

Rebels without a Clue?

Experimental Evidence on Endogenous Cartels and Outside Firms*

Georg Clemens[†] Holger A. Rau[‡]

Duesseldorf Institute for Competition Economics (DICE)
Heinrich-Heine-University Duesseldorf, Germany

Abstract

This paper provides experimental evidence on cartel formation when a cartel agreement is binding. We investigate whether cartels emerge if a binding cartel agreement is implemented through a multi-stage coordination mechanism. In a symmetric Cournot market where our multi-stage coordination mechanism is introduced, we observe a cartelization rate of 25.71%. A modification of the pay-off structure, making a partial cartel more attractive astonishingly yields an out-of-the-equilibrium rejection of partial cartels. The payoff asymmetries in partial cartels may trigger the cartel rejection. In order to infer the impact of communication on cartelization we introduce chat before the mechanism is implemented which yields cartelization rates of up to 97%.

JEL Classification numbers: D02, K21, L41.

Keywords: Cartels, Endogenous Institutions, Antitrust Law.

*We are especially grateful to Hans-Theo Normann for his input at various stages of this project. We are grateful to Tim Cason, Stephen Davies, Tomaso Duso, Justus Haucap, Michael Kosfeld, Irina Suleymanova, Tobias Wenzel and Christian Wey for their helpful support. We would like to thank participants of the ESA International conference 2011, the ESA European conference 2011 and the DICE experimental seminar for providing us with helpful comments. We also want to thank the Duesseldorf Institute of Competition Economics (DICE), Heinrich-Heine University of Duesseldorf for financial support.

[†]corresponding author, Universitaetsstr. 1, 40225 Duesseldorf, Phone: +49-211-81-15615, E-Mail: clemens@dice.uni-duesseldorf.de

[‡]corresponding author, Universitaetsstr. 1, 40225 Duesseldorf, Phone: +49-211-81-10249, E-Mail: rau@dice.uni-duesseldorf.de

What is a Rebel? A man who says no, but whose refusal does not imply a renunciation-
Albert Camus

1 Introduction

In spite of the implementation and recurrent amendment of Antitrust Laws in the U.S. and the European Union, binding collusive agreements remain a serious threat to the functioning of markets. Evidence from antitrust cases suggests that cartels induce mechanisms that facilitate coordination and ensure compliance with explicit cartel rules¹. One of the first papers to provide a theoretical model on these types of explicit collusive practices is Selten (1973). In a multi stage Cournot game with one-shot interactions, firms may coordinate towards a cartel on the first stage and ensure compliance with the cartel rules by implementing a quota scheme on the second stage. The second stage is of particular relevance in the model. In this stage a binding cartel agreement may be reached if all firms agree on a vector of quotas. Making the cartel agreement binding may prevent ex post deviation from the cartel strategy by cheating firms and induce the cartel participants to act like a multitude of firms who merged to a single one².

Since a binding cartel agreement induces firms to act like a merger, the merger literature may provide additional insight on the stability and constellation of cartels. Salant, Switzer and Reynolds (1983)(henceforth SSR (1983)) analyze the relationship between the size and the profitability of a merger. The conclusion that a merger is only profitable if it encompasses at least 80% of the firms may also be relevant for binding cartels. Ultimately a binding cartel agreement would be implemented if and only if at least 80% of the firms decided to participate. This may severely complicate coordination since nearly all firms would have to coordinate to a cartel. Hence extensive communication may be necessary to guarantee that firms may coordinate to a collusive agreement.

Another factor that might put the collusive agreement at risk is the excessive asymmetry of payoffs between cartel insiders and outsiders. As d'Aspremont, Jacquemin, Gabszewicz and Weymark (1983) underline "*...however by free-riding, fringe firms enjoy higher profits than cartel members*". Since an outside firm is beyond the reach of any retaliation mechanism implemented within a cartel, cartel insiders cannot hinder that a firm free-rides on their effort to coordinate to a collusive agreement. In this case "saying no" to the cartel does not imply any renunciation for the free-riding outside firm.

Evidence from the experimental literature on endogenous institution casts doubt on the likelihood of such an outcome. Kosfeld, Okada and Riedl (2009) (henceforth KOR(2009)) analyze the role of free-riders in a public good game. The authors design an experiment, where subjects can decide to implement an institution with sanctioning powers in three consecutive steps in

¹Retaliation mechanism that ensure the respect of the cartel rules have for instance been observed in the lysine cartel, where the "guaranteed buyings" practice forced the firms that exceeded their quotas to buy from those firms that didn't fulfill them(see Harrington and Skrzypacz (2011)).

²As Shaffer (1995) underlines "...cooperation within a cartel is equivalent to the outcome of horizontal mergers in the absence of synergies"

order to solve a social dilemma problem. The institution induces all its members to fully contribute to a public good and sanctions those that refuse to contribute their entire endowment. In the first stage the subjects have to decide whether or not they want to form an institution. In the second stage all subjects that decided to participate in the first stage, learn about the number of potential participants. Thereafter they can decide whether or not the institution will be implemented. The institution is only implemented if and only if all first stage participants unanimously decide to implement the institution in the second stage. In the last stage subjects decide about their contribution level, where members that do not contribute their entire endowment are sanctioned, making the commitment to the institution binding. This approach not only solves the coordination problem it also allows to punish outsiders for not joining, since a subject could decide not to implement the institution at all. As a result the free-riders' payoff would be significantly reduced. In such a scenario "saying no" to the institution does imply a renunciation.

Our setup builds on KOR (2009) and Selten (1973) but focuses on a binding cartel agreement. On the first stage firms can opt for the cartel formation or decide to become an outsider. The firms that opted for cartelization learn about the potential insiders and outsiders on the second stage before implementing the cartel in a unanimous voting decision. The third stage consists of an automated quantity decision which guarantees that the cartel members do not deviate from the cartel strategy and that outsider play best-response strategies. This mechanism allows to prevent ex post defection and enables us to focus on the role of outside firms. We provide an extension of the KOR (2009) framework by introducing communication in order to analyze whether this facilitates coordination. Combining an institutional structure with communication adequately reflects practices observed in cartel cases. As Genesove and Mullin (2001) point out *"Studying the Sugar Institute refocuses our attention on detection, in revealing how firms may enhance it by altering their environment through both specific rules and institutional structure, including communication"*.

