Mergers and the perception of market power: An experimental study*

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Abstract

In this paper, we study bilateral mergers in Cournot markets with initially three or four firms. Theory predicts pre- and post-merger total output well. However, merged firms produce significantly more than firms without a merger history. As a result, mergers are not as unprofitable as predicted. By analyzing two control treatments, we provide an explanation for these results based on the notion of aspiration levels.

Keywords: aspiration levels, Cournot, experiments, mergers, merger psychology, oligopoly, profitability, welfare.

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1 Introduction

Two key economic questions arise when firms plan to merge. First, from the perspective of the firms involved, how the merger will affect their joint profits, and, second, from a policy perspective, how it will affect overall welfare. Both these questions have been the focus of much theoretical and empirical research. Issues such as the internal organization of firms, production cost savings, or other types of scale economies have been put forward to explain why mergers could be profitable (see, e.g., Perry and Porter, 1985), and asymmetries between firms may be a reason that mergers can increase welfare (see Farrell and Shapiro, 1990).

However, theoretical analysis has also highlighted the fact that a merger can be disadvantageous for the merging firms under quite plausible market conditions. This point has been made most prominently in a paper by Salant, Switzer, and Reynolds (1983) who show that bilateral mergers in Cournot markets with homogenous products and constant returns to scale cannot be profitable. The reason for this result, which has triggered a wide literature,[1] is intuitive and seemingly robust. Starting from a market with n identical firms, suppose that two firms merge. This reduces the number of firms to $n-1$, increasing industry concentration and total industry profits, and reducing welfare. However, while the two firms which merged received a share of $2/n$ of the pre merger industry profits, they receive only a share of $1/(n-1)$ of post merger industry profits and this makes the merger unprofitable—excepting where two firms create a monopoly through merger.

This result poses a puzzle similar to the bargaining paradox introduced by Harsanyi (1977, p.203n.).[2] Two firms which were formerly competitors join forces. They perfectly coordinate their actions and pursue the same common objective. But, although they act jointly and pursue joint interests, and although the set of their other competitors has not changed, they lose while their competitors win. The puzzle is resolved if the underlying logic of the market game is considered. The merger does not generate one 'big' or 'powerful' new competitor. Instead, the merger simply eliminates one of the merging firms completely.

Whether or not this merger puzzle holds empirically, thus depends crucially on

[1] See, e.g., Deneckere and Davidson (1985), Gaudet and Salant (1991) and the literature cited there.

[2] The bargaining paradox describes a situation in which n players bargain about the division of a pie among themselves and compares this situation with one in which two players enter into a coalition and act as one (united) player. While the two players typically receive $2/n$ when acting independently, they receive only $1/(n-1)$ if they act jointly.

whether the merger is perceived as identical with a simple reduction in the number of firms, or whether the competitor created by the merger is perceived as different from the other firms. The true perception may depend on properties of the production technology like firms' cost savings from merging, or sunk capacity choices, but may also depend on the competitors' psychology.

Field evidence on mergers is mixed. Let us just focus on the two central questions, profits of the merging firms[3] and total welfare. With respect to the former, there are, on the one hand, event studies which investigate the stock market value of the merging firms before and after a merger. Most of these studies find that mergers improve the aggregate stock market value of the merging firms (see, for a discussion, Jarrel, Brickley and Netter, 1988, or Fridlofsson and Stennek, 1999). On the other hand, there is the empirical industrial organization literature which analyses the long-run performance of merging firms. Here, the result is often that mergers reduce profitability (see Mueller, 1980, or Scherer and Ross, 1990), although sometimes positive performance is found (e.g. in Healy, Palepu and Ruback, 1992). In a recent study Gugler, Mueller, Yurtoglu, and Zulehner (2000) report both profitable and unprofitable mergers, and try to classify them. At the same time, they report that, in contrast to the above, mergers reduced the shareholder value.

With respect to welfare, the picture is even less clear as consumer rents are hard to measure.[4] The Federal Trade Commission (1999) sums up the existing evidence by claiming that "most" mergers would benefit consumers while "some" are likely to cause adverse effects. As an example of the latter, they mention the attempt by Staples, a retailer of office supplies, to acquire its competitor Office Depot. By blocking this merger, the FTC claim to have saved consumers $1.1 billion over five years. At the other end of the spectrum, Pesendorfer (2000) provides an example of massive welfare gains. The consolidation in the US paper industry in the 1980s, it reports, would have caused annual welfare gains of $875.2 million.

The mixed evidence is probably not very surprising as merger field data are notoriously messy—to the extent that some authors question the appropriateness of event studies which are, as pointed out above, a popular tool in empirical merger studies.[5] In view of these problems, we propose an experimental analysis of mergers. Experimental

[3] Banerjee and Eckard (1998) show that, in contrast to theory, during the first great merger wave from 1897 to 1903, *competitors* of merging firms suffered significant losses.

[4] This is the reason why many empirical studies focus on concentration measures instead.

[5] See, for example, Cox and Portes (1998), Calomiris (1999) and MacKinlay (1997) for a general methodological appraisal.

methods can isolate the effect of a merger from other changes in market parameters and seem, therefore, particularly well suited to shedding some light on both the predictive power of non-cooperative merger models and the actual forces shaping market outcomes.

There is some experimental evidence on horizontal mergers in laboratory markets.[6] On the one hand, there is the "cross-sectional" approach where markets with different numbers of competitors are compared in between subject designs. Such "pure number effects" have been studied, for example, by Fouraker and Siegel (1963) and, more recently, by Dufwenberg and Gneezy (2000). Our approach is different as we implement bilateral mergers in markets that have been in existence for a while. This allows us to observe the same group of subjects before and after the merger. Relying on this within subjects design, our hypothesis is that markets with a merger history perform differently from markets in which a merger has not occurred, even if both have the same number of firms.

