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**THURGAU INSTITUTE  
OF ECONOMICS**  
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# Competition within firms\*

Lisa Bruttel<sup>†</sup>    Simeon Schudy<sup>‡</sup>

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## Abstract

We investigate the role of incentives set by a parent firm for competition among its subsidiaries. In a Cournot experiment four subsidiaries of the same parent operate in the same market. Parents earn a specific share of the joint profit and can choose how to distribute the remaining surplus (or loss). Results show that parents allocating profits equally among their subsidiaries reach outcomes close to collusion. However, almost half of the parent firms employ a proportional sharing rule instead. These groups end up with profits around the Cournot level.

*Keywords:* Cournot Competition, Subsidiary, Subcompany, Experiment

*JEL-Classification:* C92, D43, L22

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# 1 Introduction

When evaluating the competitiveness of a market, cartel authorities assume that subsidiary companies having the same parent do not compete with each other or with their parent. According to US antitrust law subsidiaries in a single entity pursue the goals of the parent. Subsidiaries in a single entity are thus not legally capable of conspiring with each other (under Section 1 of the Sherman Act). Similarly, antitrust law in the EU presumes that firms belonging to the same owner always act in the owner's interest.<sup>1</sup>

If subsidiaries commit a market infringement, a parent firm will at least have the chance to prove that the subsidiary in fact did act independently. This possibility does not exist in the field of merger control. When judging whether to allow or forbid a merger, cartel authorities have to forecast whether the planned merger will lead to a concentration of the market structure.<sup>2</sup> If the merger is generally considered to reduce competition in that market, it will not be permitted. Authorities assume that firms who are allowed to use their market power will always do so. Firms do not have the option to prove that the merger will not affect competition and that they are planning the merger for other reasons such as efficiency improvements only.

The prediction of perfect cooperation between merged firms seems a strong simplification and probably does not match the variety in actual behavior. Legal ownership and actual control may in fact be effectively separable, no matter whether this separation occurs intentionally or by inability of the parent firm. For example, high monitoring costs may impede perfect control over subsidiaries by parent firms. Instead of direct control, parent firms may use incentive schemes to coordinate their subsidiaries. We are interested in how such intra-firm incentives evolve and whether these incentives affect competition among subsidiaries. Can incentives induce collusive behavior among the subsidiaries? Will parent firms eventually implement incentive schemes resulting in collusion among its subsidiaries as presumed by law?

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<sup>1</sup>See the AKZO Nobel case: "In the specific case of a parent company holding 100% of the capital of a subsidiary which has committed an infringement, there is a simple presumption that the parent company exercises decisive influence over the conduct of its subsidiary." (European Court reports 2009 Page I-08237, Case C-97/08 P, ad para 60)

<sup>2</sup>Commission, guidelines horizontal cooperation agreements, ABl. EG C31/5, Rz. 4

In order to answer these questions we design a laboratory experiment in which a non-producing parent firm decides on the distribution of profits among its producing subsidiaries.<sup>3</sup> To study the intra-firm coordination problem in an unambiguous way and to isolate the effects of endogenously determined incentives, the subsidiaries of a parent firm operate in a separate Cournot oligopoly excluding other competitors. We find that almost all parent firms converge to a specific incentive scheme, mainly to one of two simple profit sharing rules: proportional and equal profit sharing. Subsidiaries operating under equal profit sharing rules are able to collude whereas subsidiaries operating under proportional profit sharing generate profits close to the Cournot level. Our results show that the prediction of perfect cooperation between subsidiary firms belonging to the same owner might be too restrictive. Only around half of the firms in our experiment collude. The other half of firms instead maintain Cournot competition between their subsidiaries.

