a cost advantage for small firms, profits go down. This can be explained by incumbents responding aggressive towards large entrants. For settings with multiple market incumbents, results are reversed. There, a cost advantage strengthens small firms and pricing below the incumbents' marginal cost provides the unique entry strategy.

Keywords: Judo economics; Market entry; Price competition; Capacity limitation; Experimental economics

JEL: D43; L11

"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). In their study, a market entry game is analyzed where a single entrant faces a monopolistic incumbent. Assuming products are not differentiated, the incumbent's cost of production is not higher, and the incumbent has loyal customers, she always has the possibility to match the entrant's price without making losses or losing customers to him.[1] Potential entrants can thus always be deterred. In case of a credible capacity limitation, however, accommodating instead of deterring his entry may actually be the optimal strategy for the incumbent. If the entrant commits himself to serve only a part of the customers at a low price, the incumbent is better off giving up those customers than serving all customers at the entry deterrence price. Hence, using a strict capacity limitation, the entrant can expect to be accommodated.

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[1] W.l.o.g. we use female pronouns for the dominant incumbents and male pronouns for the small entrants.

The obvious asymmetry between the two firms in the Judo model can also be observed in real market interactions, because it captures market settings with a dominant (global) firm and a small (local) competitor.[2] Small firms limit their sales to avoid competition with dominant 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) presents the story of Kiwi Airlines that 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 article, we combine a game theoretic model based on Gelman and Salop (1983) with an experimental approach, comparing four different market settings. Our results show that as predicted for the original framework with equal cost and one dominant firm, the majority of small firms limit their capacity and are accommodated. In many cases, both firms even achieve higher payoffs than in equilibrium due to tacit collusion on prices. When the small firms have a cost advantage, their observed payoffs are lower than in the symmetric setting. This is surprising, since their cost advantage theoretically provides a greater market power. When we replace the single monopolist by a competition between two dominant firms, we find that small firms without a cost advantage are more likely to be deterred. Small firms with a cost advantage, facing two competing dominant firms, are able to utilize their market power but cannot achieve payoffs that go beyond the equilibrium predictions. Hence, our results in both settings with competition amongst two dominant firms are in line with theory.

2 Related literature

Most of the literature on market entry focuses on market incumbents' strategies to deter entry. Dixit (1979) analyzes competition between an established firm and a potential market entrant. The game is modeled as a sequential quantity competition, where the established firm acts as a leader. 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 accommodation being the optimal strategy for the incumbent. In an extension of his basic model, Dixit (1980) points 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.

[2] In this article, we will mainly use the label *small firms* and *dominant firms* to refer to entrants and incumbents, which are the terms used in Gelman and Salop (1983).

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. Since 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. The similarity of the Fudenberg and Tirole (1984) model and the Gelman and Salop (1983) model is that the incumbent has a tradeoff between asking high prices from the customers that she retains after entry and reducing prices for all customers to keep the entire market.

The core idea of Judo has also been extended to more elaborate settings. The Judo outcome in competitive as well as cooperative settings has been acknowledged. Sørgard (1995), for example, analyzes the basic model of Gelman and Salop (1983), but assumes a repeated pricing game after the initial entry decision. Assuming the entrant expects the incumbent's response to be collusive, the entrant will not limit his capacity to make the non-collusive outcome less attractive for the incumbent. Allen et al. (2000) analyze sequential capacity choice before a simultaneous price competition. Assuming the incumbent has a cost advantage, they derive that the she installs a capacity to induce the Judo equilibrium. 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 that corresponds a Judo strategy. Dechenaux and Kovenock (2011) study infinetely repeated simultaneous price and quantity competitions. They show that a stationary perfect equilibrium exists in which the small firm limits both its prices and its capacity and the dominant firm acommodates. This result underlines that Judo-type equilibria are not only relevant for one-shot games but also for repeated games.

Most experiments on market entry focus on the coordination between potential entrants (without incumbents) 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 accommodation is more beneficial. Since the history of monopolists' responses is observable, the entrants' decision can be based on the monopolists' reputation. Experimental results show that weak monopolists use predatory pricing to imitate stronger ones and manage to deter entry in later periods.[3]

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 support for the Judo concept,

[3] Former experimental results are ambiguous, e.g. Harrison (1988) reports predatory pricing whereas Isaac and Smith (1985) failed to observe it in various settings where they had expected it.

where incumbents respond less aggressively towards small scale entrants than to large entrants.

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). We assume that a dominant firm serves the market as a monopolistic incumbent. A second, small firm can decide to enter the market with a homogeneous good. We assume that the marginal cost c is constant and equal for both firms. W.l.o.g. we set $c = 0$. Consumers' preferences are assumed to be lexicographical, i.e. the low price product is preferred, but if 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 small firm and one dominant firm with symmetric cost, entry is always accommodated.*

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 his capacity.[4] 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 $\bar{p}_{SF}$ and capacity $\bar{k}$, the dominant firm may either match the small firm's price ($p_{DF} = \bar{p}_{SF}$) or accommodate ($p_{DF} > \bar{p}_{SF}$). In the first case, the dominant firm serves the entire market at the price $\bar{p}_{SF}$ and has a profit of $\pi_{DF}^{match}(p_{DF}) = p_{DF}D(p_{DF}) = \bar{p}_{SF}D(\bar{p}_{SF})$. In the second case, the dominant firm serves only the residual demand and therefore maximizes its profit $\pi_{DF}^{accom}(p_{DF}) = p_{DF}\left(D(p_{DF}) - \bar{k}\right)$ with $p_{DF} > \bar{p}_{SF}$.[5] As the small firm has to ensure that entry is accommodated, it must choose a pair (p_{SF}, k) that fulfills the condition $\pi_{DF}^{match} \leq \pi_{DF}^{accom}$, 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_{SF} that fulfills the condition for each k. Then, the small firm's optimization calculus can be written as:

$$\begin{aligned} \pi_{SF}(p_{SF}, k) &= p_{SF}k \quad \rightarrow \quad max! \\ w.r.t. \quad p_{SF} &\leq \phi(k) \end{aligned} \tag{1}$$

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

[5] 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.

Gelman and Salop (1983) show that the constraint holds with equality in equilibrium. The condition for the optimal capacity k^* is $0 = \phi(k^*) + k^*\phi'(k^*)$. This determines equilibrium prices $p^*_{SF} = \phi(k^*)$ and also $p^*_{DF} = argmax\ \pi^{accom}_{DF}(k^*)$. □

3.2 Monopoly with Entry and Asymmetric Cost

This setting is similar to the aforementioned, except that the dominant firm faces a cost disadvantage $c_{DF} > c_{SF} = 0$.

Proposition 2. *In the non-cooperative equilibrium with one small firm and one cost-disadvantaged dominant firm, entry is always accommodated.*

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 ($p_{SF} < c_{DF}$), forcing accommodation. This leaves us with two candidates for equilibrium in this game (Cracau, 2013). One possibility is that the small firm chooses the corner solution in which it sets a price just below the marginal cost of the dominant firm ($p_{SF} = c_{DF} - \epsilon$), serving the entire market up to its maximum capacity, i.e. $k = \min[k^{max}; D(c_{DF})]$ 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 dominant firm ($p_{SF} > c_{DF}$) 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 $(c_{DF} - \epsilon)\min[k^{max}; D(c_{DF})] > p^*_{SF}k^*$. In either case, the dominant firm accommodates entry and maximizes its profit as a monopolist for the residual demand. □

3.3 Duopoly with Entry and Symmetric Cost

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

Proposition 3. *In the non-cooperative equilibrium with one small firm and two dominant firms with symmetric cost, entry is always deterred.*

Proof. The two dominant firms ($DF = DF1, DF2$) face a Bertrand competition without capacity constraints. As we assume zero marginal cost for all firms, in any equilibrium $p_{DF1} = p_{DF2} = 0$. Because $0 > p_{SF}$ is not feasible, the dominant firms do not accommodate entry. Hence, all firms have zero profits in equilibrium. □

3.4 Duopoly with Entry and Asymmetric cost

This setting is similar to the aforementioned, except that the dominant firms face a cost disadvantage $c_{DF1} = c_{DF2} = c_{DF} > 0$.