Experiments with this property include several papers by Davis and his coauthors. Davis and Holt (1994) study posted-offer markets with initially five firms. The merger involves three firms, but market power is held constant by design. They find a significant effect of the merger which is, however, relatively small. Davis and Wilson (1998) also analyze posted-offer markets, but their experiments involve reallocation of plant capacity among firms which may or may not create market power. While this is not literally a complete merger, the design is very useful in that it illustrates how cost savings can interact with market power. Finally, Davis and Wilson (2000) and Davis and van Boening (2000) analyze mergers in markets with differentiated products. The experiments are designed to examine the behavioral relevance of the Antitrust Litigation Model that U.S. authorities use to help determine the impact of mergers in markets with differentiated products. Their results highlight the role of price vs. quantity competition and that of different information conditions which influence the impact of mergers.

In this paper, we study experimental bilateral mergers in a model that is as close as possible to the analytical framework of Salant, Switzer and Reynolds (1983). We consider linear, symmetric three and four firm experimental Cournot markets and a duopoly control treatment. For the first half of the experiment, subjects play a standard Cournot laboratory market. Then two of the players consolidate and the second half

[6] For an experimental analysis of vertical mergers, see Martin, Normann and Snyder (2001).

of the experiment begins.

Our first result relates to the predictive power of the Cournot model more generally. As with other studies of Cournot markets,[7] we find some collusion in duopoly markets such that total output is below the Cournot level. But, with three or four firms, the standard Cournot model predicts total output remarkably well. Also, the adjustments in quantities that players make in response to a merger are clearly anti-competitive and, insofar, in line with the predictions. But in one important aspect our results depart from the theory. The linear Cournot model predicts no differences between a merged firm and its competitors. With constant returns to scale, the merged firm has no cost advantage over its competitors. Hence, the remaining firms are symmetric and are predicted to produce equal outputs.[8] But our data draw a different picture. Post merger markets are *not* symmetric. Merged firms produce systematically more than predicted, their competitors systematically less. This yields a striking effect: the profits of the merging firms are not reduced as drastically as predicted. On the contrary, the merging firms may even experience a transitory increase in profits in the short run and, in larger markets, they are roughly able to maintain their original profits (prior to merger) in the long run.

We present three possible explanations for this result, all of which allude to a specific form of what we shall call *merger psychology*: (a) the mere fact that one firm has resulted from a merger renders the firm "strong" and the whole market asymmetric; (b) as the merged firms are jointly owned (and profits are to be shared), fairness considerations shift output (and therefore profits) from unmerged to merged firms; (c) merged firms are committed to maintaining their original profits because of aspiration levels created in the pre merger markets. To discriminate between these possible explanations, we conduct two further treatments which allow us to rule out explanations (a) and (b). Thus, we are left with a result that is reminiscent of early work by Cyert and March (1956) who—drawing on Simon's work[9]—argued that firms' behavior is guided by an "acceptable–level profit norm" and provided empirical evidence that firms with declining market shares strive harder to increase sales than others.

Summarizing, with respect to the two questions we started with, we find that mergers are not as unprofitable as predicted but that they do indeed reduce welfare. The remainder of this paper is organized as follows. In the next section we present

[7] A survey can be found in Huck, Normann, and Oechssler (2001).

[8] It is this very fact which makes mergers non–profitable.

[9] See, e.g., Simon (1955 and 1959).

the theoretical predictions and the experimental design. Section 3 contains the data analysis and main results. Section 4 relates our findings to the literature on aspiration levels and discusses implications for mergers. Section 5 concludes.

2 Theory and experimental design

In a series of computerized[10] experiments, we studied bilateral mergers in symmetric n-firm Cournot oligopoly markets. For all markets we used the following demand and cost functions. The demand side of the market was modelled with the computer buying all supplied units according to the inverse demand function

$$p = \max\{100 - Q, 0\} \tag{1}$$

with $Q = \sum_{i=1}^{n} q_i$ denoting total quantity, and q_i denoting firm i's quantity. The cost function for each seller was simply

$$C(q_i) = q_i,$$

that is, marginal cost was constant and equal to one.

It is straightforward to derive the Nash equilibrium for this market. The individual equilibrium output is

$$q_i^* = \frac{99}{n+1} \tag{2}$$

and the equilibrium profit is

$$\pi_i^* = (q_i^*)^2 = 9801/(n+1)^2. \tag{3}$$

Alternative benchmark outcomes are the joint profit maximum and the competitive equilibrium. The symmetric collusive output for a firm is $q_i^c = 99/2n$, and price equals marginal cost if each firm produces $q_i^w = 99/n$.

Subjects could choose quantities from a finite grid between 0 and 100, with .01 as the smallest step. Hence, the action space had a sufficiently fine grid for continuous action spaces to be approximated. Therefore, the above benchmarks are also valid in the experiment.[11]

[10] We used the software toolbox "Z-Tree", developed by Fischbacher (1999).

[11] The fine grid also has the advantage that multiple Nash equilibria due to the discretization of the action space (Holt, 1985) can be avoided.

Treatment	subjects	periods	description
"4→3"	4	2×25	2 out of 4 firms merge after 25 periods 2 subjects share profits post merger
"3→2"	3	2×25	2 out of 3 firms merge after 25 periods 2 subjects share profits post merger
"2const"	2	25	2-firm control treatment standard Cournot duopoly
"4→3GO"	4	2×25	2 out of 4 firms merge after 25 periods 1 subject gets post merger profit, 1 leaves the lab
"3 + 1"	4	25	3 firms, profit of one firm is shared by two subjects

Table 1: Treatments.