The results show that this approach may adequately simulate an endogenous cartelization process yielding an outcome as predicted by SSR (1983) for the merger case. On the one hand we demonstrate that the combination of an institutional structure (as our multi stage coordination mechanism) with communication leads to the cartelization of 97% of the markets. On the other hand we show that in most of the cases cartels which induce a high payoff asymmetry between cartel members and outside firms are rejected.

2 The Outside Firm as a Destabilizing Factor

The seminal work by Selten (1973) is one of the first paper to analyze in detail the factors that may destabilize a collusive agreement. In a three stage game, where firms compete à la Cournot the first stage consists of a decision to join a cartel or not. In the second stage the cartel members fix a quota, making the cartel agreement binding before choosing their respective quantity in the third stage. The author shows that stable cartels may arise, that do not encompass all market

participants, a result confirmed in a multitude of other models.³ In the literature on partial cartels a cartel is deemed to be stable if the external and internal stability criteria hold. Internal stability holds if a cartel member has no incentive to leave the cartel, whereas external stability holds if no outside firm would prefer to join the cartel. In a market with n firms and a cartel with k firms, where the cartel profits are Π_c and the outsiders profits Π_f , the cartel is internally stable if :

$$\frac{\Pi_c(k)}{k} \geq \Pi_f(k+1) \quad (1)$$

holds and externally stable if

$$\Pi_f(k) \geq \frac{\Pi_c(k+1)}{(k+1)} \quad (2)$$

holds.

The criteria of internal cartel stability clarifies, why the second stage, which makes the cartel agreement binding, is crucial. In a symmetric Cournot market with one-shot interactions, where firms collude tacitly the only cartel that is internally and externally stable only encompasses one firm. In all other cartel constellations, cartel members will always have incentives to deviate from the collusive agreement. Hence no tacit cartel may arise in the standard Cournot case. Ultimately it is the desire to free-ride on the cartel formation decision that induces the collapse. Since a tacit cartel neither allows for communication by definition, nor has a workable sanctioning mechanism to punish or prevent defection cartelization is deemed to fail.

A multi-stage cartelization process as introduced in Selten (1973) allows a clear-cut distinction between two types of defection from the cartel strategy. If a firm refuses to join the cartel on the first stage, it defects from the cartel strategy, before the cartel has even been introduced. This ex ante defection makes out of the firm an outside firm, as witnessed in the vitamin cartels. A firm may also defect from the cartel strategy by choosing a quantity that differs from the quantity fixed by the cartel on the third stage. This type of defection is ex post, since it takes place after the implementation of the cartel. If the cartel manages to make the agreement binding on the second stage, all firms that decided to join the cartel have to comply with the cartel strategy. This would ultimately prevent ex post defection. Nonetheless, ex ante defection by outside firms may still occur since a cartel cannot commit outsiders to comply with the cartel rules. These outsiders free-ride on the cartel decision, since their profit exceeds the insiders profits allowing them to profit from the implementation of the cartel.

Experimental evidence shows that firms may sanction or even prevent free-riding when given the possibility to do so. Huck, Konrad, Müller and Normann (2007) (henceforth HKMN (2007)) analyze the impact of payoff asymmetries on the equilibrium quantities decision of firms in an experimental merger setting. The authors show that in a merger experiment based on SSR (1983),

³As d'Aspremont, Jacquemin, Gabszewicz and Weymark (1983), Donsimoni (1985) and Donsimoni, Economides and Polemarchakis (1986) show, partial cartels with price-leadership may arise, when the outside firms act as price-taking fringe. Furthermore Shaffer (1995) shows that in the case of quantity competition, partial cartels arise when the cartel is a Stackelberg leader and the outside firms behave as Stackelberg followers.

where outside firms excessively profit from the merger decision, free-riding may be prevented. The merged firms produce a higher output level compared to the standard neoclassical predictions.⁴ As a best-response, the outside firms produce less than predicted by theory. Regarding the profits, HKMN (2007) find that the merging firms will not face a payoff decrease in the long-run.

Our approach is similar to HKMN (2007) providing new evidence on the impact of outside firms. However, we focus on the stability of a binding cartel agreement implemented through a multi stage coordination mechanism à la KOR (2009). This setup ensures the internal and external stability of a cartel agreement and may replicate the SSR (1983) result for a cartel where at least 80% of the firms would have to cartelize. Nonetheless, the stability of the agreement may still be influenced by two factors. First of all, the 80% threshold has to be reached, to ensure that the the cartel will be implemented. Adding the possibility to chat not only adequately reflects the dynamic of communication during the negotiations between cartel members in the “smoke filled room”. It may also facilitate coordination, ensuring that enough firms will participate in the cartel to be profitable. The second aspect which may impact the stability of a cartel agreement is the payoff asymmetry between insiders and outsiders. If the cartel agreement yields relatively excessive increases in profits of the remaining outsiders compared to the profits of the insiders, the agreement may be revoked on the second stage. A stable cartel may thus also have to be “comparatively stable”, i.e it ensures that no firm excessively profits from the implementation of a cartel. This would only be the case if a cartel agreement would be reached if a cartel encompasses all firms active in the market i.e a “grand cartel”.⁵

3 Endogenous Cartelization Mechanism as a Stabilizing Factor

3.1 Underlying Theory

In order to provide a sound analysis of the endogenous cartelization mechanism we describe an oligopolistic market comprising four symmetric firms that compete à la Cournot. The respective payoffs of the cartel members and the outsiders are obtained using the Cournot example in SSR (1983). For a given linear demand function $P = a - \sum_{i=1}^n Q_i$ and marginal cost of production c we obtain the following Cournot profits for n firms:

$$\Pi(n) = \left(\frac{a - c}{n + 1} \right)^2 \quad (3)$$

⁴Huck, Müller, Normann (2001) also find in an experimental Stackelberg-setting that Stackelberg followers sanction Stackelberg leaders by increasing their quantities.

