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Firm-specific information and explicit collusion in experimental oligopolies

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ABSTRACT

We experimentally study the effect of information about competitors' actions on cartel stability and firms' incentives to form cartels in Cournot markets. As in previous experiments, markets become very competitive when individualized information is available and participants cannot communicate. In contrast, when communication is possible, results reverse: markets become less competitive and cartels become more stable when individualized information is available. We also observe that the extra profits that firms obtain thanks to the possibility to communicate are higher when individualized information is present, suggesting that firms have greater incentives to form cartels in that situation.

1. Introduction

What is the impact of publishing firm-specific data on competition in oligopolistic markets? This question has been subject to a lively debate in the economics literature. The debate goes at least back to Stigler's (1964) work. Stigler argues that market transparency facilitates collusion because firms are better able to monitor other firms deviating from a collusive agreement so that deviations can be punished more effectively.[1] Stigler's reasoning found fertile ground in the literature and can still be found in modern industrial organization textbooks. However, in the late 1990s, new theoretical insights saw the light that would cast doubt on the universality of Stigler's results. In particular, Vega-Redondo (1997) analyzes imitation learning and bounded rationality in homogeneous Cournot markets and derives the exact opposite result than Stigler's: Full disclosure of individual data makes Cournot markets more competitive, not less, when firms imitate the most profitable firm.[2]

The empirical literature has not settled the debate. Albaek et al. (1997) find support for Stigler's argument by observing a 15–20% increase in prices within one year following the Danish antitrust authority's decision to publish firms' prices in the ready-mixed concrete market. In contrast, laboratory results are more in line with Vega-Redondo's results. Laboratory markets tend to become more competitive when information about individual profits, quantities and

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[1] See, e.g., Green and Porter (1984) for a formalization of the argument in a repeated-game model.

[2] Schenk-Hoppé (2000) and Huck et al. (2000) generalize and extend Vega-Redondo's (1997) model.

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0014-2921/

prices is available than when only aggregate information is available (Huck et al., 1999, 2000, Offerman et al., 2002, Altavilla et al., 2006).[3] Imitation seems to be an important driving force: when individualized information about conduct and profits of competitors is available, participants tend to mimic the most successful firm, which is typically the firm producing the largest quantity.[4]

The question of the impact of publishing firm-specific data on competition is not only of academic interest. In December 1986, the European Commission decided in the *Fatty Acids* case that information sharing between Unilever, Henkel, and Oleofina violated Article 85(1) of the Treaty of Rome (now Article 101(1)).[5] Kühn (2001) argues more in general that "[i]ndividualized information exchange about past prices and quantities should […] be considered an anti-competitive agreement in the sense of Art. 81(1) [now Art. 101(1)]." In contrast, regulators sometimes take an effort to increase a market's transparency. For example, since the 2007–2008 financial crisis, financial regulators have imposed increasingly stringent transparency requirements for financial service providers. While the reasons for increasing transparency may lie outside the scope of competition between firms, they may have an effect on it, be it positive or negative.

In this paper, we take the position that the effect of publishing firm-specific data may depend on the opportunities for firms to collude explicitly. The publication of firm-specific data may result in two undesirable effects. First, it may increase cartel stability for the reasons put forward by Stigler (1964). Second, it may increase firms' incentives to form cartels, not only because it stabilizes cartels but also because the market may become more competitive otherwise as Vega-Redondo (1997) has pointed out. Existing experiments do not allow for identification of either effect. The reason is that in these experiments participants were not allowed to communicate so that explicit collusion was ruled out by construction. In other words, when participants wanted to collude, they could do so only tacitly. However, tacit collusion is rarely observed in the lab when oligopolies consist of three or more firms (Huck et al., 2004). The aim of our paper is to add to the debate by experimentally studying whether the effect of publishing firm-specific data on competition may depend on whether or not firms have the opportunity to form cartels.

In our experimental markets four identical firms chose quantities simultaneously for 50 periods. We exploit a two-treatment design. In the individualized information treatment, after each period, participants were informed about their own price and profits, the aggregate quantity of the market, and the quantities and profits of each of the other three firms. In the aggregate information treatment, participants only received information about their own price and profits and the aggregate quantity produced in the market. In both treatments, firms could not communicate for the first 25 periods. After that, a chat window was opened that enabled firms to communicate. Communication was optional, with no content or time restrictions, and possible every five periods.

We can summarize the results as follows. First, we found that communication helped to coordinate on collusive outcomes in both information scenarios.[6] Market quantities dramatically decreased once firms could communicate, with most of the groups producing exactly the symmetric collusive quantity in both treatments. In addition, as in previous experimental studies, when communication was not allowed, quantities were significantly higher when individualized information was present. However, when communication was introduced, results reversed and quantities were lower with individualized information. Variations in cartel stability drive this result. When participants observed individualized information, members deviated less frequently from a collusive agreement than when only aggregate information was available.