The experimental study of incentives within the firm relates to research on group decision making in experimental Cournot oligopolies by Raab and Schipper (2009). While focusing on the comparison of individual decisions and the decisions of groups, the authors also contrast treatments with different exogenously determined profit sharing rules within firms. Raab and Schipper (2009) find no significant differences in production quantities of firms under the different sharing rules. However, this result was obtained by implementing an additional effort cost only in the proportional sharing treatment but not in the treatments with equal profit sharing. The introduction of additional costs was necessary in order to maintain the same theoretical predictions for individual and group treatments, but it makes the comparison of intra firm incentives difficult. While proportional sharing should generally yield higher production quantities, additional effort costs born individually may induce risk averse subjects to choose lower production quantities under proportional sharing than under equal profit sharing. In our experiment the individual's cost structure does not vary with the implemented profit sharing rule. We further let parent firms decide on the distribution of profits among their subsidiaries instead of exogenously manipulating the profit sharing rule. This allows us to study the endogenous evolution of intra-firm incentives when the firm's subsidiaries compete on the same market.

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<sup>3</sup>This hierarchical division of owners (parent firms) and decision-makers (producing subsidiaries) also relates our work to a study on strategic delegation in a Cournot duopoly by Huck, Müller, and Normann (2004).

Intra-firm incentives have also been studied in Bertrand oligopoly experiments. Bornstein and Gneezy (2002) and Bornstein, Kugler, Budescu, and Selten (2008) underline the suggestion that intra-firm incentives matter for coordination within firms as well as for coordination among different firms in the same market. They find that incentives within the firm matter for the dynamics of prices in Bertrand duopolies. The specific structure of their game reverses the effects of equal and proportional profit sharing. Proportional profit sharing means in their context an allocation according to subsidiaries' own asking prices (the prices of intermediate products which add up to the total price of the final product). In such a vertical firm structure, sharing in proportion to asking prices creates a free rider problem within the firm which tends to increase market prices over time. This is in contrast to the effect of proportional sharing in the Cournot case we consider, which represents a horizontally integrated firm.

The remainder of this paper is organized as follows. In section 2 we introduce the experimental design and briefly discuss the theoretical benchmark solutions of this framework. Section 3 presents the results of the experiment and section 4 concludes.

## 2 Design and Procedures

### 2.1 Design

We study a linear symmetric Cournot oligopoly market, in which four subsidiaries of the same parent firm operate in the same market. From Huck, Normann, and Oechssler (2004) we know that Cournot oligopolies with four firms competing against each other are never collusive but produce aggregate quantities at or above the Cournot outcome. We consider whether and to what extent such markets become collusive if the Cournot firms do not operate independently but are governed by a parent firm. In our experiment, this parent firm is not involved in production. Its task is to decide after each round about the distribution of the group profit among the four subsidiaries. The parent firm has an incentive to maximize the joint profit of the four subsidiaries, because it receives a predetermined fixed share (20%) of the group profit. Our design focuses on the evolution of incentives within the firm and how intra-firm incentives affect coordination among subsidiaries. In order to exclude any confounding effects from market competition, no firms other than the four subsidiaries operated in the market.

Market demand in the experiment was simulated according to the function  $P = \max\{100 - Q, 0\}$ , where  $P$  denotes the market price and  $Q$  the total quantity produced by the four subsidiaries ( $Q = \sum q_i$  with  $q_i$  denoting the quantity produced by a subsidiary  $i$ ). Production costs  $C(q_i)$  were equal to  $q_i$ . The instructions<sup>4</sup> provided subjects with verbal information about demand and cost conditions. Additionally we offered a “profit calculator” on their computer screens at the beginning of each round which allowed all subjects to calculate how changes in individual quantities affected profits.

The experiment consisted of 25 rounds. At the beginning of the experiment five subjects were randomly matched to form a group. One of the five firms was randomly selected to be the parent firm. Group composition and roles remained the same until the end of the experiment. We used a partner matching procedure to study the evolution of incentives within the firm and the corresponding changes of profits over time.

We structured each round in three stages: a production stage, a redistribution stage and a summary stage. In the production stage each subsidiary chose a production quantity. We approximated a continuous action space for subsidiaries by allowing for one decimal point when entering quantities between 0 and 100. Overproduction ( $Q > 99$ ) could lead to a loss. When the loss occurred within the first rounds, subjects’ show-up fees were converted into points (1000 points = 1 euro) and automatically invested to cover the loss. In later rounds profits from past periods covered current losses.