Subjects had information about demand and cost conditions so they could calculate best replies to the quantities of the other firms. This information was provided verbally (see the Appendix) and in the form of a 'profit calculator'. The profit calculator worked as follows. When fed with data regarding the other firms (total quantities of the other firms), the calculator allowed the consequences of own actions to be tried out. Note that a profit calculator gives qualitatively the same information as a profit table which is often provided in Cournot experiments (e.g., Holt, 1985). However, the profit calculator might help to avoid a bias due to the subjects' limited computational capabilities. After each period, subjects were informed about their own quantity and profit and the aggregate quantity their competitors produced.[12]

We studied bilateral mergers in markets with initially four and three firms (treatments "4→3" and "3→2"). Additionally, we ran a duopoly control treatment ("2const"). The duopoly control treatment consisted of 25 rounds only. In both merger treatments, subjects were informed that the experiment would consist of two phases, each comprising 25 rounds. They were, however, not told what would happen after the first phase. After round 25 they received a new set of instructions informing them that a merger would occur. Table 1 summarizes the design of our treatments (the treatments "4→3GO" and "3 + 1" will be introduced below).

The merger was conducted as follows. The firms that merged were chosen randomly. One of the subjects involved in the merger became responsible for making all actual decisions, while the other remained in the lab and was able to send messages to his or

[12]Note that this informational condition was not suitable for identifying individual quantities and profits. Among various different informational conditions, this setup led to outcomes which came closest to the Nash prediction in the four firm oligopolies in Huck, Normann, and Oechssler (1999, 2000).

her partner.[13] The instructions made it clear that these messages were not binding. We allowed for these messages in order to keep the passive subject somewhat involved in the decision process. Profits were shared equally between the two of them and this was known to all participants.

Theoretically, behavior in each round of all treatments should depend only on the number of firms, i.e., one would expect to observe similar data in, say, the second phase of the treatment "3→2" and the duopoly control treatment. Therefore, from (2), the prediction for industry output is simply $Q(n) = 99n/(n+1)$.

All experiments were conducted at Humboldt University between Spring 2000 and Spring 2001. We conducted six markets for each treatment. The six duopolies were run in one session. We had 2 sessions for each of the treatments "4→3" and "3→2". Subjects were randomly allocated to computer terminals in the lab so that they could not infer with whom they would interact in a group. 102 subjects participated in this study including two additional control sessions which we will elaborate on below. Recruited via telephone and e-mail, subjects were students from various departments. We varied the exchange rates such that, depending on the number of firms, subjects would have made identical earnings at Nash equilibrium play. The average payoff was about DM 39.50 (at the time of the experiment roughly $20). Sessions for treatments "4→3" and "3→2" lasted about 90 minutes, the session for treatment "2const" about 50 minutes including instruction time.

Instructions (see the Appendix) were written on paper and distributed in the beginning of each session. After the instructions were read, we explained the different windows of the computer screen. When subjects were familiar with both the rules and the handling of the computer program, we started the first round.

3 Experimental results

We present our results in several parts. In the first part, we focus exclusively on total output. Given, as assumed, constant marginal and average cost, total output perfectly measures the degree of competition and total welfare. In the second part, we analyze firms' quantity setting behavior, focussing on the importance of merger history. The effects of merger history are quantified with the help of a linear regression. Then we

[13] Subjects could pick one of three possible messages: "produce more", "produce less" or "produce as much as before". They were allowed to do so every five periods starting at the beginning of the second period after the merger.

	"4→3"			"3→2"			"2const"
phase	pre	post		pre	post		
	last 3rd	first 3rd	last 3rd	last 3rd	first 3rd	last 3rd	last 3rd
theory	79.20	75.00		75.00	66.67		66.67
mean	81.17	70.33	75.12	72.96	63.27	67.60	60.01
(std. err.)	(2.59)	(2.03)	(3.09)	(2.10)	(3.80)	(3.01)	(3.08)

Table 2: Summary of experimental results: Total quantities

turn to firms' profits. Finally, we discuss the results of two control treatments in order to identify a behavioral explanation for our findings.

3.1 Total outputs

Table 2 provides essential summary statistics of our experimental results. It shows total output predicted by theory as well as means observed in the experiment, classified by the last third before the merger and the first and the last third post merger.[14] Recall that the duopoly market (treatment "2const") serves as a control market that lasted for only 25 rounds. Therefore, only average total quantity in the last third of this market is shown in Table 2. Note that, unless we explicitly state otherwise, in all subsequent statistical tests of this section we take one group's average total output as one observation.

We focus on the behavior in the last third of the first phase (pre merger) and the first and the last third of the second phase (post merger). This serves two purposes: Firstly, we can analyze experienced, long-run behavior by comparing the last thirds in which behavior has settled down. Secondly, by comparing the last third of the first phase and the first third of the second phase, we can analyze the (potentially transient) short-run effects of the changes induced by the merger.

As a first step, we analyze whether markets in the first phase, i.e., prior to merger, converge to the prediction. We answer this question by comparing observed average total output in the last third of the first phase with the numbers predicted by theory. Consider treatment "2const". Here, predicted industry output is 66.67, whereas we observe on average 60.01 units of output. This implies that our experimental duopoly

[14] We discarded the last round of both phases because we wanted to eliminate end-game effects (which were significant in the duopoly markets). This left us with 24 rounds for each phase which we divided into thirds (1-8, 9-16, 17-24). Comparing the thirds within each treatment it became obvious that behavior only settled down in the last thirds.

markets are significantly more collusive than theory predicts.[15] Next, consider the markets with three or four firms prior to merger. Whereas the triopoly pre merger market is slightly less competitive than predicted (72.96 vs. 75.00), we find that the quadropoly pre merger market is slightly more competitive than predicted (81.17 vs. 79.20). Moreover, comparing total outputs in the quadropoly pre merger markets with those in the triopoly markets (81.17 vs. 72.96) and the latter, in turn, with those in the duopolies (72.96 vs. 60.01), we find that "number effects" are prevalent and statistically significant.[16] We summarize these results as follows

Result 1 *The experimental duopoly markets are more collusive than predicted. Total outputs in the three and four firm pre merger markets are close to the prediction.*