⁵This is confirmed by KOR(2009) who find that the majority of public good institutions implemented are “grand institutions” which include all subjects

If m firms decide to form a cartel the insiders' profits correspond to

$$\Pi(n) = \frac{(a - c)^2}{(n - m + 2)^2 m} \quad (4)$$

whereas the outsiders' profits are given by:

$$\Pi(n) = \frac{(a - c)^2}{(n - m + 2)^2} \quad (5)$$

As outlined above, we analyze the case of $n = 4$ symmetric firms. Furthermore we parametrize the model with $a = 50$ and $c = 10$ and get for insiders' profits:

$$\Pi(n)^{insid.} = \frac{1600}{(6 - m)^2 m} \quad (6)$$

and outsiders' profits can be formulated as:

$$\Pi(n)^{outsid.} = \frac{1600}{(6 - m)^2} \quad (7)$$

Given the equilibrium profits of cartel members and outsiders we now turn to the experimental design and the implementation of the cartelization mechanism.

3.2 Experimental Design

In our Experiments we implemented four different treatments: *Standard Endogenous Cartels* (SEC), *Modified Endogenous Cartels* (MEC), *Standard Endogenous Cartels with Chat* (SECC), and *Modified Endogenous Cartels with Chat* (MECC). The subjects could simply choose whether they wanted to join the cartel (become an insider) or opt out of the cartel (become an outsider). Hence the action space did not consist of quantity choices. Table 1 gives an overview of the four treatments we analyzed.

		<i>Communication</i>	
		no chat	chat
<i>Payoff structure</i>	Standard Cournot	SEC	SECC
	Modified Cournot	MEC	MECC

Table 1: *Treatments*

A fixed matching protocol was used in all of our treatments. Cournot markets consisting of four firms in one matching group were used in every treatment. We implemented the KOR

(2009) framework in every treatment to test the endogenous cartel framework in our Cournot game. According to KOR (2009) the SEC treatment consisted of three consecutive stages.

In **stage 1** all firms in a matching group simultaneously had to state whether they wanted to join a cartel.⁶ Subjects simply had to click at a “yes-” or “no-” button in the z-tree treatment. If a firm stated in stage 1 that it is willing to form a cartel it became a *possible insider*. Furthermore firms which stated in stage 1 that they do not want to form a cartel became *ultimate outsiders*.

In **stage 2** all firms were informed about the total amount of possible cartel members and ultimate outsiders. Note that both types of firms (possible insiders as well as ultimate outsiders) got information about the total number of firms willing to establish a cartel. In stage 2 only possible insiders were allowed to decide whether they definitely want to form a cartel. Before possible insiders were asked whether they ultimately want to stick to the cartel, they were presented their possible payoff of being a cartel member as well as the possible payoff of being an outsider. Additionally information about the resulting payoffs of the ultimate outsiders was also given. Again possible insiders either had to click the “yes-” or “no-” button to state whether they ultimately wanted to join the cartel. If one of these firms clicked at the “no-” button the agreement was rejected and no cartel was established. The cartel agreement became binding if and if only *ALL* possible insiders in stage 2 clicked at the “yes-” button to confirm that they ultimately wanted to join the cartel. Ultimate outsiders had no choice in stage 2 and were only informed about the amount of possible insiders. If all possible insiders clicked at *yes* the cartel was implemented and possible insiders became ultimate cartel members. Otherwise they also became outsiders and received the Cournot Nash equilibrium profits of a standard four firm Cournot market.

In **stage 3** subjects had no choice and their payoffs were determined. Subjects were informed about whether a cartel was formed or not. Additionally they obtained information about their own and other firms’ payoffs which resulted from the occurrence or non-occurrence of the cartel.

Our MEC treatment was exactly the same as our SEC treatment (it also consisted of the three stages similar to KOR (2009)). The only crucial difference refers to the payoff table we used. In MEC we used a modified variant of table 1. To make cartels with one outsider firm more attractive we increased the payoff for three cartel members from 59 Talers to 70 Talers. The other payoffs remained the same.

Table 1 gives an overview of the subjects’ possible payoffs in *Taler*⁷ in both treatments (SEC and MEC). Subjects’ payoffs depended on their role (insider or outsider) and the total sum of other insiders/ outsiders.⁸ The exchange-rate was 1 Taler = 2 Euro cent.

Composition		Payoff Treatment SEC		Payoff Treatment MEC	
# Insiders	# Outsiders	Insider	Outsider	Insider	Outsider
0	4	na	64	na	64

⁶Note the treatments were neutrally framed using the German word “Marktabsprache” which means “market agreement”.

⁷*Taler* is a synonym for *ECU* (Experimental Currency Unit)

⁸Note that payoffs are rounded to integers.

1	3	64	64	64	64
2	2	50	100	50	100
3	1	59	178	70	178
4	0	100	na	100	na

Table 1: Every subject’s payoff in SEC and MEC depending on own and other choices

Note, we always assume the subjects to play their best responses. Thus cartel members payoffs’ are determined by assuming cartel members to play best response strategies. Consequently we also assume the outsiders to play their best reply strategies in response to the cartel members. Thus outsiders’ payoffs are determined by their best response actions. The three-stage-game was repeated for 10 periods in our SEC treatment.

The SECC and the MECC treatments were exact the same treatments as SEC and MEC. There was a crucial difference in the SECC and MECC treatments compared to their counterparts: Both treatments involved a chat stage (stage 0) prior to the stages 1-3. This chat stage was implemented in every of the 10 periods.

In **stage 0** of SECC and MECC firms of one matching group (market) were given the possibility to chat in a z-tree-window for a total of 90 seconds.⁹ After 90 seconds the window automatically closed and stage 1 started immediately.¹⁰ Stage 1-3 proceeded exactly in the same way as in SEC and MEC. Furthermore payoffs in SECC and MECC were also the same as in SEC and MEC respectively (see Table 1). The experiment was conducted at the *DICE Lab* of the University of Duesseldorf in February 2011. The subjects were recruited with the online recruitment system ORSEE (Greiner, 2004)). We ran two sessions of our SEC treatment with a total of 7 matching groups. Additionally two sessions of MEC with 7 matching groups were ran. Finally we ran one session of SECC (with 3 matching groups) and one session of MECC (with 4 matching groups).

We conducted our experiments at the “DICE Lab” (University of Duesseldorf) in April 2011. The experiments were programmed using Fischbacher’s zTree (2007) software. Subjects were recruited using Greiner’s Orsee (2004) tool. In total 84 subjects took part in the experiment and earned on average 16.96€.

