

Rebels without a Clue?

Experimental Evidence on Coordination in Cartels and Outside Firms*

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Abstract

This paper provides experimental evidence on the formation of binding cartels with endogenous coordination and cooperation. We introduce a three-stage mechanism where potential cartel members can monitor the total number of outside firms, before agreeing to a binding cartel. Our first treatment provides a test of our mechanism and yields a cartelization rate of 25.71%. In the second treatment we analyze partial cartelization and the role of outside firms in this framework. Here, the payoff structure is modified making partial cartelization more attractive. We find an out-of-the-equilibrium rejection of partial cartels in 55.56% of the cases documenting the importance of payoff asymmetries. In two further treatments we analyze the impacts of prior communication on firms' cooperative behavior. The results show that chat increases firms' cooperative behavior in the environment of our multi-stage setup. Combining the institution with chat leads to cartelization rates of up to 97%.

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

1 Introduction

The formation of a cartel which includes a multitude of rival firms unmistakably involves a complex and cumbersome coordination process. Evidence from antitrust cases suggests that cartels are forced to induce mechanisms that facilitate coordination and cooperation ultimately ensuring compliance with explicit cartel rules set by its members¹. One of the first papers to provide a theoretical model on these types of complex practices is Selten (1973). Selten (1973) designs a multi-stage mechanism allowing firms to implement a quota scheme that makes the cartel agreement binding. Making the cartel agreement binding may prevent ex post deviation from the cartel strategy by firms that plan to cheat within the cartel and allow to abstract from the problem of internal and external cartel stability. Ultimately a binding cartel agreement triggers the cartel insider to act like a multitude of firms who merged to a single entity.²

The seminal work on mergers by Salant, Switzer and Reynolds (1983; henceforth SSR (1983)) may provide important evidence on the stability and composition of cartels and the role of outside firms. Since the outcome of a horizontal merger and cooperation within a cartel is equivalent (see Shaffer (1995)), the only requisite is that 80% of the firms coordinate to a cartel. Although this approach ensures the stability of the cartel by preventing ex post defection it underestimates the disruptive effect of ex ante defection by outside firms on coordination to a cartel. In fact, “Saying no” to the cartel *does not imply* a renunciation for the outside firm. As d’Aspremont, Jacquemin, Gabszewicz and Weymark (1983) underline “...however by free-riding, fringe firms enjoy higher profits than cartel members”. The binding collusive agreement makes it particularly compelling to become an outside firm since excessive profits, made at the expense of the cartel insiders are ensured, as long as 80% of the firms join the cartel. Most important, it remains unclear why a firm should become an insider and coordinate to a cartel instead of becoming an exploiting outsider who enjoys excessive profits.

The experimental literature on endogenous institutions may provide important insights dealing with this coordination problem in the presence of potential outsiders. Kosfeld, Okada and Riedl (2009) (henceforth KOR(2009)) analyze a social dilemma situation, where subjects can prevent free-riding in a public good game by implementing an endogenous institution with sanctioning powers. In a three stage decision game, the first stage consists of a vote among the subjects who 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 partic-

¹See for instance Harrington and Skrzypacz (2011) who describe the “guaranteed buyings” retaliation mechanism in the lysine cartel, which facilitated the coordination of production and Genesove and Mullin (2001) who report that Sugar producers in the U.S. formed a “Sugar Institute” that issued an entire code of conduct ensuring lenient behavior of the cartel members.

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

ipants. The institution is only established if and only if *all* first stage participants unanimously opt for the institution in the second stage. If established, the institution sanctions those that refuse to contribute their entire endowment in the third stage. This approach allows to punish outsiders for not joining, since a subject could decide not to implement the institution at all in the second stage. As a result the free-riders' payoff would be significantly reduced. An important feature of this approach is that "saying no" to the institution *does imply* a renunciation. If the KOR (2009) mechanism was to be implemented in a cartel, every potential outsider in a cartel would know that cartel insiders might reject partial cartels, i.e. potential outsiders would refrain from becoming an outsider. Thus, KOR's (2009) approach provides a sound mechanism to solve the coordination problem in the formation process of a cartel.