Proposition 4. *In the non-cooperative equilibrium with one small firm and two symmetrically cost-disadvantaged dominant firms, entry is always accommodated.*

Proof. The decisive difference to the case with symmetric cost is, that the small firm can set a price below the dominant firms' marginal cost, forcing accommodation. In contrast to the monopoly case with asymmetric cost, the only option the small firm has in equilibrium is to undercut the dominant firms by choosing a price $p_{SF} = c_{DF} - \epsilon$ and serving the entire market up to its maximum capacity, i.e. $k = \min[k^{max}; D(c_{DF})]$. Entry and accommodation at a higher price is not an option, due to the tough competition between the dominant firms. In equilibrium, the dominant firms set their Bertrand price $p_{DF1} = p_{DF2} = c_{DF}$ and share the residual demand. Thus, the dominant firms' equilibrium profits are zero. □

4 Experimental Design

4.1 Treatment parameters

Our experiment includes 4 treatments in a 2x2-factorial design, corresponding to the four models that we discussed in the previous section. We vary the number of dominant firms in the market on the one hand and the marginal cost of the dominant firms on the other hand. The first treatment *SYM1* tests the original model of Gelman and Salop (1983). In the second treatment *ADV1*, we introduce a cost disadvantage for the monopolist in the framework of the original model. In the third treatment *SYM2*, we study situation analogous to *SYM1* but with competition among two dominant firms. Finally, in the fourth treatment *ADV2*, we combine both variations, introducing a cost disadvantage for the two dominant 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.[6]

4.2 Experimental Procedure

For each treatment we collected 6 or 7 independent observations (see Table 1). In each session, the game is 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. Subjects were mainly students of economics and management.

The experimental software was programmed in z-Tree of Fischbacher (2007). We implemented a

[6] Due to player's discrete strategy spaces, predictions slightly differ from the equilibria described in Section 3. Note that in *ADV2*, $p_{SF} = 9$, $k = 50$ and $p_{DF} = 10$ is also an equilibrium yielding $\pi_{SF} = 450$ and $\pi_{DF} = 0$. This equilibrium is, however, payoff-dominated.

Table 1: Overview of treatment parameters

Treatment	*SYM1*	*ADV1*	*SYM2*	*ADV2*
No. of DFs	1	1	2	2
Cost structure	$c = 0$	$c_{DF} = 10$, $c_{SF} = 0$	$c = 0$	$c_{DF} = 10$, $c_{SF} = 0$
p^*_{SF}	14	16	[1;100]	10
k^*	30	45	[1;50]	50
p^*_{DF}	35	23	1	11
π^*_{SF}	370	720	0	500
π^*_{DF}	1225	506	50	20
independ. obs.	7	7	6	7

sequence of decisions 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 dominant 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 firms entered their price 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 without the small firm, i.e. 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 *SYM1* and *ADV1*, the dominant firm had to decide on its price and served the market as a monopolist. The monopoly price $p^M_{SYM1} = 50$ or $p^M_{ADV1} = 55$ is therefore the profit maximizing prediction in these treatments. In *SYM2* and *ADV2* the small firm observed a price competition among the two dominant firms. The corresponding benchmark is $p_{DF1} = p_{DF2} = 1 \approx p^B_{SYM2}$ or $p_{DF1} = p_{DF2} = 11 \approx p^B_{ADV2}$, respectively.

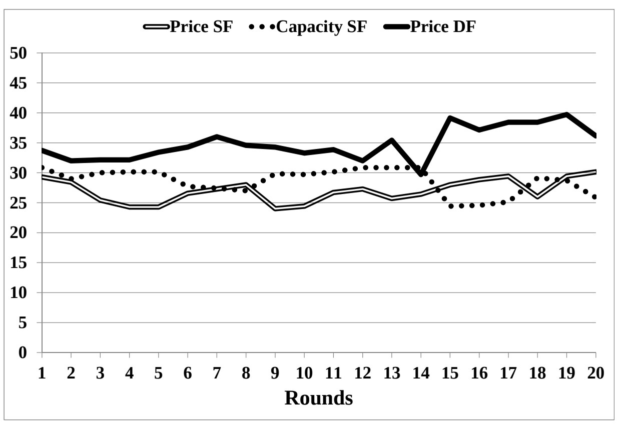
In a second set of 20 practice rounds with the small firm, we assigned a fixed capacity that was randomly drawn from $[1; 50]$ to the small firm. Other than the fact that the small firm had no capacity choice, the rest of the game in the practice rounds with the small firm was identical to the Judo game described above.

After the experiment, the subjects were paid anonymously. Their total payoffs consisted of a show-up fee plus the earnings from the practice rounds 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 rounds 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.[7]

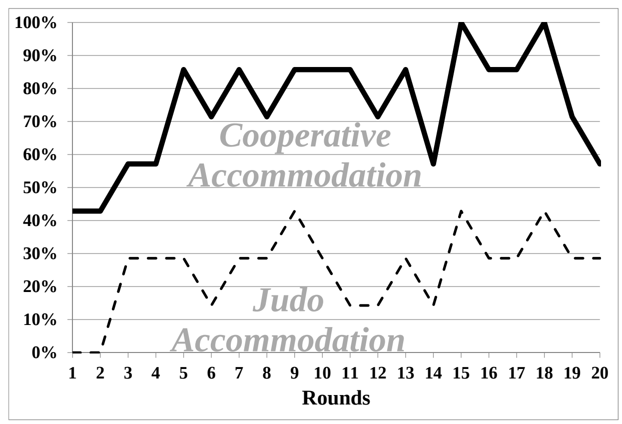
5 Results

We use the first set of practice rounds without the small firm to check the consistency of the behavior with the results of previous experiments reported in the literature. In the monopoly stages, 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 stages, we observe an initial cooperation at about two thirds of monopoly prices and profits that sharply decline over time. This is in line with previous results on Bertrand duopolies showing that cooperation rates can be high but often fall over time (Dufwenberg and Gneezy, 2000; Kübler and Müller, 2002).

5.1 Playing Judo against a monopolistic dominant firm



(a) Subject's decision variables



(b) Accommodation rate

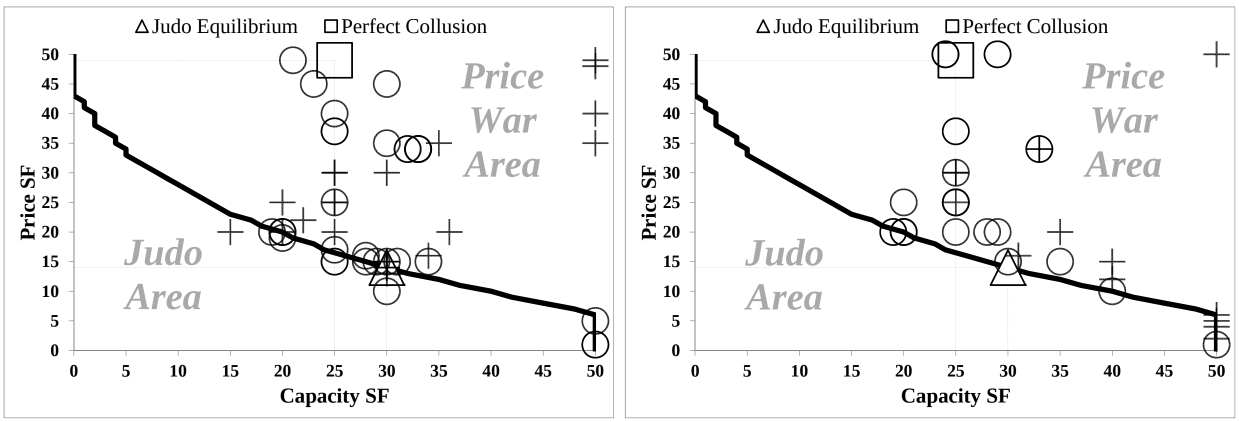
Figure 1: SYM1 — Market development over time

Figure 1 shows the development of the decision parameters over time in *SYM1*. As can be seen in the left panel, the dominant firms' average price lies almost perfectly at the equilibrium price 35 with a slight tendency to rise in the last five rounds. Similarly, the small firms' average capacity choice is almost perfectly at the equilibrium capacity of 30 throughout the experiment. The small firm's average price, however, is significantly higher than the predicted equilibrium price of 14 with no trend over time (Wilcoxon Signed Ranks test, $p = 0.016$). This is surprising on the first sight, because two of the three decision parameters seem in line with the equilibrium prediction while the third is clearly out of equilibrium. It seems that the dominant firms are not only accommodating the small firms as predicted by the equilibrium but are even willing to accept higher prices that allow a

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

long term cooperation. In the last five rounds, dominant firms seem to be reaping the advantages of the cooperative play by setting higher than equilibrium prices. The accommodation rate, shown in the right hand panel of Figure 1, supports this interpretation of increasing accommodation. While the accommodation rate is below 50% in rounds one and two, it quickly rises to above 80% and peaks to 100% at the end of the experiment.[8] This development is based on an increase of Judo accommodation, i.e. accommodations towards Judo-type small firms as well as on an increase of cooperative accommodation, i.e. accommodations that are not best responses.