In the redistribution stage, parent firms saw the profits (or losses) generated by each subsidiary and the total quantity produced. 20% of total profit (or loss) were automatically transferred to the parent. Parents then decided freely on how to assign the remaining 80% to the subsidiaries (i.e. parent firms could redistribute but could not increase profits of specific subsidiaries by creating “new” losses for other subsidiaries). This procedure allows us not only to study how the parent firm rewards or punishes quantity choices by its subsidiaries but also whether specific redistribution rules evolve over time.<sup>5</sup>

In the summary stage, all subjects saw the subsidiaries’ individually generated profits and the details of the redistribution decision of the parent firm. After the summary stage the next round started immediately. The whole procedure was common knowledge.

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<sup>4</sup>For an English translation of the instructions see the appendix.

<sup>5</sup>This kind of ex-post redistribution relates to subjective performance evaluation measures frequently used also at the top management level (for empirical evidence see e.g. Murphy and Oyer (2003)).

## 2.2 Procedures

We conducted all four sessions at the LakeLab (University of Konstanz, Germany). The experiment took place in June and July of 2010. 20 participants participated in each session, thus we had a total of 80 participants. Each participant sat at a randomly assigned and separated PC terminal and was given a copy of instructions. A set of control questions was provided on-screen to ensure the understanding of the game. If any participant answered wrongly, the experimenter provided an oral explanation to the participant. No form of communication between participants was allowed during the experiment.

Participants received a show-up fee of 2 euros (2.50\$ at that time). The experiment took about one hour and 30 minutes, average income was about 13.40 euros (\$16.75). The experiment was programmed and conducted using z-Tree (Fischbacher (2007)). We recruited participants using the online recruiting system ORSEE (Greiner (2004)). Participants were part of the LakeLab subject pool, consisting of undergraduate and graduate students of all fields of study.

## 2.3 Theoretical Benchmarks and Behavioral Predictions

The symmetric Cournot Nash equilibrium for the experimental markets is characterized by an individual equilibrium output of  $q_i^N = 99/(n + 1)$  and an individual equilibrium profit of  $\pi_i^N = (q_i^N)^2$ . The total Cournot equilibrium output in this case is  $Q^N = 99n/(n + 1)$  and industry profit is given by  $\pi^N = n(q_i^N)^2$ . Other benchmark outcomes are the collusive case with  $Q^C = 99/2$  and the rivalistic (competitive) outcome with  $Q^R = 99$ . Table 1 summarizes the numerical values of these benchmarks for  $n = 4$  subsidiary firms.

	Total Quantity	Group Profit
Collusion	49.5	2450.25
Cournot-Nash	79.2	1568.16
Perfect Competition	99	0

Table 1: Theoretical benchmarks with  $n = 4$

Actual quantity choices in the experiment depend on the profit sharing of parent firms. As parent firms have an incentive to maximize total profit of their subsidiaries we expect that they will use redistribution as an instrument to coordinate quantity choices of their subsidiaries in terms of total profit. They will communicate their agreement or disagreement with certain quantity choices by punishing or rewarding subsidiary firms when reallocating profits. This coordination can only be successful if past allocations by the parent predict future allocations and if subsidiaries have according beliefs. We therefore presume that after some initial unsystematic trials parent firms will persistently use one specific profit sharing rule.

There are two particularly prominent sharing rules which we predominantly expect to observe: proportional and equal profit sharing. Given the appealing fairness of the allocation rule “everybody gets back what he or she contributed to the joint profit of the group” we expect that some parents will implement proportional sharing rules which reward high contributions to the joint profit with a high share. Consequent redistribution proportional to contributed profits gives all subsidiaries the same incentives as firms in a Cournot oligopoly and will therefore induce quantities close to the Cournot equilibrium.