Our experimental setup is in line with Selten (1973) as we use a multi-stage mechanism where firms explicitly coordinate to a cartel. However, we provide a crucial modification by modelling the cartel as an endogenous institution with sanction powers as in KOR (2009). In the first stage of our setup, 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 in the second stage before implementing the cartel in an unanimous voting decision. The possibility to monitor the total number of potential cartel members may enhance coordination, since potential insiders do not bear the risk of being exploited by outsiders when deciding about participating in the first stage. Here, undesired constellations can easily be rejected in the second stage. This should enhance firms willingness to cooperate in stage one. The third stage consists of an automated quantity decision which guarantees that the cartel members do not deviate from the cartel strategy and outsiders to best-response. This mechanism allows to prevent ex post defection and enables us to focus on the role of outside firms on the coordination.

We also provide an innovation to the KOR (2009) framework by introducing communication in order to analyze whether this facilitates cooperation and firms' willingness in stage 1 to form a cartel.³ 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 the multi-stage mechanism may adequately facilitate coordination and cooperation. Nonetheless, a large majority of cartels which would induce high payoff asymmetries between potential insiders and outsiders are rejected. Introducing prior chat increases cooperation and induces firms to coordinate on an outcome that makes payoff asymmetries disappear. The combination of the multi-stage-coordination mechanism with communication leads to a cartelization of 97% of the markets, thus solving the coordination problem.

2 The Outside Firm as a Destabilizing Factor

The seminal work by Selten (1973) is one of the first papers to analyze in detail the factors that may destabilize a collusive agreement. In a three-stage game, where firms compete à la Cournot

³Since communication enables firms to discuss strategies, it should also facilitate coordination.

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.⁴ 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 in Selten (1973), 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 an incentive 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 at the first stage, it defects from the cartel strategy, before the cartel has even been introduced. By defecting *ex ante* the firm becomes an outsider, as the Chinese firms that were outside the vitamin cartel. 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.

⁴As 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.

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), 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.⁵ 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) for cartels, however the difference in the approach is twofold.

First, we use a multi-stage coordination mechanism à la KOR (2009) making our cartel agreement binding, which should at first sight replicate the SSR(1983) results for mergers. More important, the KOR (2009) framework adds a sequential move order to improve firm coordination. That is, in stage 1 the firms only potentially have to state whether to form a cartel. In stage 2 firms can easily monitor the number of firms willing to form a cartel. Afterwards potential cartel insiders can decide contingent on the total number of potential cartel insiders (outsiders), whether they want to form a cartel. Thus, partial cartels (which can be significantly harmful for cartel members) can be rejected in the sequential KOR (2009) scenario. This stands in contrast to setups like tacit collusion (e.g. see Fonseca, Normann (2011)) where firms simultaneously decide to choose collusive quantities. Hence, the sequential framework should facilitate coordination because firms in this framework can attempt to form cartels without the risk of being exploited by outside firms.

Second, we introduce the possibility to chat which adequately reflects the dynamic of communication during the negotiations between cartel members in the “smoke filled room”. In this regard we are interested whether the possibility to chat enhances firms’ willingness to cooperate in stage 1. The finding that “cheap talk” options significantly increase coordination and subjects’ cooperativeness is well-documented in the experimental literature (e.g. Cooper et al. (1989); Cooper et al. (1992); Duffy and Feltovich (2002)). Moreover Cooper et al. (2011) report that prior coordination avoids asymmetric outcomes in coordination games, furthermore the authors emphasize that cheap talk enables participants to refuse asymmetric outcomes when occurring. Implementing these two modifications allows us to infer whether the multi-stage setup may serve as a coordination device which may facilitate cartelization in the laboratory.⁶ Bearing in mind that cartelization strongly depends on firms’ willingness to cooperate, it might be that communication may more adequately solve the coordination problem. That is, communication might not only increase firms’ cooperativeness it might also serve as a signaling device for firms to threaten sanctions in order to trigger coordination.⁷ A stable cartel may, also have to be “comparatively stable”, i.e. it ensures that no firm excessively profits from its implementation. This is only guar-

⁵Huck, Müller, Normann (2001) also find in an experimental Stackelberg-setting that Stackelberg followers sanction Stackelberg leaders by increasing their quantities.