4 Theoretical Predictions and Hypotheses

4.1 Theoretical Prediction for the Standard Treatment

The mechanism introduced here is implemented in three consecutive stages where firms individually maximize their profits in the first two stages. The third stage guarantees that the

⁹Note that firms remained anonymous during the chat. They were only given neutral names like “firm 1-4”. During the whole experiment firms’ names did not change.

¹⁰Stage 0 only lasted 90 seconds in the first period. In periods 2-10 the chat stage was reduced to 60 seconds. We chose a duration of 90 seconds in the first period because in the beginning of the game subjects have to find out how to play the game and conversations are supposed to last longer.

cartel strategy will be implemented by all firms that opted for cartelization in the first stage and confirmed in the second stage. Hence the decision to cartelize becomes as binding as a merger decision. We now have to define whether there will be a cartel and if so, what the cartel size will be for which the cartel formation is confirmed on the second stage and initiated in the first stage. Thus, we have to determine the set of subgame perfect Nash equilibria solving the game by backward induction. Here a subgame perfect equilibrium where a cartel is implemented will be referred to as a *subgame perfect cartel equilibrium*.

Proposition 1: In the Standard Treatment there exists one subgame perfect cartel equilibrium including $m = 4$ cartel members.

Proof: the result follows from SSR(1983) which also holds for a binding cartel agreement i.e 80% of the firms have to participate. The 4 firm cartel is the only cartel to reach the 80% threshold. Hence we only obtain a “grand cartel” in our setup.

The mechanism used in the standard treatment may thus facilitate the implementation of a cartel in a market where tacit collusion is deemed to be impossible. It ensures, that outside firms which refuse to participate in the cartel always make themselves worse-off. If one or more firm(s) reject the creation of a cartel in the first stage, the cartel will not be implemented in the second stage. Although a firm might be attracted by the excessive payoffs it obtains if it becomes the outside firm in a cartelized markets, cartels will always be rejected. This owes to the fact that the inside firms always make themselves better-off by rejecting the cartel and competing à la Cournot. In order to analyze whether inequality aversion may also matter, we introduce the modified treatment (MEC). In this treatment we increase the insiders’ payoff making a partial cartel attractive enough, to be accepted from a standard preference point of view. However, the high payoff asymmetries between insiders and outsiders may induce insiders to reject the implementation of a cartel that excessively benefits a rival.

4.2 Theoretical Prediction for the Modified Treatment

In the modified treatment, insiders’ payoffs are increased in the partial cartel constellation with 3 inside firms and 1 outside firm. We increase the payoffs of the insiders from 59 to 70 Taler to ensure that on the second stage the implementation of the cartel is accepted although there exists an outside firm. In order to experimentally test firms’ behavior in a partial cartel constellation with one outside firm, we first have to ensure that a 3-firms partial cartel will be initiated in the first stage.

Proposition 2: In the modified treatment we obtain a strict subgame perfect cartel equilibrium with $m = 3$ cartel members and a symmetric subgame perfect cartel equilibrium in mixed strategies with an entry probability of $p = \frac{3}{16}$.

Following the reasoning from the former subsection only two cartels are implemented on the second stage. As in the standard treatment a four firms cartel will arise, since the members increase their payoff by accepting to implement the cartel agreement. In the case of a partial

cartel with 3 insiders and 1 outsider the payoff modification also yields acceptance.

In the modified treatment the result is not as clear cut as in the standard treatment on the first stage. Here, firms may refuse to participate in the formation of a cartel in the first stage. If a firm chooses not to participate in a cartel its payoff may increase from 100 to 178 Taler. Hence we do not obtain a subgame perfect equilibrium with a cartel composed of four firms, since there is always an incentive to become the outside firm. As a partial cartel including 3 firms will be implemented in the second stage, due to the payoff modification, we obtain a strict subgame perfect cartel equilibrium including $m = 3$ cartel members. Since firms face a coordination problem on the first stage one can also show the existence of an equilibrium in mixed strategy where firms opt for entrance with an entry probability of $p = \frac{3}{16}$.¹¹ However, it suffices for our purposes to focus on a partial cartel encompassing 3 firms.

Provided the equilibria outlined above, we now may formulate a series of hypotheses regarding the outcome of our experiment. As outlined in the next subsection, we do not only expect the creation of cartels, that would usually not arise in a standard Cournot market where no cartelization mechanism is implemented. We may also infer whether the decision to form a cartel depends on absolute profits only or if excessive profits made by the outside firms may influence the decision to form a cartel.¹²

4.3 Hypotheses

In this subsection we postulate our hypotheses. The analysis in subsection 4.2 has shown that only the “grand cartel” with 4 cartel members is a subgame perfect cartel. Thus, at the first stage all firms should have incentive to vote for the cartel and thus to become a possible insider. This stands in strong contrast to our MEC treatment where the theoretical analysis predicts that partial cartelization with 3 cartel firms and one outsider is a *subgame perfect cartel equilibrium*. Therefore firms in the first stage of the MEC treatment have incentive to become the only outsider to earn the highest possible payoff of 178. Thus, we hypothesize for the *standard* treatment that there will be a higher average number of firms which possibly want to form a cartel in contrast to the *modified* case.

Hypothesis 1 *We expect more possible insiders SEC compared to MEC.*

In our SECC and MECC treatments firms in the same markets have the possibility to communicate via chat. This should further facilitate coordination. Although the subgame perfect cartel equilibrium does not change in SECC compared to SEC, we expect that due to the chat option firms in these markets should get a better understanding of the “grand cartel” equilibrium. Therefore the chat option should facilitate collusion and we hypothesize that in SECC a

¹¹We obtain the value for the entry probability p by solving $100 \cdot p^3 + 70 \cdot p^2 \cdot (1 - p) \cdot 3 + 3 \cdot 64 \cdot p \cdot (1 - p)^2 + 64 \cdot (1 - p)^3 = 178 \cdot p^3 + 64 \cdot (1 - p^3)$ for p .

¹²The impact of the profit asymmetries on the behavior of cartel members has been outlined in the report of the Sugar Institute cartel by Genesove and Mullin (1999) saying that “Although a non-member, Hershey intermittently supplied statistics on contract enforcement.(...)Later, a group of Southern refiners proposed that the Institute either force Hershey to discontinue its “unethical” business practices in Florida or invite it to join the Institute.”

higher average number of firms is willing to form the cartel at the first stage compared to the case without chat (SEC). Regarding the modified treatment the same should be true. In the environment of communication subjects should also be able to discuss the coordination problem. That is, firms should realize that cases with more than one *possible outsider* are harmful for the insiders and will not be accepted. We therefore hypothesize for the modified treatment that the communication option should once again lead to more possible insiders compared to the non-communication case.