Parent firms who understand the detrimental effect of proportional profit sharing will seek different allocation rules avoiding this effect. Maximization of the joint profit can be reached with any allocation rule which positively relates the individually assigned shares to the industry profit but not to the contributed profit share. The simplest example for such an allocation rule (and therefore the one we will focus on in the following) is an equal sharing of profits such that each subsidiary receives 20% of the joint profit. The relation of the assigned share to the contributed share could also be uncorrelated, which we expect to be rare because such rules may lead to confusion among subsidiaries or induce envy among them. When parent firms face excessive competition among their subsidiaries they may also use an anti-proportional sharing rule which punishes firms with high production quantities and rewards firms with low production quantities. Continuing anti-proportional allocation, however, would make quantities converge to zero which lets us expect rare use of this rule in exceptional cases of dramatic overproduction only. Equal sharing, in contrast, sets total profit maximizing incentives independent of the current quantities.

To summarize, we predict to observe different sharing rules, learning and convergence to a specific rule. We expect equal sharing rules to lead to collusion and proportional profit sharing to foster competition among the subsidiaries.



### 3 Results

Average profits provide a first descriptive insight as to whether parent firms in our experiment are able to make their subsidiaries optimize profits jointly. Figure 1 illustrates that at an aggregate level firms do not succeed in collusion. Average profits are closer to the Cournot than to the collusive level. (Wilcoxon signed rank test, two sided, p-value < 0.01). We obtain Result 1.

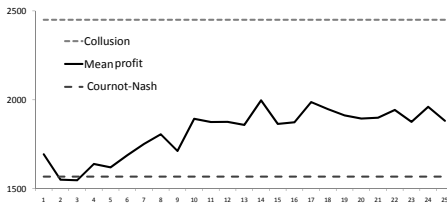


Figure 1: Mean profits over time

**Result 1** *There is competition among subsidiaries.*

Coordination failure between the subsidiary firms can have two main reasons. Either the parent firm sets incorrect incentives or the subsidiaries do not respond to correct incentives accordingly. We cluster redistribution rules employed by the parent firms (and therefore the incentives set by them) into two broad categories. “Correct” incentives imply a sharing rule that gives subsidiaries incentives to maximize joint profits, e.g. equal profit sharing.<sup>6</sup> “Incorrect” incentives, in contrast, are set with any sharing rule which rewards a high contributed profit with a higher assigned profit share when the total production quantity exceeds the optimal level (49.5) or rules which induce lower production quantities when total quantity lies below the

<sup>6</sup>In one of the groups the parent firm did not allocate profits equally in every round but took turns in giving the whole group profit to one of the subsidiaries in cyclical order. We treat this rule as “correct” or equal sharing as well.

		Industry profit closer to		
		Cartel	Cournot	
Sharing rule closer to	equal	6	4	10
	proportional	0	6	6
		6	10	

Table 2: Sharing rules and industry profits of groups

optimum. We concentrate on the first case, because in all groups, quantities (if at all) converge from above the collusive level. To classify the actual sharing rules employed by our parent firms into “correct” and “incorrect” incentives, we judge the distance to a specific sharing rule in the following way. In each round we calculate the sum of differences in percentage points of the actual share each firms receives to the point prediction of the equal (DiffE) and proportional (DiffP) sharing rule,

$$\text{DiffP}_i = \sum_j |b_j - a_j| \text{ and}$$

$$\text{DiffE}_i = \sum_j |0.25 - a_j|,$$

with  $i = \text{parent}_i$  and  $j = \text{subsidiary}_j$ ,  $a_j = \text{assigned profit share}$ ,  $b_j = \frac{q_j}{Q}$ ,  $q_j = \text{quantity produced by subsidiary}_j$  and  $Q = \text{total quantity produced by the four subsidiaries}$ .<sup>7</sup>

In a next step, we compare for each round and each parent firm, which of the two values DiffE and DiffP is smaller. Taking the average over all rounds, we derive for each parent firm a measure whether its redistribution scheme is on average over all rounds “closer to” an equal or a proportional sharing rule. This gives us a first, broad measure for different profit sharing rules. Next, we relate the relative closeness to one of the two sharing rules to the average profits realized by the subsidiaries of this firm on average (see Table 2).