Now consider the short-run effects induced by the merger. We compare average total quantities in the first third after the merger with those observed in the last third before the merger (treatments "3→2" and "4→3"). Inspecting Table 2, we find that, immediately after the merger, total quantity in both markets drops drastically—from 72.96 to 63.27 in treatment "3→2" and from 81.17 to 70.34 in treatment "4→3". In both cases, this decline in industry output is statistically significant.[17] Moreover, in both markets, total output drops to a value below the new Nash equilibrium prediction. Therefore, we have

Result 2 *In both markets the short-run effect of merger is more drastic than predicted: Total output drops below the Nash level.*

Given some time for adjustment, subjects' play may differ from that in the first third. Therefore, it seems warranted to have a look at the long-run effects induced by the merger. Here, we compare average total quantities in the last third post merger with those observed in the last third prior to merger. Inspecting Table 2 again, we see that, during the second phase of the experiment, total quantities rise in both treatments. In fact, in both cases they converge to a value close to the Cournot prediction. In treatment "3→2" average total output converges to 67.70 in the last third of the second phase where theory predicts an output of 66.67; in treatment

[15] One-sided Binomial test ($p = .017$). Our finding is consistent with results in Holt (1985) or Huck, Müller, and Normann (2001) who report that collusion frequently occurs in repeated Cournot settings with fixed pairs of participants.

[16] Using one–tailed Mann–Whitney U-tests, the p-levels are .0125 and .008, respectively.

[17] At $p = .023$ in treatment "3→2" and at $p = .014$ in treatment "4→3" (one–tailed Wilcoxon test).

"4→3" average total output converges to 75.12 where theory predicts an output of 75.00. However, although quantities are rising, we find that average industry output in the last third after the merger is still significantly lower than average industry output in the last third before the merger.[18] Summarizing we have

Result 3 *The long-run effects induced by a merger are in line with the prediction as average total quantities decrease from a value around the Nash equilibrium with n firms to a value that is close to the Nash equilibrium with $n-1$ firms.*

As argued in the introduction, we maintain that a market with a merger history may perform differently than one without a merger. If this is true at the aggregate level, output in post merger markets (last third) should be different from the output in pre merger markets (last third) with the same number of firms. However, the result above already indicates that this does not hold for three firms. Our experimental triopoly markets emerging from a merger do produce on average higher total outputs than triopoly markets without a merger history (75.12 vs. 72.96), but these differences are not significant.[19] Strikingly, with duopoly, we do find a stronger effect. From Table 2, we observe that duopoly markets emerging from a merger are more competitive than the duopoly markets without a merger history (67.60 vs. 60.01). And this difference is significant.[20] We summarize by

Result 4 *Duopoly markets emerging from a merger are significantly more competitive than duopoly markets without merger history. This does not hold for triopoly markets.*

The first part of this result indicates that our hypothesis, that history may matter, could indeed be relevant. Therefore, we turn in the next subsection to the analysis of firms' individual behavior.

3.2 Individual outputs

The central question in this subsection is: does merger history matter at the firm level? Is merger perceived as something that is equivalent to the exit of one firm, or does the fact that one of the remaining firms is generated by the fusion of two firms distinguish this firm from the others? Table 3 shows average individual quantities for the two types of firm. We observe the following facts:

[18] Again, a one–tailed Wilcoxon test, delivers $p = .058$ for treatment "3→2" and $p = .0865$ for treatment "4→3".

[19] $p = .3745$ (one–tailed Mann–Whitney U test)

[20] At $p = .0325$ (one–tailed Mann–Whitney U test).

	"4→3" (post merger)				"3→2" (post merger)			
	first 3rd		last 3rd		first 3rd		last 3rd	
merged	no	yes	no	yes	no	yes	no	yes
theory	24.75				33.00			
mean	20.04	30.25	22.62	29.88	28.25	35.02	31.25	36.35
(std. err.)	(0.89)	(1.71)	(1.96)	(2.59)	(3.00)	(2.16)	(3.04)	(2.30)

Table 3: Average individual quantities of (un)merged firms.

1. In post merger situations, the merged firms choose higher quantities than firms that have not been merged. This result is immediate from Table 3. For both treatments "4→3" and "3→2" we find that this result holds across the entire postmerger phase. In the first third, there are significant differences between merged and non-merged firms. In the last third, however, the gap in average output is slightly smaller than in the first third and is no longer significant in treatment "3→2". However, differences in treatment "4→3" are still significant.[21]

2. Merged firms also produce higher quantities than firms in markets with no merger history but the same number of competitors. More specifically, we compare the first and the last third of "3→2" post merger with the last third of "2const". And we compare the first and the last third of "4→3" post merger with the last third "3→2" prior to merger. In all four cases, the merged firm produces significantly more than a firm in a theoretically equivalent market without merger history.[22]

3. Unmerged firms in (post merger) markets with three firms produce slightly less than firms in three firm markets without a merger history. In the case of two firms, they produce slightly more. However, both observations can be reconciled by considering the behavior of the respective merged firms. Given the average quantity of a merged firm in the last third of "4→3", the unmerged firms play almost exactly according to the Cournot solution for the resulting residual demand (which predicts 23.04 and compares to 22.62). Similarly, the unmerged firms' best reply in the last third of "3→2" would be 31.33 which compares to an actual average of 31.25.

[21] First third: $p = .014$ ("4→3") and $p = .0325$ ("3→2"). Last third: $p = .087$ ("4→3") and $p = .23$ ("3→2"); one-tailed Wilcoxon tests.

[22] Treatment "4→3": first 3rd, $p = .020$; last third, $p = .027$. Treatment "3→2": first 3rd, $p = .055$; last third, $p = .0995$; one-tailed MWU tests.