Result 1. *In SYM1, the accommodation rate significantly increases over time. This is a result of both increasing Judo-type accommodation and cooperative accommodation.*



(a) First 10 periods

(b) Last 10 periods

Figure 2: SYM1 — Small firms' capacity and price choices and dominant firms' responses: accommodations (circles) vs. non-accommodations (crosses)

Since the small firms' average behavior is stable over time, the question is, why accommodation rates rise so sharply. We find an answer to this question in Figure 2 that displays the distribution of the decisions of the small firms in the capacity-price space. The left panel displays the decisions in the first 10 rounds while the right panel displays the decisions in the last ten rounds. A cross in the figure marks a small firm's capacity-price choice to which the dominant firm responds by matching or undercutting the small firm's price (i.e. the dominant firm gives a "price war" response). A circle in the figure marks a capacity-price choice that is accommodated by the dominant firm (i.e. the dominant firm does not match or undercut the small firm's price). To organize the data, we have added a curve depicting the *Judo frontier* 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

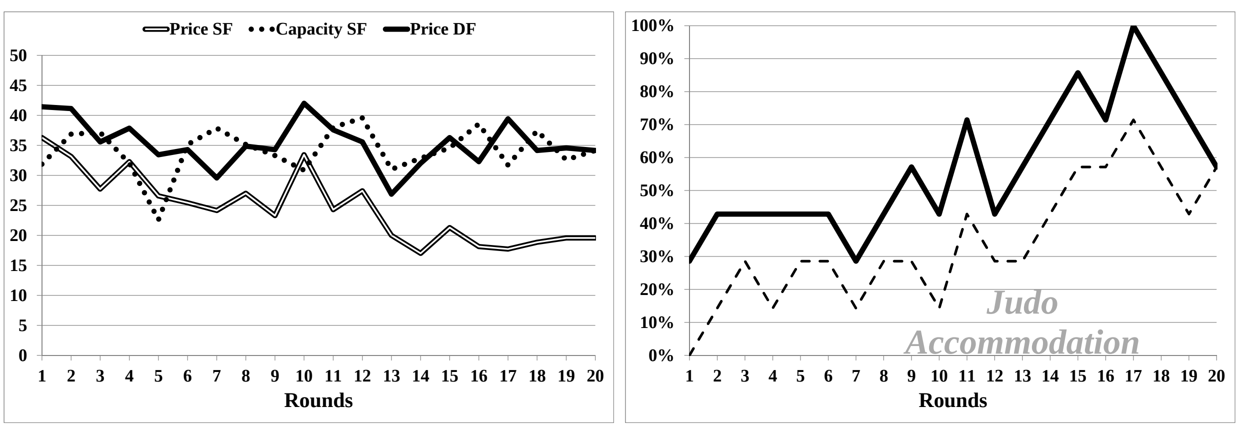
[8] As in previous experimental studies with a finite horizon, we observe an "end effect," i.e. a drop in cooperation in the last round (Argenton and Müller, 2012).

a profit maximizing dominant firm. In contrast, the best response to any combinations above the Judo frontier is to match the price of the small firm.

The majority of the small firms' decisions lies between the Judo prediction and the perfect collusion outcome in which both firms split monopoly profits (nearly) equally. A visual inspection of the two panels in Figure 2 indicates that accommodation is more likely for capacity-price decisions that are either in the Judo area or include capacities close or below the Judo capacity. This visual impression is supported by the statistics in Table 2. While almost 80% of the capacity-price decisions (over all rounds in all sessions) that are in the Judo area are accommodated, the percentage falls to about 72% for the decisions outside the Judo area, but below the Judo capacity, and to 60% of those outside the Judo area and above the Judo capacity. All in all, it is clear that accommodation is related to the strategic limitation of the capacity by the small firms.

Table 2: SYM1 — Responses of the dominant firm

	In Judo area	Outside Judo area $\left(k \leq k^{Judo}\right)$	Outside Judo area $\left(k > k^{Judo}\right)$	Total
Accommodation	79.6%	72.1%	60.0%	74.3%
No accommodation	20.4%	27.9%	40.0%	25.7%
Total	31.4%	47.6%	25.0%	100%



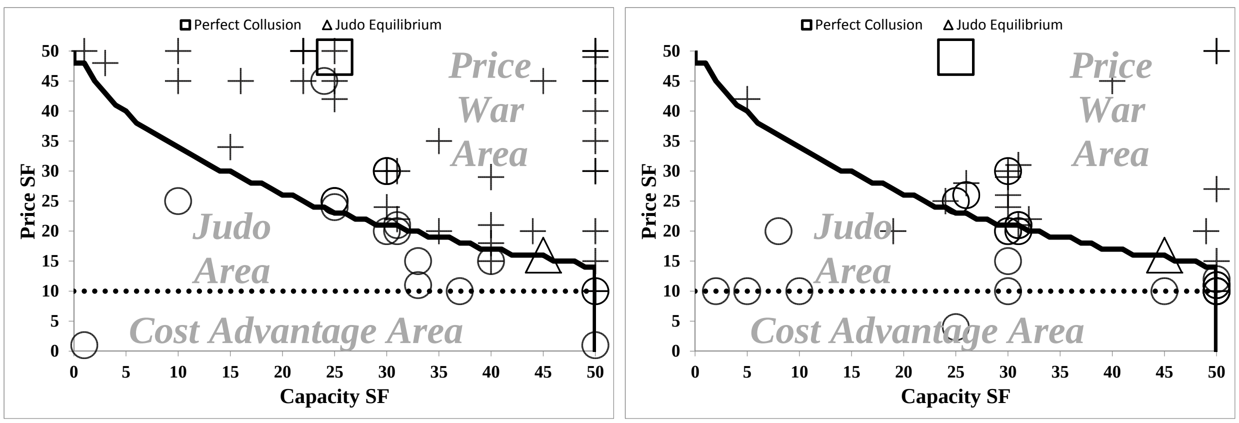
(a) Subject's decision variables

(b) Accommodation rate

Figure 3: ADV1 — Market development over time

Figure 3 shows the development of the decision parameters over time in *ADV1*. As can be seen in the left panel, the dominant firms' average price lies significantly above the equilibrium price 23 with no trend in time (Wilcoxon Signed Ranks test, $p = 0.016$). In contrast, the small firms' average capacity choice is significantly below the equilibrium capacity of 45 throughout the experiment (Wilcoxon Signed Ranks test, $p = 0.016$). The small firm's average price, is significantly higher than the predicted equilibrium price of 16 but shows a sharp, significant decline over time (Wilcoxon Signed Ranks test, $p = 0.031$). The accommodation rate, shown in the right panel of Figure 3, is below 50% in the first rounds, but significantly increases over time and peaks at 100% towards the end of the experiment. A closer look at the accommodation rate indicates that this development - in contrast to *SYM1* - is mainly based on an increase of Judo accommodations.

Result 2. *In ADV1, the accommodation rate significantly increases over time. This is a result of increasing self-restriction by small firms.*



(a) First 10 periods

(b) Last 10 periods

Figure 4: ADV1 — Small firms' capacity and price choices and dominant firms' responses: accommodations (circles) vs. non-accommodations (crosses)

In Figure 4, we display the Judo area for *ADV1* and also add a cost advantage area that includes all prices below the marginal cost of the dominant firm. In the left panel, we see that the majority of price-capacity decisions outside the Judo area are not accommodated. In contrast, the right panel (exhibiting the last ten rounds) shows markably less decisions outside the Judo area. This supports our finding of increased accommodation due to an increased tendency of the small firms to limit their capacities and prices. Table 3 summarizes the entry and accommodation decisions in *ADV1*. As in *SYM1*, we find the highest percentage of accommodations in the Judo area. Small firms with price-capacity pairs outside the Judo area are only accommodated if their capacity is below the equilibrium prediction. It seems that the small firms try to use their cost advantage to enter the market on a large scale. In turn, the dominant firm refuses cooperation and matches the small firm's price in most of the cases. Thus, the cost asymmetry that is to the advantage of the small firm from a game theoretic point of view behaviorally goes against it.