The average industry profits of parent firms employing the equal sharing rule in more than 50% of their decisions are in significantly more cases closer to the cartel level than profits by firms employing the proportional sharing rule in more than 50% of their decisions (Fisher exact test, p-value < 0.05).

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<sup>7</sup>Note that the two sharing rules make the same prediction when all subsidiaries produce exactly the same amount. However, we rarely observe this case. Differences between minimum and maximum quantities are smaller than two for only 1.5 percent of our observations.

**Result 2** *Average profits of firms employing a proportional sharing rule are always below the collusive level. Profits close to collusion are only attained by firms employing sharing rules close to equal sharing.*

Learning within sessions might bring all groups to combined profit maximization outcomes sooner or later. Figure 1 illustrates that profits in the second half of the game are higher than profits in the first rounds. To find out whether certain groups converge to the equal sharing rule we run 16 independent regressions (one for each group) to see whether the distance of the actual to the equal sharing rule  $\text{DiffE}_t$  gets smaller over time. With  $\text{DiffE}_t = \beta \cdot t + \epsilon_t$  a  $\beta$  significantly smaller than zero indicates that the distance of the actual to the equal sharing rule is decreasing over time. In this case, we say that the group is converging to equal sharing. According to this clustering we can treat eight groups as converging to equal sharing and six groups as not converging to the equal sharing rule. Two remaining groups converge to both rules.<sup>8</sup>

Figure 2 shows the groups' profits over time, separated by the above convergence criterion. The pictures indicate that parents converging to an equal profit sharing rule succeed in increasing profits over time whereas profits of groups with distribution rules not converging to equal sharing follow no time trend. We also regress group profits for the two clusters on the round index. Table 3 shows that profits are significantly increasing over time only for groups converging to an equal sharing rule.<sup>9</sup>

**Result 3** *Groups with distribution rules converging to an equal sharing rule have increasing profits over time. Profits of groups with distribution rules not converging to equal sharing follow no time trend.*

The “closer to” and the convergence measure are relatively broad ones as they do not account for the absolute distance between the prediction of the (equal or proportional) benchmark and

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<sup>8</sup>As convergence (if any) will stop once the profit maximum has been reached, we restrict the convergence analysis to sharing rules in the first 15 rounds of the game. As a robustness check we also analyzed convergence within the first 10 rounds. Using this criterion we identify 6 firms, which converge to an equal sharing rule. This does not qualitatively change the results reported in Table 3.

<sup>9</sup>Two groups converge to equal as well as to proportional sharing. The two groups are not contained in Figure 2. The regression results do not change if we include these two groups into the cluster of groups converging to equal sharing.

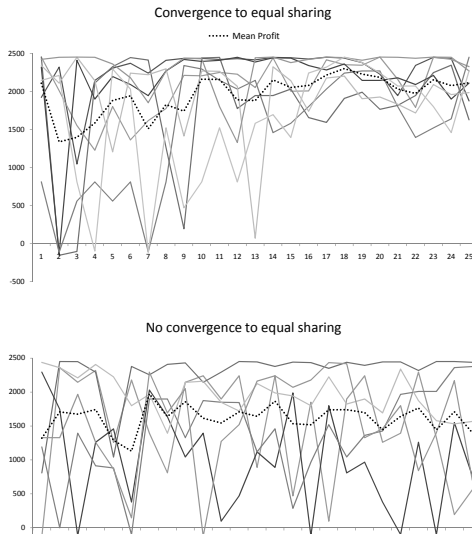


Figure 2: Development of profits over time, grouped by convergence to equal sharing