Our experiments suggest that there is a behavioral asymmetry between firms. The data indicate that merged firms produce more and unmerged firms yield to this more aggressive behavior.[23] A consequence of this asymmetry is that markets with a merger history are more concentrated than comparable markets in which a merger has never occurred. This shows nicely in Herfindahl indices. While, in general, the indices are pretty close to the prediction, we find that triopolies that have resulted from a merger are significantly more concentrated than triopolies without that history.[24] The latter average index is 3,450, the former average index is 3,950, a difference significant at a p–level of 1.9% (one-sided MWU).[25]

We summarize our observations in the following

Result 5 *Merged firms produce more than their equilibrium share. Unmerged firms choose, on average, Cournot quantities with respect to the residual demand, given the output of merged firms. Accordingly, markets resulting from mergers tend to have greater Herfindahl indices.*

In the next subsection we supplement our analysis of individual difference by a regression that indicates the quantitative effects of merger history.

3.3 A panel model

In order to assess the explanatory power of merger history we estimate the following panel regression model:

$$q_{it} = \alpha_0 + \alpha_1 TRI + \alpha_2 QUAD + \alpha_3 HIS + \alpha_4 FUS + v_i + \varepsilon_{it}$$

where q_{it} is the individual quantity set by firm i in period t, ν_i is the subject-specific random error component and ε_{it} is the overall error component. The explanatory variables included are as follows.

[23] The overall picture is quite similar to the original Stackelberg (1934) logic on which we will elaborate later.

[24] Note, however, that increasing concentration is not necessarily associated with decreasing welfare. If concentration is caused by strategic market power, consumer rents may actually increase. See, for example, Daughety (1990) or Huck, Konrad, and Müller (2001).

[25] Based on the last thirds of the first phase of treatment "3→2" and the last third of the second phase of treatment "4→3".

- TRI and $QUAD$ are dummies for market size. Markets with $n = 2$ firms are the reference group. $TRI(opoly)$ is the dummy for market size $n = 3$ (i.e., $TRI = 1$ if $n = 3$ and $TRI = 0$ otherwise), and $QUAD(ropoly)$ is the dummy for $n = 4$ (i.e., $QUAD = 1$ if $n = 4$ and $QUAD = 0$ otherwise).

- $HIS(tory)$ is a dummy for merger history. That is, $HIS = 0$, if the decision stems from a round in phase 1 of the experiment (where no merger occurred) and $HIS = 1$ if the decision stems from a round in phase 2 of the experiment (where a merger has previously occurred in the market).

- $FUS(ion)$ is a dummy variable indicating whether or not the quantity is chosen by a firm that emerged from fusion, i.e., we have $FUS = 1$ in the case of a firm that resulted from a merger and $FUS = 0$ otherwise.

If firms were choosing Cournot-Nash equilibrium quantities, the parameters α_0, $\alpha_0 + \alpha_1$ and $\alpha_0 + \alpha_2$ would equal the theoretical equilibrium quantities chosen in oligopolies with 2, 3 or 4 firms, respectively, and the coefficients α_3 and α_4 would be equal to zero.

First we estimate the model without the dummy variables capturing market history and firm type. The results are shown in the left column of Table 4.[26] A Hausman (1978) test, however, indicates that this model is misspecified as errors and regressor are correlated. Adding the market- and firm-specific history variables, HIS and FUS, resolves the problem. The estimation results of the full model are shown in the right column of Table 4.

We make the following two observations:

1. The Nash equilibrium predictions for the numbers α_0, $\alpha_0 + \alpha_1$ and $\alpha_0 + \alpha_2$ are 29.783, 24.36 and 19.358 respectively. Thus, whereas firms produce on average a quantity below the equilibrium prediction in duopoly markets, in triopoly and quadropoly markets, firms' individual quantities accurately match the equilibrium predictions.

2. While the coefficient α_3 is negative but not significant, the coefficient α_4 is positive and both substantial as well as significant. This confirms that firms that emerged from a merger produce considerably more than others.

[26] Note that according to the Breusch and Pagan (1980) Lagrange multiplier test for random effects, for both GLS estimations the H_0-hypothesis $Var(\nu_i) = 0$ is rejected, indicating that there are individual effects in the data.

GLS random-effects panel regression $q_{it} = \alpha_0 + \alpha_1 TRI + \alpha_2 QUAD + \alpha_3 HIS + \alpha_4 FUS + v_i + \varepsilon_{it}$		
	without history dummies	with history dummies
α_0	32.090^{***}	29.783^{***}
	(40.326)	(25.869)
α_1 (TRI)	-7.425^{***}	-5.423^{***}
	(-10.877)	(-6.038)
α_2 $(QUAD)$	-13.766^{***}	-10.425^{***}
	(-16.013)	(-6.615)
α_3 (HIS)		$-.511$
		$(-.531)$
α_4 (FUS)		6.382^{***}
		(6.834)
R^2	.167	.206
Breusch-Pagan test	$\chi^2_{(1)} = 1078.73$	$\chi^2_{(1)} = 741.60$
	$p = .0000$	$p = .0000$
Hausman test	$\chi^2_{(2)} = 6.35$	$\chi^2_{(3)} = .34$
	$p = .0418$	$p = .9529$

Table 4: Results of the regressions. t-values in parentheses. *** indicate significance at the 1%-level.

	"4→3"			"3→2"		
phase	pre	post		pre	post	
	last 3rd	first 3rd	last 3rd	last 3rd	first 3rd	last 3rd
theory	784.1	612.6		1225.1	1089.0	
mean	773.0	886.1	744.0	1214.6	1202.6	1112.6
(std. dev.)	(89.0)	(73.3)	(92.0)	(69.1)	(123.8)	(115.4)

Table 5: Sum of profits of the two firms involved in the merger

3.4 Profits

We next turn to the question how merger affects the individual firms' profits. First of all, we consider the prediction of Salant, Switzer and Reynolds (1983) that Cournot mergers are not profitable. Table 5 shows the average profits of the two firms involved in the merger for the last third prior to the merger, and for the first and last thirds after the merger. It also shows the theoretically expected profits.