To study the effect of price and capacity choice and the cost advantage on the accommodation decision of the dominant firms in more detail, we run a random-effects logit regression with accommodation as the dependent variable. The results are given in Table 4. As expected, both the price and the capacity of the small firm have a negative impact on accommodation by the dominant

Table 3: ADV1 — Responses of the dominant firm

	In Judo area	Outside Judo area $\left(k \leq k^{Judo}\right)$	Outside Judo area $\left(k > k^{Judo}\right)$
Accommodation	88.2%	83.7%	2.1%
No accommodation	11.8%	16.3%	97.9%
Total	17.8%	26.4%	32.9%

	In cost advantage area	Total	
Accommodation	81.2%	57.1%	
No accommodation	18.8%	42.9%	
Total	22.9%	100%	

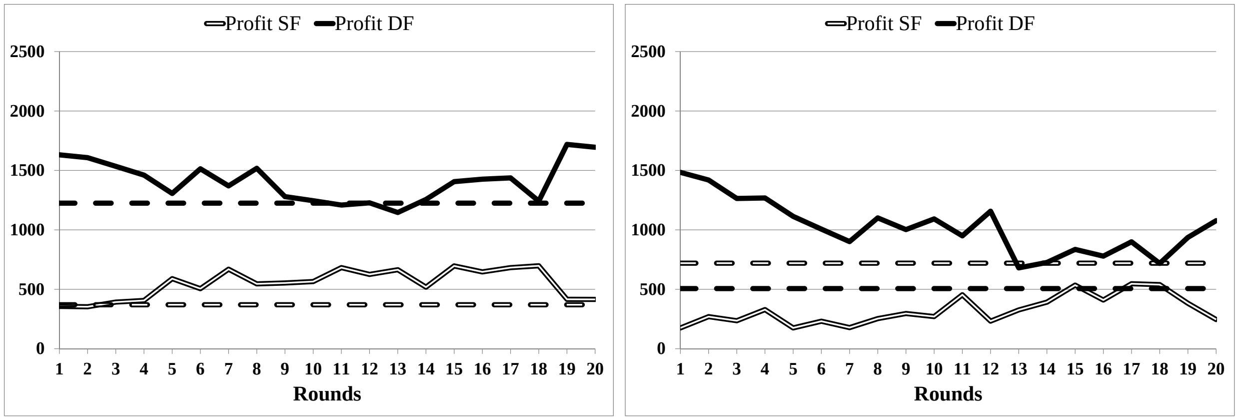
Table 4: Judo in a Monopoly — Regression results
Random-effects logit regression with accommodation
as the dependent variable.
(Wald $\chi^2 = 64.50$, $p = 0.0000$)

	Coefficient	Standard error	Z	$P > \|Z\|$
Constant	10.76722	1.32189	8.15	0.000
p_{SF}	−0.18220	0.02307	−7.90	0.000
k	−0.14602	0.02327	−6.28	0.000
ADV	−1.32469	0.94098	−1.41	0.159

firm. The coefficient of the dummy for the advantage treatment is negative but not significant. Hence, the treatment effect seems to be fully contained in the different price and capacity choices of the small firm. There is obviously no additional effect of the treatment that only influences the dominant firms accommodation choices.

Result 3. *In the monopoly treatments, the accommodation rate is significantly higher for small firms that limit capacity and choose low prices.*

We present an overview of the observed profits in the monopoly treatments in Figure 5. In *SYM1*, firms profits are above the Judo equilibrium prediction resulting from cooperative behavior in pricing. As can be seen in Table 5, this cooperation is effective in 71% of the cases for the small firm, in 70% for the dominant firm, in 49% for both. In contrast, the small firms in *ADV1* hardly manage to achieve above equilibrium profits (only in 9% of the cases). This finding is supported by the right panel of Figure 5 that shows that the small firms' profits are dramatically lower in *ADV1* than in *SYM1*. Note, however, that the small firms' profits are increasing over time in *ADV1*, coming closer to the equilibrium level towards the end of the experiment. Correspondingly, the dominant firms profits in *ADV1* decrease over time, also getting closer to the equilibrium level.



(a) SYM1 (b) ADV1

Figure 5: Average profits over time: small firms (transparent line) vs. dominant firms (solid line) vs. predictions (dashed lines)

These observations are well in line with the finding that the small firms reduce their prices over time in *ADV1* and are increasingly accommodated by the dominant firms.

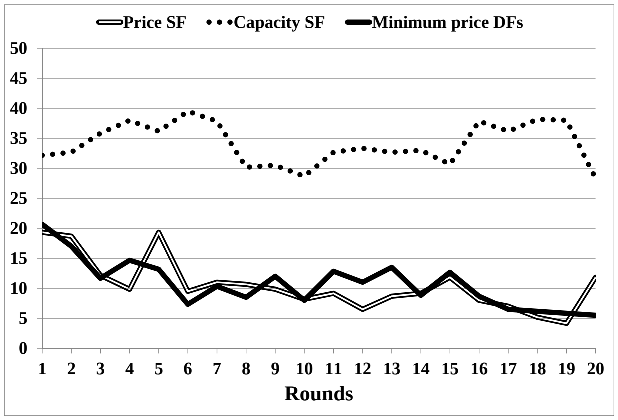
Table 5: Percentage of profits at least at the Judo prediction (accommodations only in parentheses)

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

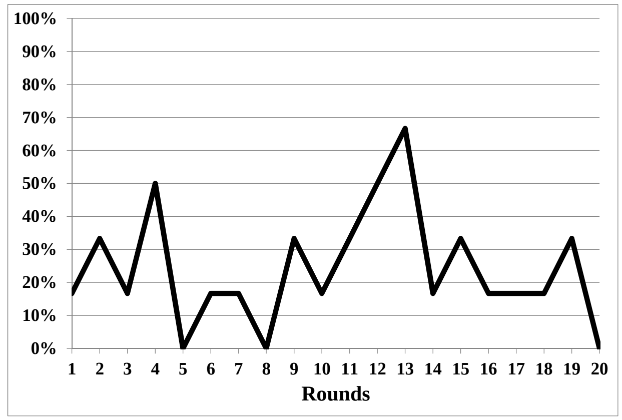
Result 4. *In SYM1, both small and dominant firms earn significantly more than in the Judo equilibrium. In ADV1, small firms earn significantly less while dominant firms earn significantly more than in the Judo equilibrium, but earnings approach equilibrium levels over time.*

5.2 Playing Judo against two dominant firms

Figure 6 displays the market dynamics in *SYM2*. We see that the prices of both firms are significantly decreasing over time. However, the prices remain significantly above the Bertrand prediction. The capacity of the small firm shows no trend in time. The accommodation rate also shows no significant trend over time. Note that in *SYM2* accommodation is never a best response, i.e. all observed accommodations are evidence for some extent of cooperative behavior. Figure 7 shows the price-capacity choices of the small firms and the accommodation decisions of the dominant firms in *SYM2*. Obviously, the small firm is only accommodated at very low price and capacity choices. In total, accommodation is only found in 24% of the observations, which is significantly less than