Hypothesis 2 *In both chat treatments we expect more possible insiders than in the non-communication counterparts.*

To derive the predicted degree of cartelization in our different treatments, we have to focus on the expected amount of firms willing to establish a cartel in the first stage of our framework. Following Hypothesis 1, there will be a higher average number of possible insiders in SEC compared to MEC. As the theoretical analysis has shown, insider firms in SEC will not accept partial cartelization. Furthermore insiders in MEC will only accept partial cartelization with at most one outsider. Thus, cartelization will be most likely when there is a higher amount of possible insiders. Since Hypothesis 1 expects a higher number of possible insiders, we hypothesize that there will be more established cartels in SEC compared to MEC.

Hypothesis 3 *The degree of cartelization will be higher in the standard treatment than in the modified variant.*

The degree of cartelization in our communication framework also depends on the number of possible insiders at the first stage of the *KOR* framework. Since Hypothesis 2 expects that communication will lead to more possible insiders compared to the treatments without chat, cartelization should be more easy to take place. Therefore we hypothesize more cartels to occur in the environment of chat.

Hypothesis 4 *In the communication treatments we expect a higher amount of cartelization compared to SEC and MEC.*

The theoretical analysis predicts no partial cartelization in our standard treatment. Therefore all cartels in SEC should consist of all firms in the market. The same is true for SECC where the subgame perfect cartel equilibrium is the same. In contrast in our modified treatments there exist four subgame perfect cartel equilibria composed of exactly one outside firm and three inside firms. Thus, partial cartelization with at most one outside firm should always be tolerated.

Hypothesis 5 *In SEC and SECC only “grand cartels” will be implemented. Whereas in the modified treatments partial cartelization with one outside firm will not be rejected.*

5 Results

In the following paragraph we test our hypotheses and outline our results. Our analysis starts with a summary statistic. Afterwards we statistically test our results and report two-sided p-values throughout.

5.1 Summary statistics

In order to get a first impression of the results provided by our experiment table 2 presents a summary statistic of our findings. Table 2 reports the average number of possible insiders, the average amount of cartels attempted, i.e. all cases where at least two or more possible insiders attempted to form a cartel. Furthermore the average amount of established cartels and their composition are presented.

	Treatment			
	SEC	MEC	SECC	MECC
Possible Insiders	3.03 (1.02)	2.04 (1.04)	3.97 (0.18)	3.7 (0.52)
Cartels attempted	91.43	65.71	100.00	100.00
Cartels established	25.71	34.29	96.67	82.50
4-Firm-Cartels established	94.44	35.71	100.00	87.88
3-Firm-Cartels established	0.06	57.14	—	12.12
2-Firm-Cartels established	—	7.14	—	—
Observations	7	7	3	4

Table 2: Summary statistics of the means of our findings (standard errors in parentheses)

The impression given by the statistics confirms the presumption that in the chat treatments the amount of possible insiders is the highest. Especially in SECC, on average, nearly all firms are possible insiders. In SEC we also observe that subjects are more willing to become a possible insider as compared to the *Modified Endogenous Cartel*. In SEC and MEC some cartels are established, however cartelization does not seem to be that harmful since only a small amount of cartels is implemented. A closer look at the communication treatments (SECC and MECC), provides a striking result: there is an overwhelming degree of cartelization.

In the next subsection we test hypotheses one and two which focus on the average number of possible insiders.

5.2 Efforts to form a cartel

Regarding the efforts to form a cartel the number of possible insiders is a crucial prerequisite within the KOR (2009) framework. First, if a firm wants to establish a cartel it needs at least a second firm to cooperate with. Secondly, payoffs increase with the number of participating firms. Figure 1 presents the development of the means of possible insiders over time. The diagram shows that in every period the average number of possible insiders is higher in SEC compared to MEC.

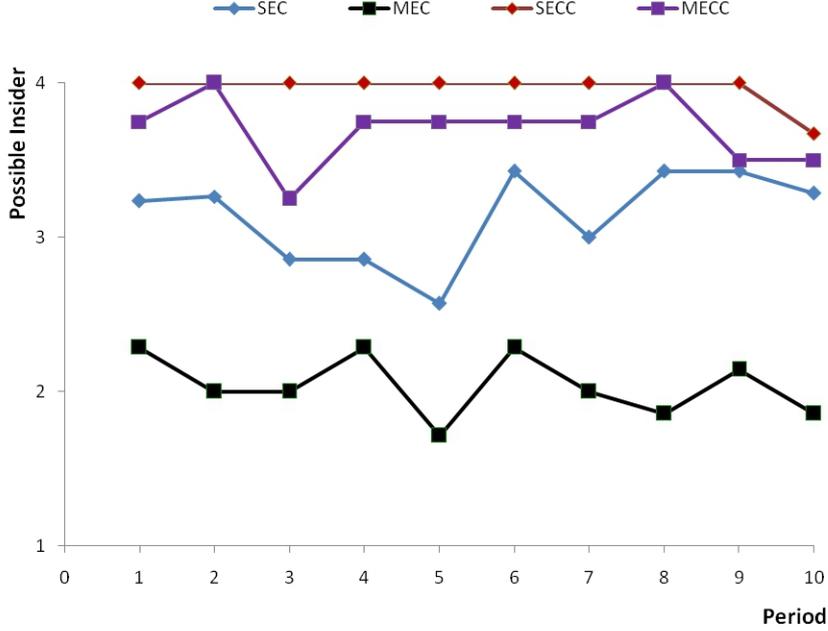


Figure 1: Development of the means of possible insiders

To give a first idea of the results we obtain here we test our four treatments for general treatment effects. A non-parametric Kruskal Wallis (KW) test reports highly significant differences regarding the average number of possible insiders in our treatments (KW-test p-value < 0.001). To test Hypothesis 1 we infer the difference in the average number of possible insiders in our two non-communication treatments. On average 3.03 firms are possible insiders in SEC, whereas only 2.04 firms try to form a cartel in MEC. A Mann Whitney test reports significant difference (p-value = 0.025). Thus we find support for Hypothesis 1.