To identify treatment effects regarding firms' incentives to form cartels, we follow Fonseca and Normann (2012) by measuring the gain from communication, i.e., the extra profits firms earn when communication is possible compared to the situation where communication is not allowed. We observe that the gain from communication is significantly higher in the individualized information treatment than in the aggregate information treatment. This result suggests that publishing firm-specific data may encourage firms to form cartels because the benefits of doing so are higher when individualized information is available, while the costs (probability of detection/punishment) would be the same in both information scenarios.

The paper is organized as follows. The next section presents the experimental design and protocol. In Section 3, we discuss the theoretical predictions. Section 4 contains the experimental results. Section 5 concludes.

[3] See Potters (2009) for a review of laboratory experiments examining the effect of transparency on the competitiveness of markets.

[4] Information sharing could also dissolve demand or cost uncertainty, which could be beneficial for both firms and consumers. See Kühn and Vives (1995) for an overview of this literature.

[5] Commission decision 87/1/EEC [1987] OJ L 3/17 (Case IV/31.128). See Kühn and Vives (1995) and Kühn (2001) for elaborate discussions of the case.

[6] It is broadly documented in the literature that communication helps participants cooperate in oligopoly games and other dilemma games. See Crawford (1998) and Balliet (2010) for surveys of the literature. Recent experimental studies on the effectiveness of communication in oligopoly games include Daughety and Forsythe (1987), Waichman and Requate (2014), and Normann et al. (2015) for Cournot games, and Andersson and Wengström (2007), Cooper and Kühn (2014), and Fonseca and Normann (2012, 2014) for Bertrand games. A different strand of the experimental literature deals with the question how players can credibly communicate private information (Dickhaut et al., 1995; Blume et al., 2001; Cai and Wang, 2006; Wang et al., 2010; De Groot Ruiz et al., 2014).

2. Experimental design and protocol

All sessions consisted of oligopoly market games where four identical firms, labeled $i = 1, \ldots, 4$, played a repeated differentiated Cournot game (fixed matching). Each firm i was represented by a participant who had to choose the firm's quantity q_i in each period. Marginal costs are constant and equal to $c > 0$. Firm i faced the following inverse-demand function:

$$P_i = \max\left\{a - q_i - \theta \sum_{j \neq i} q_j, 0\right\}, a > 0, \theta \in [0, 1),$$

where a and θ represent demand parameters that are constant across firms. Because $\theta \in [0, 1)$, products are differentiated and therefore market prices need not be the same (firms may charge different prices for their products). We used the following parameters in the experiment:[7]

$$a = 150, \theta = \frac{2}{3}, \text{ and } c = 2.$$

We employed differentiated products rather than homogeneous ones for the following reasons. First, under differentiated products, participants make strictly positive profits in the imitation equilibrium in contrast to the homogeneous products case. A zero-profit outcome could be relatively unattractive for participants so that it may steer their behavior away from it. Second, the homogeneous-product Cournot game has a large range of joint-profit maximizing outcomes (any outcome in which total quantity equals the monopoly quantity) in contrast to the heterogeneous-products game. We discuss the theoretical predictions in more detail in the next section.

All participants had full information about the demand and cost structure. In the instructions, formulas were provided. In addition, examples helped participants to understand how their own decisions and the quantities decided by the other firms affected the price at which they would sell the product. Moreover, they had access to an on-screen profit calculator in order to facilitate decision-making. The calculator gave the profits they would obtain under any combination of their own quantity and the total quantity produced by the other firms. The calculator was available at all times and the participants could try as many quantity combinations as they wanted. In contrast to related experiments such as Huck et al. (1999, 2000), the calculator did not include a best-response button, because we feared that this would steer behavior.[8]

We employed two information treatments, which varied in the information available to the participants about other firms' actions and outcomes. In both treatments, firms interacted for 50 periods in fixed groups. In each period, firms simultaneously chose their quantities from the set of integers between 0 and 200. In the aggregate information treatment (AGG), at the end of each period, participants were only informed about their own selling price, their own profits, and the aggregate quantity produced in the market in the current period. In the individualized information treatment (IND), in addition to the information revealed in AGG, firms were informed about the quantity decisions by each of the other three firms and their respective profits. As a way of illustration of how information was provided to the participants, Fig. A1 in Appendix A shows a screen shot for both treatments.