the actual sharing rule. A certain distribution rule might be relatively closer to one of the two rules but far away from the predictions of both rules in absolute terms. To capture these absolute difference between predicted and actual share, we use an OLS regression explaining current profits with the sharing rule in the previous two rounds. “DiffP - DiffE” denotes the relative closeness to one of the allocation rules. The closer (farther) the sharing rule in a certain round is to equal (from proportional) sharing, the larger is the value of this difference. We therefore expect a positive impact of “DiffP - DiffE” on group profit. “DiffP” and “DiffE” measure the impact of closeness to the two allocation rules separately. We expect that a large difference to equal sharing in  $t - 1$  (and  $t - 2$ ) has a negative impact on group profit in round  $t$  and that a large difference to proportional sharing has a positive impact on group profit. The regression specifications (1) and (3) include only allocation rules from the previous round while the specifications (2) and (4) take  $t - 2$  into account as well.

	Not converging	Converging	Converging (incl. group 6 & 9)
Round	1.629 (8.904)	23.49*** (6.448)	22.75*** (5.880)
Constant	1,593*** (133.2)	1,652*** (116.5)	1,652*** (104.5)
Observations	150	200	250
R-squared	0.000	0.075	0.064

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 3: Regression results: group profit and convergence to the equal sharing rule

All results point in the expected direction and most of them are strongly significant (see Table 4). Sharing equally in the previous round increases profits in the current round. (Note that the negative sign of DiffE indicates that profits decrease the farther an observed sharing rule is away from equal sharing.) Sharing proportionally leads on average to an increase in quantities and thereby reduces profits. The positive effect of equal sharing on profits is stronger than the negative effect of proportional sharing. Furthermore, with proportional sharing, the effect of “DiffP in  $t - 1$ ” is only significant if we do not include  $t-2$  into the regression as well. This indicates that proportional sharing in round  $t - 1$  on group profit is highly correlated with proportional sharing in  $t - 2$  already (Spearman’s  $\rho = 0.68$ , p-value  $< 0.01$ ). With equal sharing, the effect rather accumulates over time. Including “DiffE in  $t - 2$ ” into the regression reduces the impact of “DiffE in  $t - 1$ ” only to a small extent and the twice lagged variable is highly significant itself. We conclude with Result 4.

**Result 4** *The closer the profit allocation in one round is to equal sharing, the higher are group profits in the two following rounds.*

	Group profit in $t$			
	(1)	(2)	(3)	(4)
DiffP - DiffE in $t - 1$	848.3*** (135.7)	545.7*** (170.3)		
DiffP - DiffE in $t - 2$		484.6*** (145.3)		
DiffP in $t - 1$			545.0*** (154.9)	309.4 (226.2)
DiffP in $t - 2$				221.8 (189.0)
DiffE in $t - 1$			-1,170*** (211.5)	-920.9*** (218.8)
DiffE in $t - 2$				-750.7*** (203.6)
Constant	1,782*** (35.79)	1,779*** (35.09)	1,909*** (52.21)	2,006*** (50.88)
Observations	384	368	384	368
R-squared	0.130	0.157	0.150	0.204

Robust standard errors in parentheses

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Table 4: Regression results: group profit explained by past profit allocation rules

## 4 Discussion and conclusion

We investigated the evolution of incentives set by parent firms for their subsidiaries in a Cournot oligopoly experiment. In the experiment, simple profit sharing rules evolved which created strong incentives for producing subsidiaries. All measures we used in the analysis point in the same direction: Incentives are decisive for the degree of competition among subsidiaries of the same parent. Subsidiaries do compete when the sharing rule employed by the parent is proportional to subsidiaries' contributions to the joint profit. In contrast, parent firms implementing equal profit sharing rules were able to eventually coordinate their subsidiaries to the collusive outcome.

In the experiment, half of the parent firms implemented incentives which led to competition within firms. Would parent firms in the real world do so? In fact, the organization of divisions as independent profit centers is quite popular as it allows the parent firm to determine the subsidiaries' individual profitability and reduces monitoring costs. As in our experiment this organizational structure does not provide explicit incentives to maximize the total profit of the company. Consequently, competition within the firm may emerge.