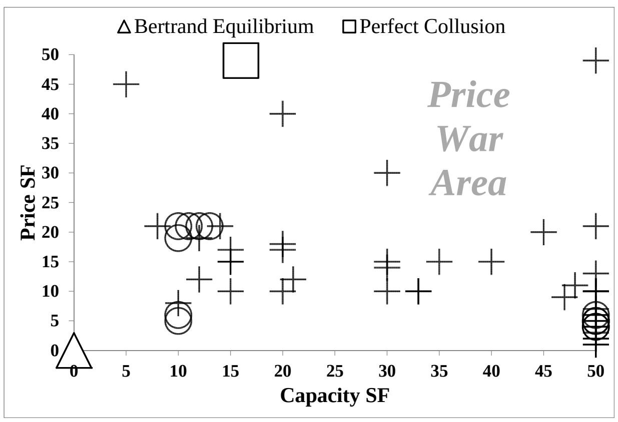


(a) Subject's decision variables

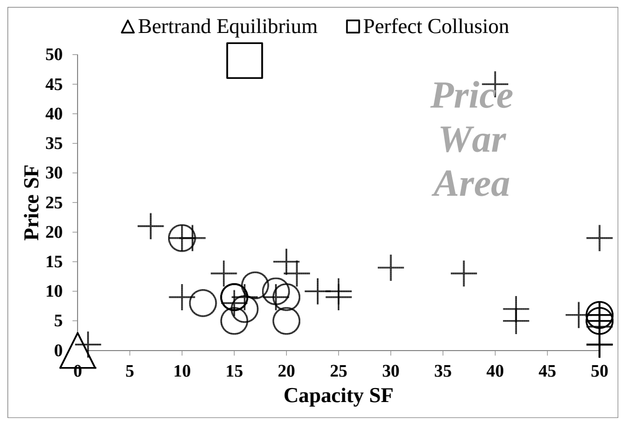


(b) Accommodation rate

Figure 6: SYM2 — Market development over time



(a) First 10 periods

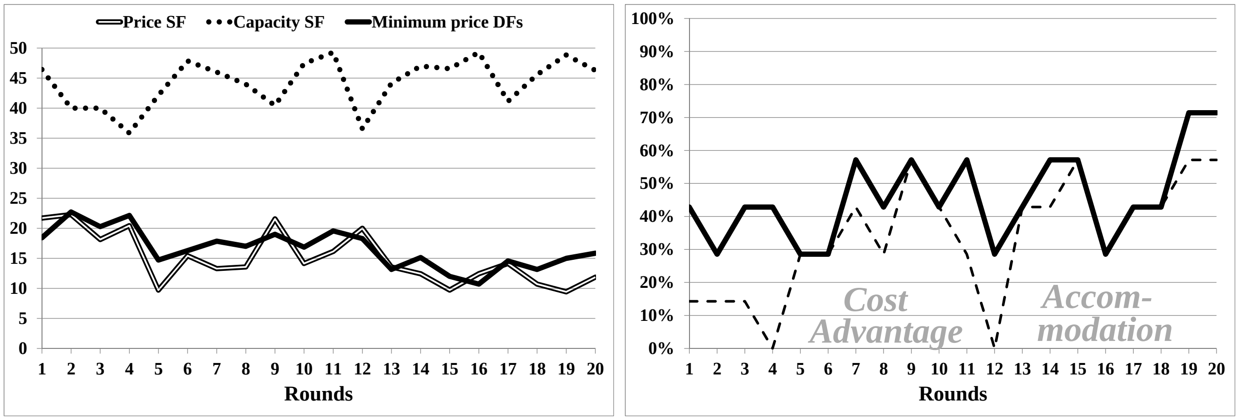


(b) Last 10 periods

Figure 7: SYM2 — Small firms' capacity and price choices and dominant firms' responses: accommodations (circles) vs. non-accommodations (crosses)

in *SYM1*.[9] For *ADV2*, the development of decision variables and accommodation rate over the 20 rounds is shown in Figure 8. As in *SYM2*, prices of all firms significantly decrease over time, approaching the equilibrium values. Note that in *ADV2* the predicted equilibrium price is at the marginal cost of the dominant firms. The capacities of the small firms in *ADV2* are generally close to the maximum capacity (50 units), which is higher than in all other treatments. From the right panel of Figure 8, we see that the accommodation rate slightly increases over time even though the small firms do not limit their capacities. This is due to fact that the small firms reduce their

[9] The low prices in *SYM2* are not due to the additional competition that arises from the small firm. Although a higher number of market competitors is typically expected to increase competition (Huck et al., 2004), the small firm in this treatment only amplifies the price and profit decline already observed in the duopoly practice rounds without a small firm.

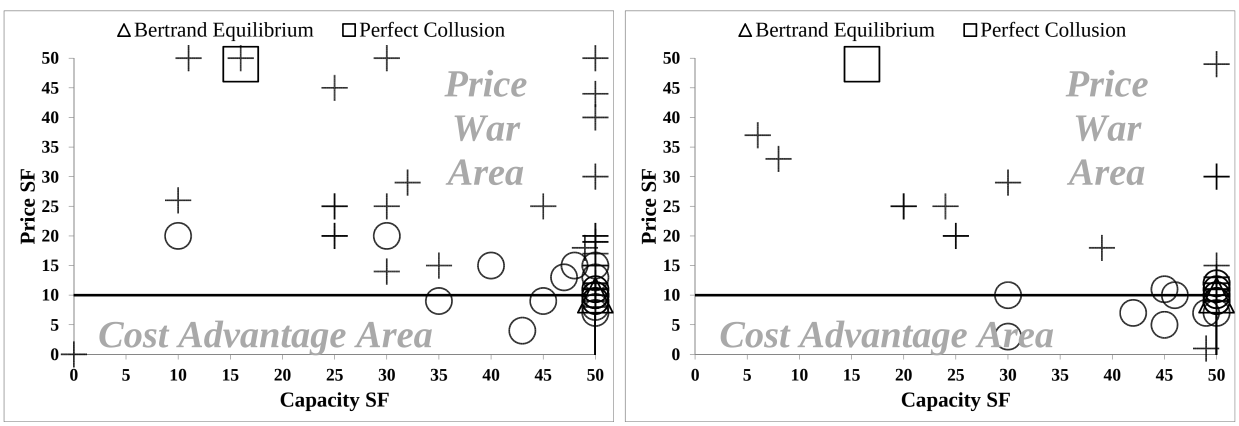


(a) Subject's decision variables (b) Accommodation rate

Figure 8: ADV2 — Market development over time

prices almost down to the marginal cost of the dominant firms, leaving them with no option, but to accommodate. Since accommodation is basically inevitable, one may conjecture that the dominant firms will increase cooperation over time. However, in line with the observed price decline in *SYM2* and earlier Bertrand duopoly results, prices tend to decline over time, even though accommodation is increased.

Figure 9 visualizes the price-capacity decisions in *ADV2*. We observe that - just as in *SYM2* –



(a) First 10 periods (b) Last 10 periods

Figure 9: ADV2 — Small firms' capacity and price choices and dominant firms' responses: accommodations (circles) vs. non-accommodations (crosses)

many small firms choose prices above the equilibrium price and are not accommodated. In the last rounds of the experiment (right panel of Figure 9), we can find the vast majority of small firms close to the equilibrium point, with capacity close to the maximum (50) and prices close to the marginal cost of the dominant firms (10). This corresponds to the observed price decline and the increasing accommodation rate. Table 6 displays the results of a random effects logit regression

Table 6: Judo in a Duopoly — Regression results
Random-effects logit regression with accommodation
as the dependent variable.
(Wald $\chi^2 = 26.98$, $p = 0.0000$)

	Coefficient	Standard error	Z	$P > \|Z\|$
$Constant$	0.84013	1.14821	0.73	0.464
p_{SF}	−0.21755	0.04479	−4.86	0.000
k	−0.01049	0.02201	−0.48	0.634
ADV	2.25456	0.92652	2.43	0.015

with accommodation as the dependent variable. Just as in the monopoly case, we find that the small firms prices have a strong and significantly negative influence on accommodation, with accommodation more likely the lower the chosen prices. However, unlike the observed behavior in the monopoly case, we find no effect of capacity choices on accommodation. Moreover, we find a positive and significant treatment effect, which is not surprising, because accommodation is the equilibrium behavior in *ADV2* but not in *SYM2*.