Communication possibilities are varied within-subjects. Both AGG and IND consisted of two parts of 25 periods each. In part 1, participants could not communicate while in part 2 they could communicate with the other firms in the same market using a chat window at the start of every five periods, i.e., in periods 26, 31, 36, 41, and 46. Firms had access to the profit calculator during the chat. During part 1, we did not inform the participants about the possibility to communicate in part 2. Our communication protocol closely follows Fonseca and Normann (2012). There was no time limit and the content was unrestricted[9] for several reasons. First, cartels in real life usually arise from unrestricted communication among firms (the only restriction is that communication should be secret). In addition, restricting messages could have induced experimenter demand effects. Finally, previous literature has found that open communication is more effective in facilitating collusion in experimental markets than restricted communication.[10] In our experiment, communication was costless and there was no risk to be discovered by an antitrust authority. This allows us to identify the benefits of communication, which, in turn, is informative about what information regime is more conducive to cartel formation in a setting where communication is costly. All chat content and all operations made in the profit calculator were recorded.

We did not include additional treatments where the parts of the experiment were reversed. Fonseca and Normann (2012), in a similar oligopoly market experiment, did not find order effects, i.e., the effect of communication for the competitiveness of oligopoly markets is the same when communication is preceded by periods of no communication than when

[7] Our demand is half the demand used in Huck et al. (2000), while the marginal costs are the same in the two experiments.

[8] Requate and Waichman (2011) observe that a profit calculator does not yield different results than a payoff table unless the profit calculator contains a best-response button.

[9] The usual restrictions were imposed: participants were not allowed to use offensive language or to reveal their identity.

[10] Earlier experiments show that the set of messages that participants can use to communicate is quite crucial for sustaining collusion in laboratory markets. Cooper and Kühn (2014) find that collusion is persistent when rich communication between participants is possible, but not when only messages referring to cheating or punishing are allowed. The recent literature on the effectiveness of anti-cartel policy uses both non-restrictive communication (Apesteguia et al., 2007; Bigoni et al., 2014; Dijkstra et al., 2014) and restrictive communication (Hinloopen and Soetevent, 2008; Bigoni et al., 2012, 2015; Hinloopen and Onderstal, 2014).

Table 1
Experimental design.

Treatment	Information for firm i	Part 1 (25 periods)	Part 2 (25 periods)
AGG	$P_i, \sum_{j\neq i} q_j, q_i, \pi_i$	No communication	Free communication
IND	$P_i, \sum_{j\neq i} q_j, \left\{q_j, \pi_j\right\}_{j=1}^{4}$	No communication	Free communication

Notes: P_j (q_j) [π_j] represents firm j's price (quantity) [profits], $j = 1, \ldots, 4$.

this order is reversed. Table 1 summarizes the parts and treatments of the experiment. Both printed and computerized instructions were provided to the participants. A copy of the instructions for IND can be found in Appendix B. Before the experiment started, participants answered test questions to make sure that they understood the demand function they faced and the information to which they would have access after each period. In addition, participants could try the profit calculator before the experiment started.

We ran nine computerized experimental sessions, four sessions for AGG and five sessions for IND, at the CREED laboratory, University of Amsterdam.[11] The 144 participants were students from a variety of areas (approximately half of them having a background in Business or Economics). Depending on the number of participants that showed up, three to five groups (markets) of four people were formed in each session. In total, 18 markets were formed in both AGG and IND. Each participant only participated in one of the sessions. Participants were randomly allocated to different computers so they could not infer which participants were in the same market. Sessions lasted between 75 and 100 min. Payment consisted of a show-up fee of 7 euros plus a payoff related to the total profits earned in the 50 periods. In particular, 5000 experimental points were equivalent to 1 euro. Average earnings for participants, including the show-up fee, were 21.99 euros.

3. Theoretical predictions

In this section, three predictions for the experimental Cournot game are described: the one-shot Cournot-Nash equilibrium, the collusive benchmark, and the imitate-the-best benchmark.

The Cournot game has a unique one-shot Cournot-Nash equilibrium where all firms choose quantity[12]

$$q^{COURNOT} = \frac{a-c}{2+3\theta} = 37.$$

Choosing this quantity in each period is also a subgame perfect Nash equilibrium for the finitely repeated Cournot game. On the basis of the existing experimental literature on four-firm oligopoly games,[13] we expect this outcome when communication among participants is not allowed and when a behavioral rule based on imitation is not possible (this is the case when individualized information is not presented to the individuals as in our treatment AGG).

Secondly, it is often observed in experiments that if the time horizon is long enough, participants may behave as if the time horizon is infinite. Therefore another possible theoretical benchmark prediction is a symmetric collusive outcome where firms maximize their joint profits. If participants in the lab perfectly collude, the individual quantity is:[14]

$$q^{COLLUSION} = \frac{a-c}{2+6\theta} \approx 25.$$

On the basis of the current literature on four-firm oligopoly games, this scenario is expected to arise only if firms can communicate.[15] In addition, according to theory, the stability of collusive agreements does not depend on whether or not individualized information about other firms' quantities is revealed. In our setting, firms can perfectly deduce when another firm has deviated by observing the individual price or the total quantity produced by the other firms. So, in contrast to Stigler's (1964) and Green and Porter's (1984) setting, in our setting publishing individualized information should not affect cartel stability.