⁶Note that SSR (1983) solely focus on what kind of merger equilibrium will occur. However it remains unclear how firms may coordinate to such an equilibrium

⁷If there are too many outside firms or if the cartel insiders refuse to accept that an outside firm excessively profits from the cartel creation, they may decide not to implement it.

anteed, if a cartel agreement would be reached where all firms being active in the market form a so called “grand cartel”.⁸

3 Cartel Coordination 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:

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

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 obtain following insiders’ profits:

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

whereas the 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.

⁸This is confirmed by KOR(2009) who find that the majority of public good institutions implemented are “grand institutions” which include all subjects

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.⁹ 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. Additional 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

⁹Note the treatments were neutrally framed using the German word “Marktabsprache” which means “market agreement”.

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*¹⁰ in both treatments (SEC and MEC). Subjects' payoffs depended on their role (insider or outsider) and the total sum of other insiders/ outsiders.¹¹ 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
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.¹² After 90 seconds the window automatically closed and stage 1 started immediately.¹³ Stage 1-3 proceeded exactly in the same

¹⁰*Taler* is a synonym for *ECU* (Experimental Currency Unit)

¹¹Note that payoffs are rounded to integers.

¹²Note 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.

¹³Stage 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

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). 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). The experiment was conducted at the *DICE Lab* of the University of Duesseldorf in February 2011. In total 84 subjects from the University of Duesseldorf from various fields took part in the experiment. On average they earned 16.96€. The subjects were recruited with the online recruitment system ORSEE (Greiner, 2004)).

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 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 firms care about relative payoffs between possible insiders and ultimate outsiders, 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

subjects have to find out how to play the game and conversations are supposed to last longer.

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 four strict subgame perfect cartel equilibria each with $m = 3$ cartel members and every firm as the only outsider in each of the equilibria. We also obtain a symmetric subgame perfect cartel equilibrium in mixed strategies with an entry probability of $p = \frac{35}{48}$.

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 four strict subgame perfect cartel equilibria each 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 $p = \frac{35}{48}$.¹⁴ 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.¹⁵

¹⁴We obtain the value for the entry probability p by solving $100 \cdot p^3 + 70 \cdot p^2 \cdot (1 - p) \cdot 3 = 178 \cdot p^3$ for p .

¹⁵The 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."

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 firms’ willingness to cooperate is higher in stage 1, i.e. 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 before deciding in stage 1. Following the results of Cooper et al. (2011) this should increase firms’ willingness to cooperate in stage 1. Thus, we expect a higher average number of possible inside firms in SECC compared to SEC. Regarding the modified treatment the same should be true. In the environment of communication subjects’ willingness to cooperate should increase. The 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 might not be accepted. We therefore hypothesize for the modified treatment that the communication option should once again lead to more possible insiders compared to MEC.

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 cooperate and, thus want 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. Insiders in MEC will only accept partial cartelization with at most one outsider. Thus, cartelization will be most likely when there is a high amount of cooperation, i.e a high number of possible insiders in stage 1. Following Hypothesis 1 we also 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 firms’ willingness of cooperation at the first stage of the *KOR* framework. Since Hypothesis 2 expects that communication will lead to a higher willingness to cooperate compared to the treatments without chat, cartelization should be more easy to take place in the presence of prior communication. 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. Finally the table depicts the average producer surplus in the treatments.

	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%	20.00%	82.50%	96.60%
4-Firm-Cartels established	94.44%	35.71%	100.00%	87.88%
3-Firm-Cartels established	5.56%	57.14%	--	12.12%
2-Firm-Cartels established	--	7.14%	--	--
Producer Surplus	292.39 (62.18)	282.00 (53.24)	395.20 (25.96)	385.60 (43.38)
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. As a consequence the average producer surplus is the highest in the two communication treatments.