Result 5. *In the duopoly treatments, accommodation rate is significantly higher for cost-advantaged small firms. Accommodation is more likely, the lower the small firms price is, but it is not affected by capacity limitation.*

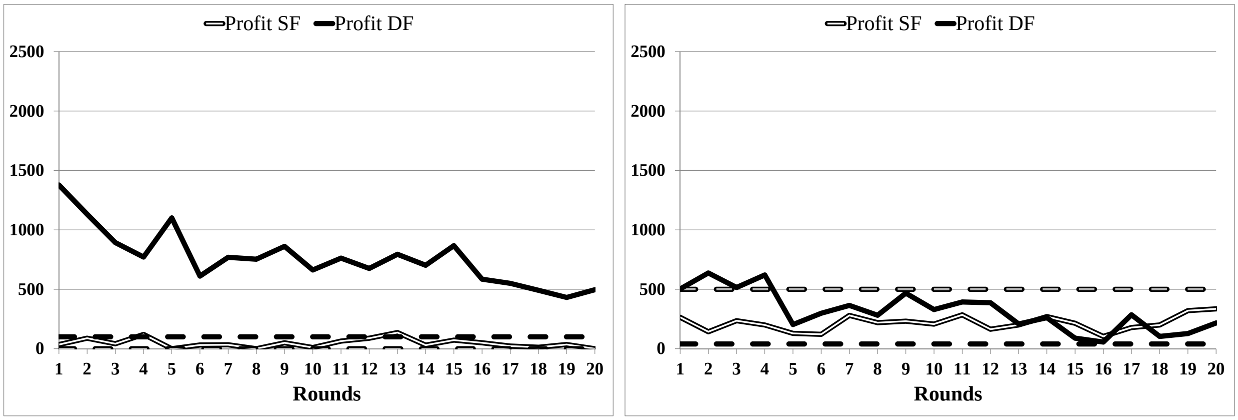
An overview of the development of profits in the duopoly treatments is presented in Figure 10. In the left panel, we see that the the small firms' profits in *SYM2* remain very close to the equilibrium prediction of zero profits. The dominant firms' profits lie significantly above the equilibrium prediction but show a significant negative trend.

The right-hand panel of Figure 10 shows the profits in *ADV2*. The small firms' profits are significantly lower than the equilibrium prediction of 500, whereas the dominant firms' profits are significantly higher than the equilibrium prediction. This is due to the fact that some small firms do not use their cost advantage to force accommodation and are not accommodated at higher prices. As a consequence, dominant firms can often serve a market that is larger than predicted.

Result 6. *In SYM2, both firms' profits are above the equilibrium level with the dominant firms' profits declining over time. In ADV2, small firms earn significantly less while dominant firms earn significantly more than in equilibrium.*

6 Discussion and economic implications

Our results indicate that capacity and price limitation as predicted by the Judo equilibrium can be a successful strategy for small firms to survive in a Bertrand competition with homogeneous goods. In the original Judo setting with one dominant monopolist and a small firm, the small



(a) SYM2

(b) ADV2

Figure 10: Average profits over time: small firms (transparent line) vs. dominant firms (solid line) vs. predictions (dashed lines)

firm's capacity limitation is not only rewarded with accommodation, but often leads to cooperative pricing above equilibrium.[10] Surprisingly, we observe significantly less cooperation when the small firm has a cost advantage. It seems that the expansive behavior of the small firm in the early rounds of this setting induce aggressive responses by the dominant firm and hampers cooperation. In contrast to the high degree of cooperation observed in the original Judo setting, we observe almost no cooperation in markets in which a small firm competes with two dominant firms. In these markets, small firms with a cost advantage are better off than those without, because they can survive with positive profits by choosing a price that cannot be matched by the dominant firms. Hence, while a cost advantage is a profit disadvantage in the competition with a single dominant firm, it is a profit advantage in the competition against multiple dominant firms.

Our behavioral results have important implications for small firms such as local companies competing against global market leaders. We find that a small firm facing a stiff price competition between dominant firms has no option but to seek cost leadership. If however, the small firm faces a high-price market, for example with a dominant monopolistic incumbent, pursuing cost leadership may be interpreted as aggressive behavior and may decrease the probability of accommodation by the dominant firm. In these "relaxed" markets, it seems more advantageous for the small firm to signal cooperation by limiting capacity.

This result may account for the fact that in markets such as transportation markets, in which a credible capacity limitation is easily achieved, we observe different strategies for small firms. In

[10] In fact, we observe more cooperation than in Kreps-Scheinkman-type settings (Kreps and Scheinkman, 1983) with symmetric duopolies (Anderhub et al., 2003). It seems that we observe more cooperation because the dominant firm in our setting reciprocates after having observed whether the small firm has limited capacity and priced high enough to signal cooperation. In the experiment by Anderhub et al. (2003), both capacity choices and both price choices are simultaneous, thus allowing for more strategic uncertainty and leading to less cooperation.

markets with a dominant incumbent, capacity (size) limitation provides a tool for small competitors to successfully coexist with the monopolistic dominant firm. DeCamp Bus Lines, for example, operates at a smaller scale than NJ Transit that dominates the market, offering a smaller number of bus trips per day from New Jersey to New York and charging slightly lower prices. NJ Transit in turn accommodates this small competitor as it remains a quasi-monopolist for the residual market. In other markets, where competition between market incumbents is already high, e.g. in the US airline market, we find small local competitors only surviving if they have a cost advantage. Allegiant Air for example operates at a small scale (less than 6 million passengers in 2010) compared to Delta Air Lines (more than 111 million passengers in 2010) and United Airlines (nearly 100 million passengers in 2010) but has a lower per passenger cost (in 2010, approximately 95 USD for Allegiant vs. 192 USD for Delta and 258 USD for United).[11] For the limited number of routes Allegiant Air serves, they use their cost advantage and offer prices below that of their dominant competitors.

While our study provides detailed insights in the competition behavior in a single market with small and dominant firms, more research is needed to analyze other market environments. A natural extension is the analysis of small firms competing against dominant firms that are active in multiple markets. Moreover, we could use our methodology to study behavior in environments that entail market growth as in Shen and Villas-Boas (2010). Another interesting aspect of market dynamics concerns the sustainability of competition after entry. Analyzing empirical data, Geroski (1995), for example, reports that most small firms are driven out of the market before they can reach the size of an average incumbent. Our appraoch can be easily adapted to study these and other sustainability aspects of oligopoly markets with competitors of different sizes.

Acknowledgements

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Experiment 1: Instructions

Welcome to the experiment!

From now on, please stop any communication and read the following information with great care. Questions will be answered after reading the instructions individually at your place.

The following experiment deals with the sale of goods. There is one well-established firm. Moreover, there is a new firm which enters the market.

- The experiment consists of 2 stages, which are played consecutively.
- At the beginning of the experiment, you are randomly assigned the role of the well-established firm or the new firm.
    - During the whole experiment, the assignment of roles remains fixed.
- At the beginning of the experiment, pairs of firms (1 well-established firm/1 new firm) are randomly assigned to the markets.
    - During the whole experiment, the assignment of the pairs is fixed.

Stage 1

First, 10 rounds will be played with the well-established firm being the sole firm in the market.

Activities of the new firm:

- If you were assigned the role of the new firm, you have no activities in this stage. However you can observe the well-established firm's decision on a sales price.

Activities of the well-established firm:

- If you were assigned the role of the well-established firm, you decide on your sales price in Taler.
    - Your sales price is integer from the interval **[0; 100]** Taler.

Round payoffs:

- The new firm earns **4500** Taler.
- Round payoff of the well-established firm:
  = **sales price X (100 – sales price)**

At the end of this stage, one round will be chosen randomly and this round determines the payoff of the well-established firm. (The exchange rate is: **1500 Taler = 1 Euro**.)

Stage 2

There will be **20 practice rounds**. Afterward, **20 rounds** will be played which are **payoff-relevant**. At the end of this stage, the sum of all round payoffs determines the total payoff for the well-established firm and the new firm. (The exchange rate is: **1500 Taler = 1 Euro**.)

Activities of the new firm:

- If you were assigned the role of the new firm, you decide on your sales price in Taler.
- Moreover you decide on your production capacity (= the maximum output you can sell.)
    - In the practice rounds, your production capacity will be assigned randomly.
    - In the payoff rounds, you decide on your production capacity.
    - Your sales price as well as your production capacity is integer from the interval **[0; 50]**.
- You can use a what-if calculator.

Activities of the well-established firm:

- If you were assigned the role of the well-established firm, you are informed about the decision of the new firm. You are informed about its sales price and its production capacity
- Afterward, you decide on your sales price in Taler.
    - Your sales price is integer from the interval **[0; 100]** Taler.
- A well-established firm has no capacity limitation.
- You can use a what-if calculator which already includes the decisions of the new firm.

Round payoffs:

Depending on the decisions of both players, two scenarios are possible:

Scenario A: The well-established firm has chosen a sales price which is equal to or below that of the new firm.