Finally, the last benchmark prediction is based on individuals using an imitation rule. If participants imitate the firm with the highest earnings (and make a mistake with a small probability by randomizing uniformly over the quantity space), the

[11] The program was written using PHP and mySQL.
[12] In Appendix D, we show that the outcome remains unique if the strategy space is restricted to integers only, as in the experiment.
[13] See Huck et al. (2004) for an overview of this literature.
[14] Quantities are rounded to the nearest integer as in the experiment participants can only enter integer quantities. The joint-profit maximizing symmetric outcome is when all firms produce 25. However, firms yield slightly higher total profits if one of them produces 24 and the others 25.
[15] See Fonseca and Normann (2012).

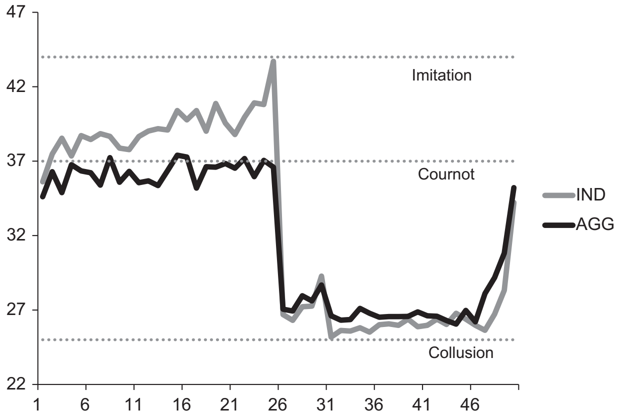

Fig. 1. Evolution of average individual quantities per treatment.

Table 2
Average individual quantities per treatment.

	IND	AGG	*p*-Value (Mann–Whitney test)
Part 1, periods 6–20: no communication	39.17 (1.75)	36.24 (2.14)	< .001
Part 2, periods 31–45: communication	25.98 (4.36)	26.50 (2.84)	.046
p-Value (Wilcoxon test)	< .001	< .001	

Notes: Standard deviations between brackets; *p*-values are from 2-sided tests.

prediction for individual quantities is:[16]

$$q^{IMITATION} = \frac{3(a-c)}{6+6\theta} \approx 44$$

Huck et al. (2000) show that the same outcome emerges in a Nash equilibrium if firms are assumed to maximize relative profits rather than absolute profits.

Note that the imitation benchmark predicts more competitive market outcomes than the Cournot-Nash equilibrium. As discussed in the introduction, the experimental literature suggests that the imitation benchmark is a good predictor in environments without communication where individualized information is provided, like in our IND treatment.

4. Results

This section reports the experimental results. Statistical analyses employ non-parametric two-sided Mann–Whitney and Wilcoxon tests with groups (18 in both AGG and IND) as independent observations. Section 4.1 describes the differences in quantities produced between treatments and parts, i.e., how communication and the availability of firm-specific information affect the competitiveness of the experimental markets. Section 4.2 focuses on the stability of cartels formed when communication is possible. Section 4.3 examines the effect of presenting individualized data on the gain from communication.

4.1. Quantities

Fig. 1 plots the evolution of average individual quantities per period and per treatment. In the first part of the experiment, quantities are higher in IND than in AGG. This difference increases over time, suggesting that participants tend to imitate the most successful firm, which is usually the firm producing the highest output (an analysis of the use of imitation and best-reply strategies in the no-communication part is included in Appendix C).

As of period 26, the first period in which firms can communicate, we observe a dramatic decrease in quantities produced in both treatments. In the following periods, average quantities are reasonably stable over time. Only in the first periods and in the last periods, quantities are somewhat higher.

[16] The proof of this result can be found in Huck et al. (2000). In the discrete environment implemented in the experiment, all choosing a quantity of 44 constitutes a Walrasian equilibrium and, hence, an imitation equilibrium (see Vega-Redondo (1997)).

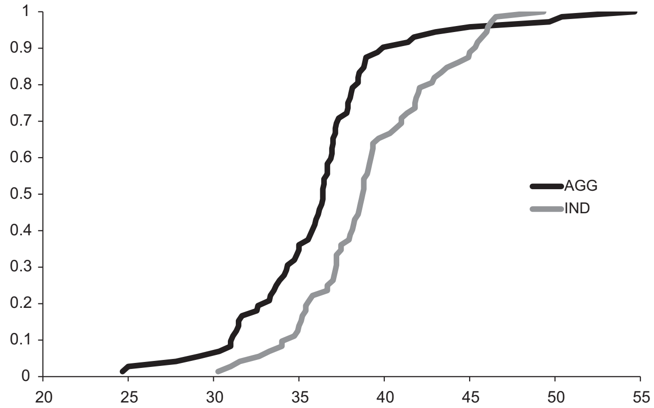

Fig. 2. Cumulative distributions of average individual production in the first, no-communication part of the experiment (periods 6–20).