In treatment "3→2" the merging firms initially manage to sustain their profits. There is only a tiny insignificant difference. However, in later rounds, the profit of the merged firm falls by 7.8% which is significant at $p = 5.8\%$ (one-sided Wilcoxon). A slightly different picture emerges in treatment "4→3". Here, the merging firms initially increase their profits by 14.6% to see them drop back roughly to the original level in the last phase of the experiment (and stay far above the predicted equilibrium profits).

Thus, we find

Result 6 *When two firms merge in a market with three firms, their profits are eventually lower than in the pre merger market. When two firms merge in a market with four firms, they experience short–run gains while, in the long run, their profits remain virtually unaffected.*

Finally, we turn to the profits of the merging firms' competitors. Theoretically, they are expected to rise. Table 6 shows the average profits of the outside firms for the same time intervals as above. Here, the qualitative prediction of the theory is fully confirmed, although the two competitors of the merged firm in treatment "4→3" are not able to reach Cournot profits.

Result 7 *Average profits of outside firms increase substantially and significantly in both treatments. This is true in the short run as well as in the long run.*[27]

[27] The respective p–values are all below 5% (one-sided Wilcoxon).

	"4→3"			"3→2"		
phase	pre	post		pre	post	
	last 3rd	first 3rd	last 3rd	last 3rd	first 3rd	last 3rd
theory	392.0	612.6		612.6	1089.0	
mean	356.7	549.7	497.3	627.7	942.8	938.5
(std. dev.)	(26.8)	(40.4)	(58.6)	(31.8)	(71.2)	(85.5)

Table 6: Average profits of the firms not involved in the merger

Comparing Tables 5 and 6 we observe that, once the merger has taken place, firms' profits vary substantially even if we focus on the last third where the merged firms earn considerably less than in the initial adjustment phase. In the duopoly which results from the merger in treatment "3→2", merged firms earn on average 18.5% more than their competitors, in treatment "4→3" this figure becomes even 49.7%. Statistically, only the latter difference is significant ($p = 3.8\%$, one-sided Wilcoxon).

3.5 Merger psychology

While the results from our main treatment are clear, it is not easy to determine the correct explanation for them. Given the institutional details of our design, we find three plausible explanations for what we observe: (a) the mere fact that one firm has resulted from a merger renders the firm "strong" and the whole market asymmetric; (b) as the merged firms are jointly owned (and profits are to be shared), fairness considerations shift output from unmerged to merged firms; (c) merged firms are committed to maintaining their original profits because of aspiration levels created in the pre merger markets.

In order to be able to discriminate between (a) on the one hand and (b) and (c) on the other, we conducted a treatment which we will refer to as "4→3GO". This treatment is identical to "4→3" with one exception: after the two firms that merge are selected, and after one of the two participants involved is chosen as the manager of the newly merged firm, the second subject does not remain in the laboratory and is sent away. This subject received, in addition to the earnings of the first phase, a flat payment of DM 10 and this was observed by all subjects. The remaining subject received the total profits of the merged firm. Again we conducted six markets.

The hypothesis based on explanation (a) is that we should observe the same asymmetry between merged and unmerged firms as in the main treatment. The alternative hypothesis, based on either (b) or (c), is that the differences between merged and un-

	"4→3"			"4→3GO"			"3 + 1"
phase	pre	post		pre	post		
	last 3rd	first 3rd	last 3rd	last 3rd	first 3rd	last 3rd	last 3rd
theory	79.20	75.00		79.20	75.00		75.00
mean	81.17	70.33	75.12	80.11	69.62	73.50	75.38
(std. err.)	(2.59)	(2.03)	(3.09)	(1.86)	(2.25)	(2.12)	(1.48)

Table 7: Additional treatments: Total quantities

merged firms disappear. (b) makes this prediction as now all participants earn the same amount in equilibrium, also post merger. And (c) makes the same prediction as the sole owner of the newly merged firm now makes higher profits than before, i.e., profits above his/her potential aspiration levels. (We will elaborate on the notion of aspiration levels in detail below.)

The results of "4→3GO" are shown in Table 7 (total quantities) and Table 8 (individual quantities). From Table 7, we observe that there are only slight differences with respect to total output in treatments "4→3" and "4→3GO". For example, whereas total output in the last third before merger is 81.17 in treatment "4→3", it is 80.11 in treatment "4→3GO". Observed industry outputs in treatment "4→3GO" are slightly lower than in treatment "4→3", but these differences are statistically not significant.[28]

Next, consider (average) individual quantity choices of merged and unmerged firms in post merger situations as shown in Table 8. The result is striking: whereas we find significant and substantial differences in individual output of merged and unmerged firms in treatment "4→3" (see fact 1 in section 3.2), firms in "4→3GO" are more or less symmetric after the merger.[29] This clearly rejects explanation (a). History alone cannot explain the more aggressive and quite successful behavior of merged firms in our main treatment.

Thus, we are left with the fairness explanation (b) and/or the aspiration-levels explanation (c). To discriminate between them, we designed a further treatment which we will call "3 + 1". This treatment is identical with the second (post merger) phase of our main treatment "4→3". There is simply no first phase.[30] Thus, the treatment

[28] Pre merger, last third: $p = .873$; post merger, first third $p = .749$; post merger last third: $p = .575$ (two-tailed MWU tests).

[29] Note that, shortly after the merger, average quantities of merged firms are greater than those of others (24.94 vs. 22.34) whereas this reversed in the last third of the experiment (24.98 vs. 23.54). None of these differences are, however, statistically significant.

[30] Of course, there is also no merger between phases. Instead, the instructions introduce two firms, one with a sole owner and one with two joint owners.