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

5.2 Willingness to Cooperate

Regarding the efforts to form a cartel, firms' willingness to cooperate, i.e. 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.

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

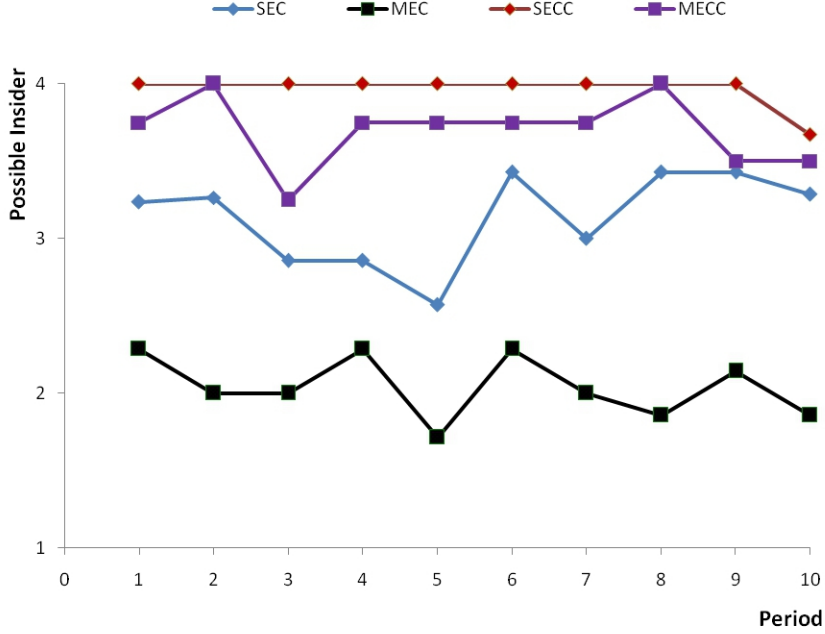


Figure 1: Development of the means of possible insiders

difference (p-value = 0.025). Thus we find support for Hypothesis 1.

In the chat treatments firms behave more cooperative in stage 1. That is, 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 highly significant (MW-test p-value < 0.001). 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 firms¹⁶ 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 < 0.001). 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.

A striking result of our experiment is that in the SECC treatment in 96.7% of all cases all firms behaved cooperative in stage 1 and wanted to be a possible insider. A similar pattern

¹⁶Note, 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. If we ignore this group in our data the average of possible insiders would be 3.9 in MECC.

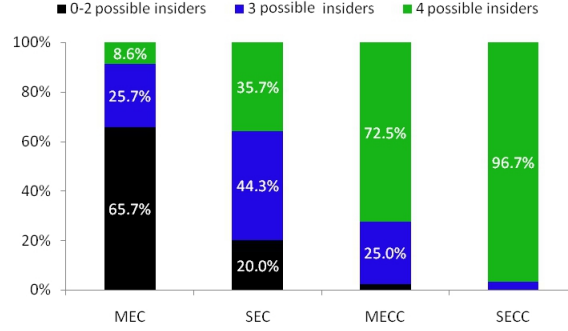


Figure 2: Aggregated composition of possible insiders in all treatments

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 are willing to cooperate and potentially want to form cartels compared to the non-communication cases.*

5.3 Coordination: Established Cartels

In stage 2 of our experiment the KOR (2009) framework enhances coordination because of its sequential move order. Thus, it enables our firms to observe the amount of possible cooperators willing to form a cartel. In addition the sum of *ultimate outsiders* can also be monitored by the firms. Therefore, coordination takes place in stage 2. A higher amount of firms willing to cooperate in stage 1 should lead to more cartels being established in stage 2, 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.

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%)¹⁷ with our non-communication treatments

¹⁷If we again ignore the group in MECC which played the strategy where in each period another firm was allowed to be the outsider, we obtain a cartelization rate of 90%.