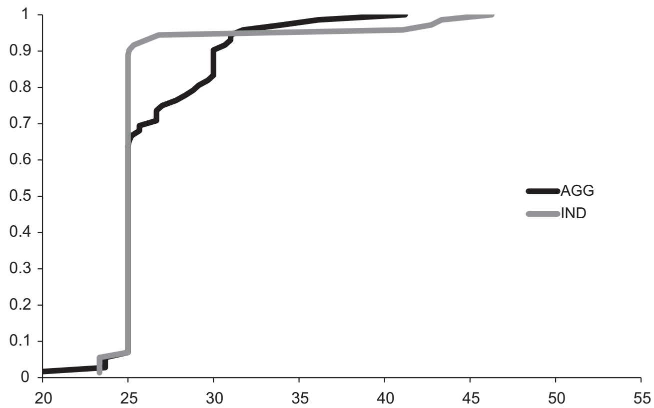

Fig. 3. Cumulative distributions of average individual production in the second, communication part of the experiment (periods 31–45).

In the remainder we focus on the periods 6–20 and 31–45 to exclude learning and end-game effects. Table 2 shows average individual quantities produced in a market over all groups per treatment and per part.[17] First, note that, when communication is not possible, the average individual quantity in AGG is close to the one-shot Cournot-Nash prediction (37). Moreover, the average quantity produced in IND is between the Cournot-Nash outcome and the imitate-the-best benchmark (44). More importantly, when communication is not possible, the average quantity produced is significantly higher in IND than in AGG. This means that information about competitors' actions and profits makes markets more competitive when firms do not communicate. This is in line with the previous experimental literature. Moreover, when communication is not possible, firms do not manage to collude in either treatment: there is not a single period in the first part of the experiment where the total quantity produced by a group is close to the symmetric collusive total quantity of 100 (25 each firm).[18] So, we can clearly reject the hypothesis that collusion is more stable when firms can observe individual decisions of other firms in the same market when communication is not possible. When communication is possible, two important effects become apparent. First, the average quantity produced in the communication part is significantly lower than in the no-communication part for both treatments. Non-restricted communication turns out to be quite helpful for participants to coordinate on collusive outcomes. Second, the difference in quantities produced among treatments is reversed: now IND is less competitive than AGG. This suggests that firm-specific data affects the competitiveness of oligopoly markets in a different direction when firms communicate.

Summarizing, we find the following results:

Experimental result 1: The average quantity is significantly lower in the communication part than in the no-communication part for both treatments, meaning that communication helps to coordinate on collusive outcomes in both information scenarios.

[17] Tables C1 in the Appendix C present, for each group, average individual quantities over periods 6–20 and 31–45 in each of the treatments and in both parts of the experiment.

[18] The lowest total quantity produced in a group in a certain period of the no communication part was 122.

Experimental result 2: If firms cannot communicate, the average quantity is significantly greater in IND than in AGG. In contrast, if firms can communicate, the average quantity is significantly greater in AGG than in IND.

Figs. 2 and 3 further illustrate this result. Each line in the graph represents the cumulative distribution function of the average individual quantity produced in each treatment. Fig. 2 refers to the periods 6–20, where communication is not possible. Fig. 3 refers to the periods 31–45, when communication among firms in the same market is possible: in both treatments a production of 25 is most common,[19] but in the AGG treatment about 35% of the production are higher than 25, compared with less than 10% in the IND treatment. Therefore, we can conclude that individualized information about competitors' actions and profits affects the competitiveness of oligopoly markets in opposite directions depending on whether firms communicate or not. Markets are more competitive when individualized information is available and communication is not possible, but become very anticompetitive when communication among firms is possible. In the next section this fact will be related to the stability of collusive agreements formed in the second part of the experiment.

Fig. 3 suggests that the likelihood of perfect collusion depends on the information available to the firms in the same market. Collusion is defined to be 'successful' in a period when the group production lies in the interval [96,104]. The average number of periods (out of periods 31–45) with successful collusion is 13.7 in IND and 10.3 in AGG, and this difference is statistically significant (Wilcoxon test, $p=0.038$). We can state the third result as follows:

Experimental result 3: With communication, we observe successful collusion in a greater number of periods in IND than in AGG.

4.2. Cartel stability

In the first part of the experiment, when communication among participants in the same group is impossible, formal cartels are ruled out and only implicit collusion may arise. However, we do not find successful collusion (group production in the interval [96,104]) in any period. This is in line with previous experimental literature in oligopoly markets that suggests that tacit collusion is very unlikely in experimental markets with four firms (Huck et al., 2004).