In the chat treatments more firms opt for a cartel in contrast to the non-communication treatments. One remarkable result is that in SECC all 4 firms are possible insiders in 9 out of 10 periods. On average there are more firms in SECC who want to form a cartel compared to the non-communication treatments. That is, the difference between SECC (3.97) and SEC (3.03) is significant (MW-test p-value = 0.016). The same is true if we compare SECC's possible insiders to MEC (2.04) (MW-test p-value = 0.016). Focusing on MECC, we observe the same pattern: On average 3.7 firms want to form the cartel compared to SEC (3.03) (MW-test p-value = 0.057). It appears that the chat option furthermore yields a highly significant difference of the number of possible insiders in MECC compared to MEC (MW-test p-value = 0.008). Thus we find support for Hypothesis 2 as well.

Figure 2 summarizes the aggregated composition of possible insiders in all treatments. The figure emphasizes that in the communication treatments four possible insiders were the most frequent composition in stage 1. Furthermore, there are higher incentives to be an outsider in MEC compared to SEC. In 35.7% of all SEC cases, four firms wanted to be a possible insider compared to 8.6% only in MEC.

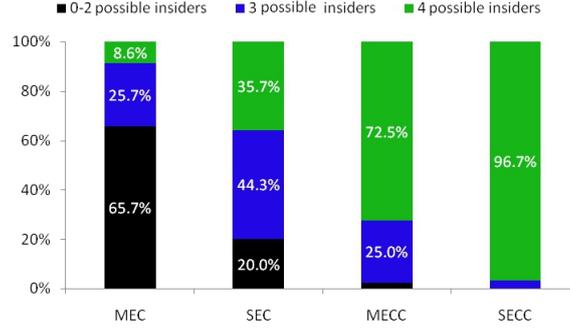


Figure 2: Aggregated composition of possible insiders in all treatments

A striking result of our experiment is that in the SECC treatment in 96.7% of all cases all firms wanted to be a possible insider. A similar pattern can be observed in the MECC treatment where the case of 4 possible insiders is also the most frequent case (72.5%). Our findings can now be summarized as follows:

Result 1 *In SEC there is a higher amount of possible insiders than in MEC. The chat treatments offer the highest incentives to form a cartel: more firms potentially want to form cartels compared to the non-communication cases.*

5.3 Established Cartels

In stage 2 of our experiment the KOR (2009) framework enables our firms to observe the amount of possible insiders willing to form a cartel. In addition the sum of *ultimate outsiders* can also be monitored by the firms. A higher amount of possible insiders should lead to more cartels being established because payoffs increase with the number of cartel members. Result 1 reports the highest amount of possible insiders in the chat treatments. Hence it pronounces that we should observe the largest degree of cartelization in the communication treatments. We start our analysis with a Kruskal Wallis test which reports a highly significant difference regarding the degree of cartelization in our treatments (KW-test p-value < 0.001). Figure 3 compares the amount of established cartels in our 4 treatments.

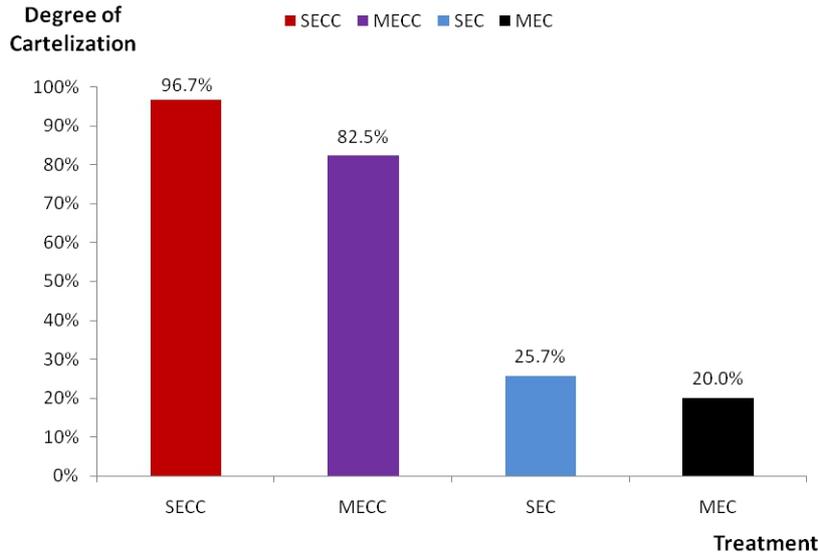


Figure 3: Degree of cartelization in our 4 Treatments

A first glimpse reports slightly more cartelization for SEC (25.5%) in contrast to the modified payoff case (20.0%). This tendency intuitively supports our Hypothesis 3. However, this difference is statistically not significant (MW-test p-value = 0.422). Thus we reject the alternate Hypothesis 3 that cartelization is higher in SEC compared to MEC. If we analyze the results of our communication treatment, we find highly significant differences between the cartelization rate in SECC (96.7%) and SEC (25.7%) (MW-test p-value < 0.001). The difference between SECC and MEC (20.0%) is highly significant (MW-test p-value < 0.001) as well. The same pattern can be observed when comparing MECC (82.5%) with our non-communication treatments SEC (MW-test p-value < 0.001) and MEC (MW-test p-value < 0.001). Thus we find intense support for Hypothesis 4.

Result 2 *In the non-communication treatment we find a small cartelization rate. The difference between SEC and MEC is statistically not significant. Combining the KOR (2009) framework with a chat option leads to a considerably higher degree of cartelization than in the non-chat environments. In the chat treatments nearly all markets get cartelized.*

5.4 Firms' acceptance of possible cartel compositions

As already outlined in section 4, the composition of possible cartels result from the number of possible insiders. Depending on the total number of possible insiders and possible outsiders it may be the case that payoffs of insiders and outsiders are asymmetric. In this subsection we test the implementation rate of different cartel compositions. Table 3 summarizes the implementation and rejection rates of cartels depending on the number of possible insiders.