The implications of our findings are twofold. First, antitrust authorities may take our results as a hint that the simple presumption of collusion among subsidiaries of the same parent may be too restrictive. Cost saving mergers do not necessarily imply subsequent collusion among the subsidiaries of the same parent. Instead, the likelihood of concerted action depends on the incentives for the subsidiaries within the merged firm. Second, our results illustrate the tradeoff corporate management faces when deciding on incentive schemes for the executives of the different divisions. Bonus payments at the executive level typically depend on the division's profit and on the total profit of the company as well. Our experiment can reproduce this tradeoff at a very stylized level and may therefore serve as a basic design to study the effects of different variants of such combined bonus payment rules.

## **Appendix: Translated Instructions**

### **General information**

Today you are taking part in an decision-making experiment. If you read the following instructions carefully, you will be able to earn money. The amount you earn depends on your own and on other participants' decisions.

For the entire duration of the experiment, communication with other participants is not allowed. We therefore ask you not to talk to each other. Breaking this rule leads to exclusion from the experiments and any payoffs.

If you have problems understanding the experiment, please have a second look at the instructions. If you still have questions, please raise your hand. We will come to your cubicle and answer your questions personally. During the experiment, we do not use euros, we use points.

The number of points you earn in the experiment are converted into euros with the following exchange rate.

$$\mathbf{1000\ Points = 1\ euro}$$

At the end of the experiment, you will receive all points earned during the experiment converted into euros.

The following pages will explain the experiment in detail. First we explain the general procedure. Then we explain the different decision making screens. Before the experiments starts, control questions will appear on the screen in order to help you to fully understand the procedure. The experiment does not start until all participants have solved the control questions and are completely familiar with the course of the experiment.

## **The Experiment**

At the beginning of the experiment you will be randomly matched with 4 other participants. That is, you make decisions in a group of 5 people. Neither you nor other participants learn anything about your identity, either during or after the experiment.

The experiment consists of 25 rounds. In each round you interact with the same people. Each participant in your group represents a firm. There are four producing firms (Firm 1 to 4) and one firm (Firm 5), which does not produce but instead decides on the distribution of profits between the five firms in your group. At the beginning of the experiment you see on the screen which firm you represent. You will represent the same firm in all 25 rounds.

Firms 1, 2, 3 and 4 produce the same (virtual) good and sell it on the same market. Production costs per unit are equal to one point. All producing firms decide simultaneously on how many units of the good they produce. There is one important rule: The higher the total quantity produced by the four firms, the lower is the market price. If some maximum of total output is reached the price will be equal to zero.

The per unit profit of each producing firm (“generated profit”) equals the difference between the market price and the unit cost of production. The “generated profit” (in points) thus equals:



$$\text{Generated profit of a producing firm} = (\text{Market price} - 1) \times \text{Quantity produced by the firm}$$

In each round, firms 1 to 4 decide simultaneously on how many units of the good they produce. The computer calculates the total quantity produced by the four firms and the corresponding market price. The “generated profit” is not equivalent to payoffs earned by the firms in this round. Firm 5 decides on the actual payoff to each producing firm after the production decision: Firm 5 receives information about the total quantity produced and the profits generated by each firm as well as information about the resulting total profit. Firm 5 automatically receives 20% of the total profit. Then, firm 5 decides on how to distribute the remaining 80% of the total profit among firms 1 to 4. Firm 5 can freely choose how to distribute the profit among the firms 1 to 4.

If the total profit is negative, Firm 5 automatically bears 20% of the loss and decides on how to distribute the remaining 80% of the loss among firms 1 to 4 (in this case the 2 euros you received for participating will be automatically converted into points and used to compensate for the loss)

Importantly, firm 5 can only redistribute profits or losses from the current round. That is, it is also impossible to transfer a loss to one firm in order to transfer additional profits to another firm.

After firm 5 made the distribution choice all firms receive feedback on the chosen distribution. Then the next round starts. Again firms 1 to 4 make a production decision and firm five decides on the distribution.