In the second, communication, part of the experiment, cartel formation is possible. We define a cartel to be formed when at least one of the following two events occur:

a) All participants in the same market explicitly agree in the chat to produce a certain quantity. Usually this happens as follows. Someone suggests a certain quantity that each firm should produce per period. Then participants discuss, and finally all explicitly agree about the quantity suggested.
b) All played a certain quantity discussed in the chat for at least 3 consecutive periods. It may be the case that one or more of the participants in the same group did not say explicitly "ok" or "I agree" in the chat but implicitly agreed with the strategy. If all the participants produce the quantity discussed in the chat for 3 or more consecutive periods, the cartel is considered to be formed.

The previous section showed that successful collusion is more often observed in IND than in AGG. This can be caused by *more* cartels formed in IND, or by the cartels in IND to be more stable, or both. However, all groups in both treatments formed cartels in the periods 31–45 with only two exceptions, one in IND (IND.3) and one in AGG (AGG.2). This suggests that a difference in the stability of cartels is the driving force.

The stability of a cartel can be measured in several ways. When counting the average number of individual deviations from the agreement per group, we find many more deviations in AGG than in IND (3.35 versus 0.29, Mann-Whitney, 2-sided $p=0.040$).[20] The longest sequence of no deviations is on average 11.4 in AGG and 14.5 in IND (Mann–Whitney, 2-sided $p=0.034$). Fig. C1 in Appendix C illustrates the difference in cartel stability between treatments.

Experimental result 4: Collusion is more stable (i.e., fewer individual deviations from a cartel agreement emerge) in IND than in AGG.

To conclude, cartels are more stable in IND than in AGG, explaining the difference in quantities found in previous section. This result may arise because participants in IND feel ashamed to deviate from the quantities agreed upon when other participants can observe their individual decisions. This individual monitoring is not possible in AGG, allowing participants to hide behind the aggregate quantities and making competitors not able to distinguish who is the one cheating. The chats presented in Appendix E provide some anecdotal support for this intuition.[21]

[19] In one group, one firm produced 24 and the other three firms 25, which yields higher joint profits than all producing 25 (see also footnote 14). This group only managed to coordinate on this outcome once, in the very last period of the experiment.

[20] This measure ignores the size of the deviations. An alternative measure, suggested by a referee, is to calculate in each period the relative overproduction: (production – agreed production)/(agreed production) and average this for each group. We find that in AGG the total production in a period is on average 1.85% more than agreed upon, and in IND this is only 0.16%. The difference is statistically significant (Mann–Whitney test, 2-sided $p=0.033$).

[21] In AGG, in nine groups, when a firm deviated, participants tried to find out in the chat who did so. Only in one case did the deviating participant admit that it was him or her who deviated, indicating that participants indeed feel ashamed to be recognized as a cheater. In line with this, in one group in IND (out of three where someone deviated), the deviating participant publicly apologized after the other participants complained about his or her behavior.

Table 3
Average gain from communication per period and per treatment.

	IND	AGG	*p*-Value 2-sided Mann–Whitney test
Per-period gain from communication	608 (259)	390 (175)	0.001

Notes: Periods 6–20 (no communication) and 31–45 (communication). Standard deviations between brackets.

Individuals may also be less likely to deviate in IND than in AGG because in the former treatment, a very competitive outcome is imminent if the cartel breaks down. If this alternative explanation has any bite, also within treatments, we should find more stable cartels in part 2 for groups that experienced a more competitive outcome in part 1. To check whether such patterns emerge in the data, we ran separate logit regressions for both treatments to test whether the average group quantity in part 1 explains whether or not there was a deviation in a group in part 2. While both regressions show the expected negative sign for part-1 average quantity, the estimated coefficients are small are far from statistically significant. Similar results emerge in various other regressions that explain decisions in part 2 (regarding deviations, quantities, or profits) on various outcomes in part 1 (regarding quantities or profits). All in all, the threat of competition does not seem to be an important driving force behind the observed treatment effect.

4.3. Gain from communication

It is clear from previous sections that communication helped firms to coordinate on collusive outcomes by reducing the total quantity produced in the market. This is reflected in the profits that firms earned in each part of the experiment. Firms' average profits increased by about 39% when communication was possible. Average individual profits during the first part of the experiment were 1263 experimental points per period and in the second part 1762 experimental points per period. In addition, participants clearly anticipated this fact. Almost all participants (138 of 144) that took part in the experiment decided to access to the first chat window and participate in the conversations. This suggests that participants anticipated the fact that communication among firms in the same market may have a positive impact on their profits. This positive influence of communication on profits earned by a firm is what Fonseca and Normann (2012) called "gain from communication".[22] The gain from communication is a measure for the incentives for firms to start illegal conversations. This section compares the gain from communication in the two information scenarios.