Treatment	Possible Insiders			Treatment	Possible Insiders		
	2	3	4		2	3	4
SEC				SECC			
Implementation	0.00	3.23	68.00	Implementation	–	0.00	100.00
Rejection	100.00	96.77	32.00	Rejection	–	100.00	0.00
Observations	8	31	25	Observations	0	1	29
MEC				MECC			
Implementation	4.55	44.44	83.33	Implementation	0.00	40.00	100.00
Rejection	95.45	55.56	16.67	Rejection	100.00	60.00	0.00
Observations	0	1	29	Observations	1	10	29

Table 3: Implementation and rejection rates of cartels

In every treatment most cartels have been established when four firms wanted to be an insider. In SEC only 3.23% partial cartels (with one outsider) are implemented. In contrast there is a significant higher implementation rate of 68% 4-firm-cartels (Wilcoxon Signrank test p-value = 0.033).¹³ Interestingly, the most frequent observed cartel composition is again the 4-firm-cartel in MEC where theory predicts that partial cartelization (i.e. three insiders and one outsider) is an equilibrium. In contrast to standard neoclassical theoretical predictions, 55.56% of the cartels with three insiders and one outsider are rejected by the insiders. Even though possible insiders would earn 70 when accepting the cartel, they prefer to reject it and earn only 64. This result is in line with the findings of KOR (2009) who also find that subjects refuse to accept payoff differences. Furthermore the findings are similar to the evidence of many other experiments which highlight the importance of other-regarding preferences (e.g. Fehr and Schmidt (1999), Bolton and Ockenfels (2000)).¹⁴ When possible insiders in our setup accept a cartel with one outsider, payoffs are extremely asymmetric. That is every insider firm earns 70 whereas the outsider firm receives 178. In contrast, when not accepting a cartel every firm earns the same payoff of 64. Thus in MEC the most implemented cartel composition is the 4-firm-cartel which can be observed in 83.33% of the time. In contrast, the implementation rate of 3-firm-cartels is only 44.44% (Wilcoxon Signrank test one-sided p-value = 0.083). When focusing on the communication treatments the same pattern occurs: again the most frequent cartel composition is the 4-firm-cartel. In SECC all possible 4-firm-cartels are accepted and every 3-firm-cartel is

¹³As opposed to theoretical predictions there are also 4-firm cartels which are rejected. In terms of purely monetary preferences this does not make any sense, because firms earn more when accepting the 4-firm-cartel compared to the standard Cournot case. Our data reveals that 70% of the 4-firm-cartels rejections happen in periods 7-10. Maybe this could be attributed to an end game effect that firms wanted to punish other firms for not cooperating in the early periods. Note also, that these rejections happened only in 4 of our 21 matching groups.

¹⁴We are aware that in reality firms have different motives than other-regarding preferences. Nevertheless there exist evidence that firms do care about other firms' payoffs and show greed or envious behavior.

rejected. In MECC, we again find an implementation rate of 100% for 4-firm-cartels. However, only 40% cartels with one outsider are accepted (Wilcoxon Signrank test p-value = 0.059).¹⁵ Thus, we have to reject alternative Hypothesis 5 which postulates that cartels with one outside firm will always be accepted in the modified treatments. We can now formulate following result:

Result 3 *In both treatments with standard payoffs only “grand cartels” are implemented. Whereas in the modified treatments partial cartelization with at most one outside firm can be found. Opposed to standard neoclassical predictions inequality aversion also crucially matters: many inside firms do not accepted cartels with one outside firm.*

6 Discussion and Conclusion

This work provides experimental evidence on the role of a binding agreement combined with extensive communication on the cartelization of markets. We started with a market setting where firms compete à la Cournot and no stable cartel may arise within a one-shot interaction yielding a cartelization rate of 0%. In our first treatment we introduced a mechanism which allowed the firms to implement a cartel that works exactly like an endogenous institution with sanctioning power as observed in various cartel cases. The introduction of this mechanism yielded a cartelization rate of 25.71%. In a further treatment we added the possibility to chat, reflecting the rapid and recurrent communication observed in many uncovered cartels. The combination of the cartel institution and prior chat enhanced coordination even further yielding an explosion of the cartelization rate of up to 97%. In both treatments most of the implemented cartels were “grand cartels”, with symmetric profits. In order to infer the impact of asymmetric profits on cartelization we introduced two treatments where a partial cartel with an outside firm “rebellious” against the cartel institution, is a predicted equilibrium. However, we observed that in 55.56% of the cases, this partial cartel is not implemented. In a fourth treatment, where chat is added the rate of refusal even corresponded to 60%.

These results provide evidence on the role of outside firms in a binding cartel agreement. As already outlined above, the incentive to become an outside firm in a standard Cournot market, induces the collapse of every cartel due to the high profits made at the expense of the cartel members. The implementation of our mechanism that makes out of the cartel an institution, prevents such a situation, since the cartel agreement becomes as binding as a merger. A firm may only become an outsider if it announces its refusal to become a cartel member, before the other firms implement the cartel. The MECC treatment shows that such a strategy is deemed to fail even if a partial cartel with an outside firm is a predicted theoretical equilibrium. In

¹⁵Note, the chat protocol revealed that one of our four matching groups in the MECC treatment decided to coordinate to a partial cartel with three insiders and one outsider. Subjects agreed that in every period only one firm of the group will be permitted to be the only outsider. However, this corresponds to an irrational strategy as the joint payoff of partial cartelization is 388 compared to a joint payoff of 400 in the 4-firm-cartel case. Ultimately the players realized that the strategy did not maximize their profits and switched to full cooperation.

most of the cases potential cartel members refuse to implement a partial cartel where an outside firm would excessively profit from the cartel decision. It appears that firms prevent situation where the profit of a rival would be comparatively excessive. Hence, the refusal to participate in the cartel ultimately implies a renunciation, since the outside firm only obtains Cournot profits instead of the collusive profits it would have obtained, had it joined the cartel.

Furthermore our analysis may allow to assess the efficiency of competition policy in general. Our results simulate a market situation that could be observed in the late nineteenth century in the U.S. At a time where antitrust laws were inexistent oligopolistic markets such as the oil, sugar, steel or tobacco markets were dominated by trusts, business entities that sought to influence the market outcome through price or quantity agreements. Ultimately these trusts even started to influence politics which induced the implementation of the Sherman Act and the launch of the “trust-busting” era as a response. In our SECC treatment the combination of an endogenous cartelization mechanism and extensive chat induced a cartelization rate of 97% thus replicating the historic evidence from the U.S. So far, we followed a descriptive approach which did not provide any recommendations for antitrust experts and cartel authorities. In a possible extension, a prescriptive approach may be chosen that measures the efficiency of antitrust authorities in deterring endogenous cartelization and allowing to infer whether or not leniency programs facilitate or disrupt endogenous cartelization.