The experiment consists of 25 rounds. After the last round all participants see a summary of their points received in each round on the computer screen. You receive all points received converted into euro.

## Procedure on screen

Firms 1 to 4 see the following screen. (Example for firm 1):

Round: 1 out of 25 remaining time [sec]: 41

You are firm 1.

With this calculator you can calculate your profit by entering your own and the other firms production quantities.

Total quantity by the other three firms:

Own quantity:

With the quantities you entered you and the other firms will have a	0.0
total profit of	0.0
Your contribution to the total profit would be	0.0

Please enter here the quantity you want to produce in this round

(Please indicate decimals with a ".")

On the left hand side you see a profit calculator. With this calculator you can test how your “generated profit” varies in production quantities. You can try out how the generated profit changes when you change your own production quantity or the total quantity produced by the other three firms. The quantities you enter in the calculator are completely hypothetical. You can use the calculator to receive information on the consequences of your own and others’ decisions. You can try as many calculations as you like. When you have decided on how much to produce, enter the amount on the right hand side and click on “confirm”. You cannot decide on the production quantity of other firms.

Firm 5 can also use a profit calculator. While firms 1 to 4 choose their production quantities, Firm 5 can try out, how the profits of each firm and the total profit vary when production quantities vary. The screen for firm 5 looks as follows:

Round 1 out of 25 remaining time [sec] 0

You are firm 5.

With this calculator you can calculate the profits of the four firms by entering the firms' production quantities.

Just guess the production quantities of the four firms.

Then the program will display the effects of the quantities produced by the firms on their contribution to the total profit.

The quantities you enter are for testing only. They have no consequences for your payouts nor for the payouts of other firms.

Quantity firm 1

Quantity firm 2

Quantity firm 3

Quantity firm 4

(Please indicate decimals with a ".")

Calculate

The total profits of the four firms resulting from the quantities you entered is displayed here. You also see the contribution to the profit by each firm.

Firm 1 0.0

Firm 2 0.0

Firm 3 0.0

Firm 4 0.0

Total Profit 0.0

continue

After firms 1 to 4 have made their production decisions, firm 5 sees the following screen.

Round 1 out of 25 remaining time [sec] 45

The total quantity produced by the four firms in this round is      The total profit in this round is      Points

Here you see each firm's contribution to the total profit.

	Firm 1	Firm 2	Firm 3	Firm 4
Contribution to total profit				
Contribution to total profit (after subtracting your share of 20%)				

Your share of the total profit is 20% (      Points). Please enter now how you want to distribute the remaining      Points over the four firms.

(Please indicate decimals with a ".")

	Firm 1	Firm 2	Firm 3	Firm 4
Share (in Points) for each of the four firms	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Calculate the sum

Confirm

The screen shows the “generated profits” by each producing firm and the “generated profits” after the deduction of the 20% for firm 5. Firm 5 then decides on how many points it will assign to firms 1 to 4. In order to do so, firm 5 enters the number of points for each producing firm in the blue-shaded fields. A click on calculate shows the sum of assigned points and the number of points left for distribution. Clicking on “confirm” implements the chosen distribution of points. Then all firms see the following screen.

The screenshot shows a web-based interface for an experiment. At the top, it displays "Round 1 out of 25" and "remaining time [sec] 27". The main content area contains the following text:

In this round you receive a payoff of \_\_\_\_\_ points.

Here you see the contributions of the four firms to the total profit and the profit shares received by each of the four firms.

	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5
Contribution to total profit in points					
Contribution to profits (after subtracting the 20% for firm 5)					
Profit share (in points) received after redistribution					

At the bottom right of the interface is a "continue" button.

## Control Questions

Please click now on the “continue” button on your computer screen. We will display some control questions on screen. Please answer these questions. The questions only serve for the understanding of the course of the experiment. **Your answers do not affect the payoffs received in the experiment.**

If you have any questions, please raise your hand. We will come to your cubicle and answer your questions.

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