- Round payoff of the new firm
  = **0**
- Round payoff of the well-established firm:
  = **(sales price – 10) X (100 – sales price)**

Scenario B: The well-established firm has chosen a sales price which is above that of the new firm.

- Round payoff of the new firm
  = **sales price X capacity**
- Round payoff of the well-established firm:
  = **(sales price – 10) X (100 – capacity – sales price)**

Please note: negative payoffs are not considered.

Comprehension Questions:

Soon, you will see a what-if calculator on the screen. You can type in any sales price of the new firm, any production capacity of the new firm and any sales price of the well-established firm. Then, you can calculate the corresponding profits for both firms.

For the following 4 examples, please calculate the profit of the new firm and of the well-established firm and indicate whether this refers to scenario A or B.

Example 1

Price of the new firm:	35
Capacity:	42
Price of the well-established firm:	23
Profit of the new firm:	[ ]
Profit of the well-established firm:	[ ]
Scenario:	[ ]

Example 2

Price of the new firm:	45
Capacity:	16
Price of the well-established firm:	53
Profit of the new firm:	[ ]
Profit of the well-established firm:	[ ]
Scenario:	[ ]

Example 3

Price of the new firm:	10
Capacity:	37
Price of the well-established firm:	22
Profit of the new firm:	[ ]
Profit of the well-established firm:	[ ]
Scenario:	[ ]

Example 4

Price of the new firm:	11
Capacity:	14
Price of the well-established firm:	11
Profit of the new firm:	[ ]
Profit of the well-established firm:	[ ]
Scenario:	[ ]

Experiment 2: Instructions

Welcome to the experiment!

From now on, please stop any communication and read the following information with great care. Questions will be answered after reading the instructions individually at your place.

The following experiment deals with the sale of goods. There is one well-established firm. Moreover, there is a new firm which enters the market.

- The experiment consists of 2 stages, which are played consecutively.
- At the beginning of the experiment, you are randomly assigned the role of the well-established firm or the new firm.
    - During the whole experiment, the assignment of roles remains fixed.
- At the beginning of the experiment, pairs of firms (1 well-established firm/1 new firm) are randomly assigned to the markets.
    - During the whole experiment, the assignment of the pairs is fixed.
- Each player earns a **fix payoff** of **5 EURO**.

Stage 1

First, 10 rounds will be played with the well-established firm being the sole firm in the market.

Activities of the new firm:

- If you were assigned the role of the new firm, you have no activities in this stage. However you can observe the well-established firm's decision on a sales price.

Activities of the well-established firm:

- If you were assigned the role of the well-established firm, you decide on your sales price in Taler.
    - Your sales price is integer from the interval **[0; 100]** Taler.

Round payoffs:

- The new firm earns **1500** Taler.
- Round payoff of the well-established firm:
  = **(sales price – 10) X (100 – sales price)**

At the end of this stage, one round will be chosen randomly and this round determines the payoff of the well-established firm. (The exchange rate is: **1500 Taler = 1 Euro**.)

Stage 2

There will be **20 practice rounds**. Afterward, **20 rounds** will be played which are **payoff-relevant**. At the end of this stage, the sum of all round payoffs determines the total payoff for the well-established firm and the new firm. (The exchange rate is: **1500 Taler = 1 Euro**.)

Activities of the new firm:

- If you were assigned the role of the new firm, you decide on your sales price in Taler.
- Moreover you decide on your production capacity (= the maximum output you can sell.)
    - In the practice rounds, your production capacity will be assigned randomly.
    - In the payoff rounds, you decide on your production capacity.
    - Your sales price as well as your production capacity is integer from the interval **[0; 50]**.
- You can use a what-if calculator.

Activities of the well-established firm:

- If you were assigned the role of the well-established firm, you are informed about the decision of the new firm. You are informed about its sales price and its production capacity
- Afterward, you decide on your sales price in Taler.
    - Your sales price is integer from the interval **[0; 100]** Taler.
- A well-established firm has no capacity limitation.
- You can use a what-if calculator which already includes the decisions of the new firm.

Round payoffs:

Depending on the decisions of both players, two scenarios are possible:

Scenario A: The well-established firm has chosen a sales price which is equal to or below that of the new firm.

- Round payoff of the new firm
  = **0**
- Round payoff of the well-established firm:
  = **(sales price – 10) X (100 – sales price)**

Scenario B: The well-established firm has chosen a sales price which is above that of the new firm.

- Round payoff of the new firm
  = **sales price X capacity**
- Round payoff of the well-established firm:
  = **(sales price – 10) X (100 – capacity – sales price)**

Please note: negative payoffs are not considered.

Comprehension Questions:

Soon, you will see a what-if calculator on the screen. You can type in any sales price of the new firm, any production capacity of the new firm and any sales price of the well-established firm. Then, you can calculate the corresponding profits for both firms.

For the following 4 examples, please calculate the profit of the new firm and of the well-established firm and indicate whether this refers to scenario A or B.

Example 1

Price of the new firm:	35
Capacity:	42
Price of the well-established firm:	23
Profit of the new firm:	[ ]
Profit of the well-established firm:	[ ]
Scenario:	[ ]

Example 2

Price of the new firm:	45
Capacity:	16
Price of the well-established firm:	53
Profit of the new firm:	[ ]
Profit of the well-established firm:	[ ]
Scenario:	[ ]

Example 3

Price of the new firm:	10
Capacity:	37
Price of the well-established firm:	22
Profit of the new firm:	[ ]
Profit of the well-established firm:	[ ]
Scenario:	[ ]

Example 4

Price of the new firm:	11
Capacity:	14
Price of the well-established firm:	11
Profit of the new firm:	[ ]
Profit of the well-established firm:	[ ]
Scenario:	[ ]

Experiment 3: Instructions

Welcome to the experiment!

From now on, please stop any communication and read the following information with great care. Questions will be answered after reading the instructions individually at your place.

The following experiment deals with the sale of goods. There are two well-established firms. Moreover, there is a new firm which enters the market.

- The experiment consists of 2 stages, which are played consecutively.
- At the beginning of the experiment, you are randomly assigned the role of one of the two well-established firms or the new firm.
    - During the whole experiment, the assignment of roles remains fixed.
- At the beginning of the experiment, groups of firms (2 well-established firms/1 new firm) are randomly assigned to the markets.
    - During the whole experiment, the assignment of the pairs is fixed.

Stage 1

First, 10 rounds will be played with the well-established firms being the sole firms in the market.

Activities of the new firm:

- If you were assigned the role of the new firm, you have no activities in this stage. However you can observe the well-established firms' decisions on their sales prices.

Activities of the well-established firms:

- If you were assigned the role of the well-established firm, you decide on your sales price in Taler.
    - Your sales price is integer from the interval **[0; 100]** Taler.

Round payoffs:

- The new firm earns **3000** Taler.
- If both well-established firms have chosen the same sales price:
    - Round payoff of each well-established firm:
      = **0.5 X [(sales price – 10) X (100 – sales price)]**
- If the two well-established firms have chosen different sales prices:
    - Round payoff of the well-established firm with the low price:
      (sales price – 10) X (100 – sales price)
    - Round payoff of the well-established firm with the high price:
      = **0**

At the end of this stage, one round will be chosen randomly and this round determines the payoffs of the well-established firms. (The exchange rate is: **1000 Taler = 1 Euro**.)

Stage 2

There will be **20 practice rounds**. Afterward, **20 rounds** will be played which are **payoff-relevant**. At the end of this stage, the sum of all round payoffs determines the total payoff for the well-established firms and the new firm. (The exchange rate is: **1000 Taler = 1 Euro**.)

Activities of the new firm:

- If you were assigned the role of the new firm, you decide on your sales price in Taler.
- Moreover you decide on your production capacity (= the maximum output you can sell.)
    - In the practice rounds, your production capacity will be assigned randomly.
    - In the payoff rounds, you decide on your production capacity.
    - Your sales price as well as your production capacity is integer from the interval **[0; 50]**.
- You can use a what-if calculator.

Activities of the well-established firms:

- If you were assigned the role of the well-established firm, you are informed about the decision of the new firm. You are informed about its sales price and its production capacity
- Afterward, you decide on your sales price in Taler.
    - Your sales price is integer from the interval **[0; 100]** Taler.
- A well-established firm has no capacity limitation.
- You can use a what-if calculator which already includes the decisions of the new firm.