References

- [1] Apesteguia, J., Dufwenberg, M., Selten, R., (2007): “*Blowing the Whistle*”, *Economic Theory*, 31, 143-166.
- [2] Bolton, G., E., Ockenfels, A., (2000): “*ERC: A Theory of Equity, Reciprocity, and Competition*”, *American Economic Review* 90, 166-193.
- [3] Borenstein, S. (2003) “*A Rapid Price Communication and Coordination: The Airline Tariff Publishing Case (1994)*”, in *The Antitrust Revolution: Economics, Competition, and Policy*. John E. Kwoka, Jr. and Lawrence J. White, eds., 4th ed. New York: Oxford University Press, 233-51.
- [4] Bos, I., Harrington, J.E., (2010): “*Endogenous Cartel Formation with Heterogeneous Firms*”, *Rand Journal of Economics*, 41, 92-117.
- [5] Connor, J.M., (1997): “*The Global Lysine Price-Fixing Conspiracy of 1992-1995*”, *Review of Agricultural Economics*, 19, 412-427.
- [6] Dal Bò, P., Foster, A., Putterman, L., (2010): “*Institutions and Behavior: Experimental Evidence on the Effects of Democracy*”, *American Economic Review*, 100, 2205-2229.
- [7] D’Aspremont, C., Jacquemin, A., Gabszewicz, J.J., Weymark J.A. (1983): “*On the Stability of Collusive Price Leadership*”, *Canadian Journal of Economics*, 16, 17-25.
- [8] Donsimoni, M.-P. (1985): “*Stable Heterogeneous Cartels*” *International Journal of Industrial Organization*, 3, 451-467.
- [9] Donsimoni, M.-P., Economides, N.S., Polemarchakis, H.M. (1986): “*Stable Cartels*”, *International Economic Review*, Vol. 27, pp. 317-327.
- [10] Ertan, A., Page, T., Putterman, L. (2005): “*Who to Punish? Individual Decisions and Majority Rule in Mitigating the Free Rider Problem*”, *European Economic Review*, 53, 495-511.
- [11] Farrell, J., Rabin, M., (1996): “*Cheap Talk*”, *Journal of Economic Perspectives*, 10, 103-118.
- [12] Fehr, E., Schmidt, K., (1999): “*A Theory of Fairness, Competition, and Cooperation*”, *Quarterly Journal of Economics*, 114, 817-868.
- [13] Fonseca, M., Normann, H-T., (2011): “*When Will They Talk? Tacit vs. Overt Collusion in Laboratory Experiments*”, Working Paper.
- [14] Genesove, D., Mullin, W.P., (2001): “*Rules Communication, and Collusion: Narrative Evidence from the Sugar Institute Cartel*”, *American Economic Review* , 91(3), 379-98.
- [15] Genesove, D., Mullin, W.P., (1999): “*The Sugar Institute Learns to Organize Information Exchange*” in Naomi R. Lamoreaux, Daniel M. G. Raff, and Peter Termin, eds., *Learning by doing in markets, firms, and countries*. Chicago: University of Chicago Press, 1999, pp. 103-38.

- [16] Greiner, B., (2004): “An online recruitment system for economic experiments, In: Kremer, K., Macho, V. (Eds.), *Forschung und wissenschaftliches Rechnen 2003*, GWDG Bericht 63. Ges. für Wiss. Datenverarbeitung, Göttingen, pp. 79-93.
- [17] Gürer, Ö., Irlenbusch, B., Rockenbach, B., (2006): “*The Competitive Advantage of Sanctioning Institutions*”, *Science*, 312, 108-111.
- [18] Harrington, J.E., Skrzypacz, A., (2011): “*Private Monitoring and Communication in Cartels: Explaining Recent Collusive Practices*” Forthcoming in *American Economic Review*.
- [19] Hinloopen, J., Soetevent, A.R., (2008): “*Laboratory Evidence on the Effectiveness of Corporate Leniency Programs*”, *Rand Journal of Economics*, 39, 607-616.
- [20] Holt, C. A., Scheffman D.T. (1987) “*Facilitating Practices: The Effects of Advance Notice and Best-Price Policies*”, *Rand Journal of Economics*, 18, 187-97.
- [21] Huck, S., Konrad, K.A., Müller, W., Normann, H.T., (2007): “*The Merger Paradox and why Aspiration Levels let it Fail in the Laboratory*” *Economic Journal*, 117, 1073-1095.
- [22] Huck, S., Müller, W., Normann, H.T., (2001): “*Stackelberg Beats Cournot: On Collusion and Efficiency in Experimental Markets*” *Economic Journal*, 111, 749-765.
- [23] Kosfeld, M., Okada, A., Riedl, A. (2009): “*Institution Formation in Public Goods Games*” *American Economic Review*, 99, 1335-1355.
- [24] Levenstein, M.C., Suslow, V., (2006): “*What Determines Cartel Success?*” *Journal of Economic Literature*, 44, 43-95.
- [25] Salant, S.W., Switzer, S., Reynolds, R.J. (1983): “*Losses from Horizontal Merger: The Effects of an Exogenous Change in Industry Structure on Cournot-Nash Equilibrium*”, *Quarterly Journal of Economics*, 98, 185-199.
- [26] Selten, R., (1973): “*A Simple Model of Imperfect Competition, Where 4 are Few and 6 are Many*”, *International Journal of Game Theory*, 2, 141-201.
- [27] Stigler, G.J., (1964): “*A Theory of Oligopoly*”, *Journal of Political Economy*, 72, 44-61.
- [28] Sutter, M., Haigner, S., Kocher, M.G., (2010): “*Choosing the Stick or the Carrot?: Endogenous Institutional Choice in Social Dilemma Situations*” *Review of Economic Studies*, 77(4), 1540-1566.
- [29] Shaffer, S. (1995): “*Stable Cartels with a Cournot Fringe*” *Southern Economic Journal*, 55(2), 231-246.
- [30] Vives, X., (1990) “*Trade Association Disclosure Rules, Incentives to share Information, and Welfare*”, *Rand Journal of Economics*, 21, 409-30.