	"4→3" (post merger)				"4→3GO" (post merger)				"3 + 1"	
	first 3rd		last 3rd		first 3rd		last 3rd		last 3rd	
merged	no	yes	no	yes	no	yes	no	yes	no	yes
theory	24.75				24.75				24.75	
mean	20.04	30.25	22.62	29.88	22.34	24.94	24.98	23.54	24.20	26.98
(std. err.)	(0.89)	(1.71)	(1.96)	(2.59)	(1.26)	(1.50)	(0.61)	(1.61)	(0.62)	(1.88)

Table 8: Additional treatments: Average individual quantities of (un)merged firms.

consisted of 25 periods and, as with all other treatments, we conducted six markets.

In "3 + 1" explanations (b) and (c) make opposite predictions. If fairness matters, one would expect asymmetric outcomes as in our main treatment "4→3". If instead aspiration levels are driving the results of our main treatment, one would expect symmetric Cournot-Nash equilibrium behavior. With the first phase missing, aspiration levels have not been induced.

The results of treatment "3 + 1" are also shown in Tables 7 (total quantities) and 8 (individual quantities). We focus exclusively on the last third when behavior has settled down. Although not decisive for our two explanations, let us start by considering total quantities as shown in Table 7. Total output in the last third of treatment "3 + 1" is 75.38 and, thus, matches the Nash equilibrium prediction as closely as did the last third of the two other treatments.

Next consider (average) individual quantities as shown in Table 8. We observe only a slight difference between the jointly owned firm and the two others. While the former produces on average an output of 26.98, the latter produce on average 24.20, roughly 10% less compared to roughly 25% in the main treatment. Moreover, the difference is *not* statistically significant. Thus, we can also rule out the fairness explanation (b). Indeed, it seems that the success of mergers in our main treatment is driven by aspiration levels. Firm owners do not want to see their profits fall. Merger history matters mainly because firms form aspiration levels prior to the merger.

4 Aspiration levels, oligopoly, and merger

In the late 1950s and early 1960s the maximization paradigm in economics seemed for a while imperilled. With Herbert Simon leading the charge, the notion of satisficing became a serious contender for a new paradigm. And, in contrast to much of (neo)classical theory, the building blocks that were envisaged to lay the foundation for

a new theory were largely based on empirical (and often experimental) evidence. One of these building blocks was that what decision makers find satisfactory is a function of (*i*) outside comparisons and (*ii*) past experience.[31]

In a fairly influential paper, Cyert and March (1956) applied the notion of satisficing to oligopoly theory. They claimed that firms are guided by an "acceptable-level profit norm" that is determined by experience and comparison. And, more importantly, they also provided empirical evidence for this claim. They found, for example, that firms fight harder to increase their sales if they experienced declining profits. This is exactly what we observe.

Related to this is a small effect we find in the messages that passive players could send to active players in the main treatments. In "4→3" it shows that the message "increase quantity" was only sent if firms experienced in the prior round decreasing profits (which accounts for 80% of all these messages) or constant profits (which accounts for the remaining 20%).[32]

Since the publication of Cyert and March's paper, more than forty years have passed during which models based on satisficing became pretty unfashionable. Recently however, they have experienced a renaissance[33] that seems to be closely related to the rise of evolutionary and learning models.

Evolutionary and learning models share one important feature with models of aspiration levels: They are truly dynamic and at least as much concerned with (transient) adaptations as with (long-run) asymptotics. In fact, there are many models which combine ideas from the literature on evolution and learning with aspiration levels. Examples include Karandikar, Mookerherjee, Ray, and Vega-Redondo (1998) who study how satisficing players achieve cooperation in 2x2 games; Posch (1999) who focuses on prisoners' dilemma games;[34] Kim (1999) who looks at common interest games; and

[31] For early experimental evidence see, e.g., Simon, Shaw, and Gilchrist (1954).

[32] Recall that the passive players were allowed to send messages in periods 7, 12, 17, and 22 of the second half. To analyse whether there are any other patterns in the messages we form groups based on the message sent. Then we compare the groups by analysing quantities, profits and changes in both prior to the message. We find that firms in which the passive player sent the "reduce quantity" message had a significantly higher output than firms where the passive player sent the "increase" message. This holds for both treatments. (The significance levels are $p = .02$ for "3→2" and $p = .05$ for "4→3.") Also, we analyse whether active players followed their partners' recommendations. We find that they do so in 30 of 60 cases. If the message indicates a change, i.e., if it is not "stay", active players follow it in 21 out of 35 cases.

[33] The *Journal of Mathematical Psychology*, for example, recently published a revised (and English) version of a classical German article by Sauermann and Selten (1962) on "aspiration adaptation theory" (Selten 1998).

[34] His approach is closely related to Nowak and Sigmund (1993) who rediscover Thorndike's (1911)

Börgers and Sarin (2000) who combine aspiration levels with reinforcement learning. All these models have one feature in common, namely that aspiration levels depend only on own payoff experiences and not on comparisons. Models in which aspiration levels are also based on outside comparisons include Posch, Pichler, and Sigmund (1999) who study under which conditions aspiration-based strategies become efficient in 2x2 games; and Palomino and Vega-Redondo (1999) who also analyze prisoners' dilemma games.

Papers studying traditional economic problems with aspiration-level models include Gilboa and Schmeidler (2001) who analyze how satisficing consumers react to price changes[35] as well as Dixon (2000) and Oechssler (2001) who both study how behavioral rules based on aspiration levels can induce collusion in Cournot games. In contrast to this, our results indicate that aspiration levels may also cause more aggressive behavior in markets to which others, in turn, yield.