Table 3 contains the average gain from communication per treatment, i.e. the average extra profits that a participant earns per period in the communication stage compared to the profits during the no communication stage. Table 3 shows that on average, the extra profits that a participant earns when communicating in IND is almost twice as large as the extra profits earned in AGG. This difference is statistically significant. As a consequence, the gain from communication is higher in IND than in AGG. Observe that this result is mainly driven by the relative competitiveness in the IND treatment without communication (although the cartels are also more stable in IND than in AGG).

This result has important policy implications. Firms in markets where firm-specific data is accessible have stronger incentives to secretly talk and try to reach collusive agreements. The reason is that the potential gains of these talks are higher under this information scenario. Not only would cartels be more stable when individualized information is available, as shown in the last section, but firms (ex ante) would also know that potential collusive talks would have bigger benefits in that situation. As a consequence, publishing individualized information may encourage firms to talk in order to try to form cartels, because the benefits of doing so increase, but the costs (probability of detection or punishment by an antitrust authority) remain the same.

5. Conclusion

The effect that firm-specific data have on the competitiveness of oligopoly markets is still an open debate in the economic literature. In our experiment, we compared markets where individualized data is available to participants (IND), with markets with only aggregate data (AGG). In the first part of the experiment communication among firms was not possible and, as in previous experiments, IND markets were more competitive than AGG markets. In the second part of the experiment unrestricted communication among participants in the same market was introduced. This reversed the results: IND markets were *less* competitive than AGG markets. In particular, collusive agreements were more stable in IND. This is surprising in that in both treatments, participants could find out that someone cheated because the aggregate quantity would increase. So, theoretically, the likelihood of being caught cheating does not differ between treatments. However, anecdotal evidence obtained from the chats suggests that participants feel ashamed to be identified as a cheater. This could explain why fewer participants deviated in IND because only in that treatment, all competitors could monitor individual

[22] In a follow-up experiment, Fonseca and Normann (2014) confirm that cartels are more likely to form in four-firm oligopolies than in duopolies, consistent with the relative gain from communication in the two markets.

quantity decisions. Still, further research is needed to find the actual mechanism through which individualized information makes cartels more stable. We also showed that the gain from communication is higher in the individualized treatment compared to the aggregate treatment. This means that for a given cost of communication, cartel formation is more likely when individualized information is available. Summarizing, our results point to a perverse effect of publishing firm-specific data in the sense that more public information could both stabilize cartels and encourage cartel formation.

Our results also suggest that it is in the firms' interest to share firm-specific data because it would allow them to form more stable collusive agreements. In this sense, our observations are consistent with Potters' (2009) conjecture that "[i]nformation exchange is more likely to be a consequence of explicit collusion than to be a cause of implicit collusion". Viewed in this perspective, our findings support the European Commission's decision in the *Fatty Acids* case to declare the individual information exchange between Unilever, Henkel, and Oleofina illegal. More generally, our findings suggest that information exchange about firm-specific outputs and profits should be discouraged (if not declared illegal in view of competition law) in markets where explicit collusive behavior is likely to occur.

Moreover, our results indicate that regulators should be careful when increasing market transparency because this could fuel cartel formation. For example, financial regulators should keep in mind that more stringent transparency requirements for financial service providers might increase cartel formation in the market as an undesirable byproduct. If regulators do not want to harm competition, they should only boost transparency in financial markets that are not very concentrated, i.e., where cartel formation is unlikely.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.euroecorev.2015.11.002.