Round payoffs:

Depending on the decisions of the three players, 4 scenarios are possible:

Scenario A: Both well-established firms have chosen the same sales price. This sales price is equal to or below that of the new firm.

- Round payoff of the new firm
  = **0**
- Round payoff of each well-established firm:
  = **0.5 X [(sales price – 10) X (100 – sales price)]**

Scenario B: The two well-established firms have chosen different sales prices. The lower one of these sales prices is equal to or below that of the new firm.

- Round payoff of the new firm
  = **0**
- Round payoff of the well-established firm with the low price:
  = **(sales price – 10) X (100 – sales price)**
- Round payoff of the well-established firm with the high price:
  = **0**

Scenario C: The well-established firm has chosen the same sales price. This sales price is above that of the new firm.

- Round payoff of the new firm
  = **sales price X capacity**
- Round payoff of each well-established firm:
  = **0.5 X [(sales price – 10) X (100 – capacity – sales price)]**

Scenario D: The two well-established firms have chosen different sales prices. Both of these sales prices are above that of the new firm.

- Round payoff of the new firm
  = **sales price X capacity**
- Round payoff of the well-established firm with the low price:
  = **(sales price – 10) X (100 – capacity – sales price)**
- Round payoff of the well-established firm with the high price:
  = **0**

Please note: negative payoffs are not considered.

Comprehension Questions:

Soon, you will see a what-if calculator on the screen. You can type in any sales price of the new firm, any production capacity of the new firm and any combination of sales price of the well-established firms. Then, you can calculate the corresponding profits for all firms.

For the following 4 examples, please calculate the profit of the new firm and of each well-established firm and indicate whether this refers to scenario A, B, C or D.

Example 1

Price of the new firm:	35
Capacity:	42
Price of the well-established firm 1:	23
Price of the well-established firm 2:	23
Profit of the new firm:	[ ]
Profit of the well-established firm 1:	[ ]
Profit of the well-established firm 2:	[ ]
Scenario:	[ ]

Example 2

Price of the new firm:	45
Capacity:	16
Price of the well-established firm 1:	53
Price of the well-established firm 2:	66
Profit of the new firm:	[ ]
Profit of the well-established firm 1:	[ ]
Profit of the well-established firm 2:	[ ]
Scenario:	[ ]

Example 3

Price of the new firm:	12
Capacity:	24
Price of the well-established firm 1:	21
Price of the well-established firm 2:	21
Profit of the new firm:	[ ]
Profit of the well-established firm 1:	[ ]
Profit of the well-established firm 2:	[ ]
Scenario:	[ ]

Example 4

Price of the new firm:	11
Capacity:	14
Price of the well-established firm 1:	27
Price of the well-established firm 2:	11
Profit of the new firm:	[ ]
Profit of the well-established firm 1:	[ ]
Profit of the well-established firm 2:	[ ]
Scenario:	[ ]

Experiment 4: Instructions

Welcome to the experiment!

From now on, please stop any communication and read the following information with great care. Questions will be answered after reading the instructions individually at your place.

The following experiment deals with the sale of goods. There are two well-established firms. Moreover, there is a new firm which enters the market.

- The experiment consists of 2 stages, which are played consecutively.
- At the beginning of the experiment, you are randomly assigned the role of one of the two well-established firms or the new firm.
  - During the whole experiment, the assignment of roles remains fixed.
- At the beginning of the experiment, groups of firms (2 well-established firms/1 new firm) are randomly assigned to the markets.
  - During the whole experiment, the assignment of the pairs is fixed.
- Each player earns a **fix payoff** of **5 EURO**.

Stage 1

First, 10 rounds will be played with the well-established firms being the sole firms in the market.

Activities of the new firm:

- If you were assigned the role of the new firm, you have no activities in this stage. However you can observe the well-established firms' decisions on their sales prices.

Activities of the well-established firms:

- If you were assigned the role of the well-established firm, you decide on your sales price in Taler.
  - Your sales price is integer from the interval **[0; 100]** Taler.

Round payoffs:

- The new firm earns **1000** Taler.
- If both well-established firms have chosen the same sales price:
  - Round payoff of each well-established firm:
    = **0.5 X [(sales price – 10) X (100 – sales price)]**
- If the two well-established firms have chosen different sales prices:
  - Round payoff of the well-established firm with the low price:
    (sales price – 10) X (100 – sales price)
  - Round payoff of the well-established firm with the high price:
    = **0**

At the end of this stage, one round will be chosen randomly and this round determines the payoffs of the well-established firms. (The exchange rate is: **1000 Taler = 1 Euro**.)

Stage 2

There will be **20 practice rounds**. Afterward, **20 rounds** will be played which are **payoff-relevant**. At the end of this stage, the sum of all round payoffs determines the total payoff for the well-established firms and the new firm. (The exchange rate is: **1000 Taler = 1 Euro**.)

Activities of the new firm:

- If you were assigned the role of the new firm, you decide on your sales price in Taler.
- Moreover you decide on your production capacity (= the maximum output you can sell.)
  - In the practice rounds, your production capacity will be assigned randomly.
  - In the payoff rounds, you decide on your production capacity.
  - Your sales price as well as your production capacity is integer from the interval **[0; 50]**.
- You can use a what-if calculator.

Activities of the well-established firms:

- If you were assigned the role of the well-established firm, you are informed about the decision of the new firm. You are informed about its sales price and its production capacity
- Afterward, you decide on your sales price in Taler.
    - Your sales price is integer from the interval **[0; 100]** Taler.
- A well-established firm has no capacity limitation.
- You can use a what-if calculator which already includes the decisions of the new firm.

Round payoffs:

Depending on the decisions of the three players, 4 scenarios are possible:

Scenario A: Both well-established firms have chosen the same sales price. This sales price is equal to or below that of the new firm.

- Round payoff of the new firm
  = **0**
- Round payoff of each well-established firm:
  = **0.5 X [(sales price – 10) X (100 – sales price)]**

Scenario B: The two well-established firms have chosen different sales prices. The lower one of these sales prices is equal to or below that of the new firm.

- Round payoff of the new firm
  = **0**
- Round payoff of the well-established firm with the low price:
  = **(sales price – 10) X (100 – sales price)**
- Round payoff of the well-established firm with the high price:
  = **0**

Scenario C: The well-established firm has chosen the same sales price. This sales price is above that of the new firm.

- Round payoff of the new firm
  = **sales price X capacity**
- Round payoff of each well-established firm:
  = **0.5 X [(sales price – 10) X (100 – capacity – sales price)]**

Scenario D: The two well-established firms have chosen different sales prices. Both of these sales prices are above that of the new firm.

- Round payoff of the new firm
  = **sales price X capacity**
- Round payoff of the well-established firm with the low price:
  = **(sales price – 10) X (100 – capacity – sales price)**
- Round payoff of the well-established firm with the high price:
  = **0**

Please note: negative payoffs are not considered.

Comprehension Questions:

Soon, you will see a what-if calculator on the screen. You can type in any sales price of the new firm, any production capacity of the new firm and any combination of sales price of the well-established firms. Then, you can calculate the corresponding profits for all firms.

For the following 4 examples, please calculate the profit of the new firm and of each well-established firm and indicate whether this refers to scenario A, B, C or D.

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Profit of the well-established firm 1:	[ ]	
Profit of the well-established firm 2:	[ ]	
Scenario:	[ ]	

Example 2

Price of the new firm:	45
Capacity:	16
Price of the well-established firm 1:	53
Price of the well-established firm 2:	66
Profit of the new firm:	[ ]
Profit of the well-established firm 1:	[ ]
Profit of the well-established firm 2:	[ ]
Scenario:	[ ]

Example 3

Price of the new firm:	12
Capacity:	24
Price of the well-established firm 1:	21
Price of the well-established firm 2:	21
Profit of the new firm:	[ ]
Profit of the well-established firm 1:	[ ]
Profit of the well-established firm 2:	[ ]
Scenario:	[ ]

Example 4

Price of the new firm:	11
Capacity:	14
Price of the well-established firm 1:	27
Price of the well-established firm 2:	11
Profit of the new firm:	[ ]
Profit of the well-established firm 1:	[ ]
Profit of the well-established firm 2:	[ ]
Scenario:	[ ]

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