What happens in our experiments looks, in fact, very similar to Stackelberg's hypothesis that there may be behaviorally strong and weak firms even if they share the same technology. Today's game–theoretic interpretation of Stackelberg's "leader-follower" model implies a sequential order of moves. But Stackelberg's original idea[36] was purely behavioral. Stackelberg followers are firms that react according to the Cournot best-reply logic while Stackelberg leaders are firms that consider themselves stronger and, anticipating the "weakness" of followers, take strategic advantage of the adaptive behavior of their competitors and produce higher quantities. Our experiments suggest an explanation based on industry structure and aspiration levels for this behavioral asymmetry.

Here we do not want to develop a fully-fledged aspiration level-based theory of merger in oligopoly but we would like to highlight at least two implications our findings may have for markets outside the laboratory.

- Merger success might become a self-fulfilling prophecy. In a world where mergers are endogenous, firms have to form believes about market outcomes post merger. Hence, observing a voluntary merger, competitors might expect that the merging firms want to sustain at least their original profits. Otherwise they shouldn't

win-stay, lose-shift strategy which, essentially, is based on aspiration levels and plays an important role in many new studies.

[35] This is an application of Gilboa and Schmeidler's (1995) case-based decision theory which can be seen as an axiomatic foundation for satisficing behavior.

[36] See Stackelberg (1934, pp.16-24).

have merged. This argument is similar to forward-induction reasoning where past decisions convey information about future intentions (see, e.g., van Damme, 1989). As firms have the (outside) option of simply continuing without a merger, the decision to merge conveys some vital information about their future plans. If this works, as it largely did in our experiment, a merged firm might sell more than its competitors even if firms are otherwise completely symmetric. If firms anticipate this kind of "merger psychology", they may very well go ahead and join forces.

- Merged firms that nevertheless incur losses might be expected to use more aggressive pricing or marketing strategies than normally predicted. This hypothesis, it seems to us, should be genuinely testable with field data. For example, one could analyze whether merged firms are more likely to start expensive advertising campaigns.

5 Conclusions

In the experiments reported in this paper, we imposed mergers in three and four firm Cournot oligopolies. With respect to the two central economic questions—profitability and welfare—we find that theory predicts welfare effects well. Based on the U.S. merger guidelines, the mergers in our experimental markets would probably have been challenged, and the significant reduction of competition and welfare show that the guidelines would have been appropriate in these cases.

With respect to profitability, theory largely fails. This is an immediate consequence of its failure at the level of individual behavior. Post merger markets are not symmetric. A likely explanation for this is that subjects form aspiration levels prior to the merger. Therefore, merged firms produce a larger output compared to unmerged firms, and unmerged firms yield to the more aggressive behavior of merged firms. As a result, in our experimental markets, a merger is something very different from the exit of a firm even in symmetric Cournot oligopoly with constant marginal cost. Merger psychology plays an important role as firms' market power is not perceived as being symmetric. In the larger markets with initially four firms, this behavioral asymmetry is sufficient to render the merger profitable in the short run, and to enable firms to break even in the long run. So, in contrast to theory, firms might have an incentive to merge even if there are no cost advantages from merging.

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Instructions of treatment "4→3"

Welcome to our experiment!

Please read these instructions carefully! Do not speak to your neighbors and keep quiet during the entire experiment! If you have a question raise your hand! We will come to you.

In this experiment, you will repeatedly make decisions. By doing this you can earn money. How much you earn depends on your decisions and on the decisions of other participants. All participants receive the same instructions.

You will stay anonymous for us and for the other randomly chosen participants you get in touch with during the experiment.

In this experiment, you represent a firm that, like three other firms, produces and sells one and the same product in a market. You will be continually matched with the same other participants. Costs of production are 1 ECU per unit (this holds for all firms). All firms will always have to make one decision, namely, the quantity they wish to produce.

The following important rule holds: the larger total quantity of all firms the smaller the price will emerge in the market. Moreover, the price will be zero from a certain amount of total output upwards.

Your profit per unit of output will then be the difference between the market price and the unit cost of 1 ECU. Note that you can make a loss, if the market price is below the unit costs. Your profit per round is thus equal to the profit per unit multiplied by the number of units you sell.

In each round the outputs of all four firms will be registered, the corresponding price will be determined and the respective profits will be computed.

From the second period on, in every period you will learn about the total output produced by the other firms and your own profit of the previous period.

Furthermore, you may simulate your decisions in advance. You can do this on the left side of the decision screen. You may simply enter an arbitrary value for your own output and for the total output of the other firms. After pressing the "compute" button, you will be shown the profit that would result for you in the upper left corner of the screen.

Once you have decided about your quantity, you enter it on the right hand side of the screen and press the "OK" button.

In the first phase of the experiment, there are 25 periods. We will tell you about the rules for the second phase after the first phase is over.

Your payment consists of the earnings made in all periods. At the end of the experiment, your earnings will be changed into DM. You will receive 1 DM for every 300 ECU. At the beginning of the experiment, you will receive a initial payment of 500 ECU.

Instructions for the second phase of the experiment.

In the second phase of the experiment, two of the four firms in the market will merge so that there are only three firms left in the market. Which firms merge will not be decided by you but by a random choice of the computer. Before we start the second phase we will let you know whether or not you are participating in the merger.

The second phase of the experiment consists again of 25 periods.

While the two firms which do not participate in the merger continue deciding about their output, only one of the two firms participating the merger will decide about the output of the merged firm. The other firm participating in the merger can only send a message to the firm which decides for the merged firm at the beginning of the second period (and at the beginning of the 7th, 12th, 17th, and 22nd period). More precisely, this firm can recommend producing "more", "less" or "as much as before". This message will not be sent to the firms not participating in the merger. The decision about which of the two participants decides about output and who may send messages is again determined by a random computer choice. Note that the profits of the merged firms will be split equally. When you participate in a merger, you will get half the profit of the merged firm.

All firms, whether participating in a merger or not, will, from the second period on, in every period learn about the total output produced by the other firms and about the individual output and profit of the previous period.

Again, all participants who have to decide about output may simulate their decisions in advance.

Your payment in the second phase consists of the earnings made in all periods.