References

Albaek, S., Møllgaard, P., Overgaard, P.B., 1997. Government-assisted oligopoly coordination? A concrete case. J. Ind. Econ. 45 (4), 429–443.
Altavilla, C., Luini, L., Sbriglia, P., 2006. Social learning in market games. J. Econ. Behav. Organ. 61 (4), 632–652.
Andersson, O., Wengström, E., 2007. Do antitrust laws facilitate collusion? Experimental evidence on costly communication in duopolies. Scand. J. Econ. 109 (2), 321–339.
Apesteguia, J., Dufwenberg, M., Selten, R., 2007. Blowing the whistle. Econ. Theory 31 (1), 143–166.
Balliet, D., 2010. Communication and cooperation in social dilemmas: a meta-analytic review. J. Confl. Resolut. 54 (1), 39–57.
Bigoni, M., Fridolfsson, S.O., Le Coq, C., Spagnolo, G., 2012. Fines, leniency, and rewards in antitrust. RAND J. Econ. 43 (2), 368–390.
Bigoni, M., Fridolfsson, S.O., Le Coq, C., Spagnolo, G., 2015. Trust, salience and deterrence: evidence from an antitrust experiment. J. Law Econ. Organ. forthcoming.
Bigoni, M., Potters, J., Spagnolo, G., 2014. Flexibility and Cooperation with Imperfect Monitoring. Tilburg University, Netherlands Working paper.
Blume, A., DeJong, D.V., Kim, Y.-G., Sprinkle, G.B., 2001. Evolution of communication with partial common interest. Games Econ. Behav. 37, 79–120.
Cai, H., Wang, J.T., 2006. Overcommunication in strategic information transmission games. Games Econ. Behav. 56, 7–36.
Cooper, D.J., Kühn, K.-U., 2014. Communication, Renegotiation, and the scope for collusion. Am. Econ. J.: Microeconomics 6 (2), 247–278.
Crawford, V., 1998. A survey of experiments on communication via cheap talk. J. Econ. Theory 78 (2), 286–298.
Daughety, A.F., Forsythe, R., 1987. The effects of industry-wide price regulation on industrial organization. J. Law Econ. Organ. 3, 397–434.
De Groot Ruiz, A., Offerman, T., Onderstal, S., 2014. For those about to talk we salute you: an experimental study of credible deviations and ACDC. Exp. Econ. 17 (2), 173–199.
Dickhaut, J.W., McCabe, K.A., Mukherji, A., 1995. An experimental study of strategic information transmission. Econ. Theory 6, 389–403.
Dijkstra, P.T., Haan, M.A., Schoonbeek, L., 2014. Leniency Programs and the Design of Antitrust: Experimental Evidence With Rich Communication. University of Groningen Working paper.
Fonseca, M.A., Normann, H.T., 2012. Explicit vs. tacit collusion—The impact of communication in oligopoly experiments. Eur. Econ. Rev. 56 (8), 1759–1772.
Fonseca, M.A., Normann, H.T., 2014. Endogenous cartel formation: experimental evidence. Econ. Lett. 125 (2), 223–225.
Green, E.J., Porter, R.H., 1984. Noncooperative collusion under imperfect price information. Econometrica 52 (1), 87–100.
Hinloopen, J., Soetevent, A.R., 2008. Laboratory evidence on the effectiveness of corporate leniency programs. RAND J. Econ. 39 (2), 607–616.
Hinloopen, J., Onderstal, S., 2014. Going once, going twice, reported! Cartel activity and the effectiveness of antitrust policies in experimental auctions. Eur. Econ. Rev. 70, 317–336.
Huck, S., Normann, H.T., Oechssler, J., 1999. Learning in Cournot oligopoly – an experiment. Econ. J. 109 (454), 80–95.
Huck, S., Normann, H.T., Oechssler, J., 2000. Does information about competitors' actions increase or decrease competition in experimental oligopoly markets? Int. J. Ind. Organ. 18 (1), 39–57.
Huck, S., Normann, H.T., Oechssler, J., 2004. Two are few and four are many: number effects in experimental oligopolies. J. Econ. Behav. Organ. 53 (4), 435–446.
Kühn, K.U., 2001. Fighting collusion by regulating communication between firms. Econ. Policy 16 (32), 168–204.
Kühn, K.U., Vives, X., 1995. Information Exchange Among Firms and Their Impact on Competition. European Commission paper.
Normann, H.T., Rösch, J., Schultz, L.M., 2015. Do buyer groups facilitate collusion? J. Econ. Behav. Organ. 109, 72–84.

Offerman, T., Potters, J., Sonnemans, J., 2002. Imitation and belief learning in an oligopoly experiment. Rev. Econ. Stud. 69 (4), 973–997.
Potters, J., 2009. Transparency about past, present and future conduct. Experimental evidence on the impact on competitiveness. In: Hinloopen, J., Normann, H.-T. (Eds.), Experiments and Competition Policy, Cambridge University Press, Cambridge.
Requate, T., Waichman, I., 2011. “A profit table or a profit calculator?" A note on the design of Cournot oligopoly experiments. Exp. Econ. 14 (1), 36–46.
Schenk-Hoppé, K.R., 2000. The evolution of Walrasian behavior in oligopolies. J. Math. Econ. 33 (1), 35–55.
Stigler, G.J., 1964. A theory of oligopoly. J. Polit. Econ. 72 (1), 44–61.
Vega-Redondo, F., 1997. The evolution of Walrasian behavior. Econometrica 65 (2), 375–384.
Waichman, I., Requate, T., 2014. Communication in Cournot competition: an experimental study. J. Econ. Psychol. 42, 1–16.
Wang, J.T., Spezio, M., Camerer, C.F., 2010. Pinocchio’s pupil: using eyetracking and pupil dilation to understand truth telling and deception in sender-receiver games. Am. Econ. Rev. 100, 984–1007.