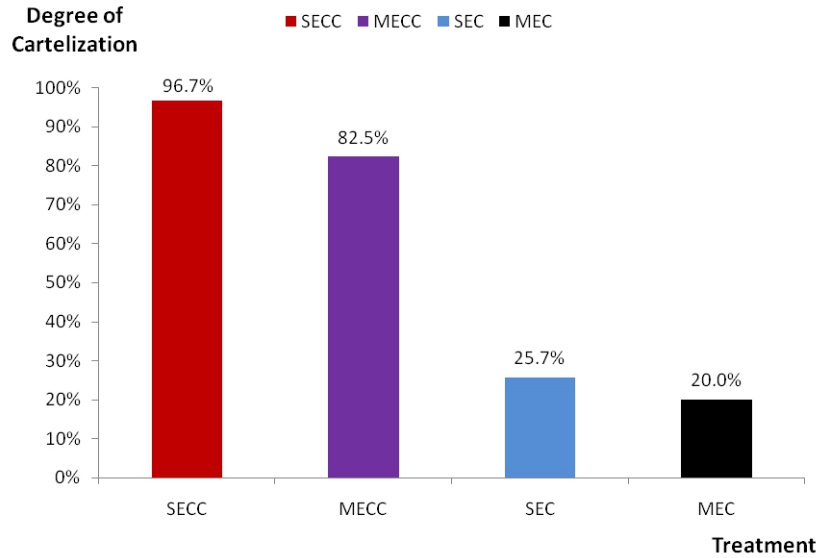


Figure 3: Degree of cartelization in our 4 Treatments

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 treatments 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 cooperators in stage 1. Depending on the total number of possible cooperators and ultimate 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).¹⁸ 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)).¹⁹ 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

¹⁸As 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.

¹⁹We 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 accepted²⁰ (Wilcoxon Signrank test p-value = 0.059). 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 coordination to a cartel and the role of outside firms. 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 the SEC and MEC treatments we introduced a coordination mechanism which allowed the firms to implement a cartel that works exactly like an endogenous institution with sanctioning power. The introduction of this mechanism yielded a cartelization rate of 25.71%. In both treatments most of the implemented cartels were “grand cartels”, with symmetric profits. In order to infer the impact of asymmetric profits on coordination within a cartel, we introduced a treatment where a partial cartel with an outside firm “rebellious” against the cartel institution, is a predicted equilibrium. The results document that in the absence of chat, cooperation decreased in this modified treatment because firms have an incentive to be the only outsider and to earn excessive profits. However, we observed that in 55.56% of the cases, this partial cartel is not implemented. In two further treatments we included the possibility to chat, adding an additional driver to enhance cooperation and making coordination more easy. The combination of the cartel institution and prior chat increased cooperation and coordination significantly. The average number of possible cooperators increased in SECC to 3.96. Thus, coordination was much easier in stage 2 further yielding an explosion of the cartelization rate of up to 97%. In MECC the average number of possible cooperators increased to 3.7, i.e. only few asymmetric constellations appeared. Interestingly in this treatment the rate of refusal even corresponded to 60%, whereas most of the implemented cartels are grand cartels, where there is no profit asymmetry. However, because of the high amount of possible insiders in MECC the “problem” of inequality aversion which hindered cartelization was nearly “deactivated”.

These results allow to reassess the role of outside firms on the formation of cartels. In a partial cartel, the excessive profits of the outside firm may induce all firms to opt for the outsider

²⁰If we again ignore the group which played the special strategy, we obtain a rejection rate of 100%, documenting that the communication device served as an excellent threat that ultimate outsider will be punished.

position and ultimately jeopardize coordination to the cartel. The MECC treatment demonstrates that in spite of the potential disruptive effect of profit asymmetries, firms coordinate to a cartel. Astonishingly we find that our results contradict the theoretical prediction since the large majority of the cartels are grand cartels. The MEC treatment shows that in most of the cases firms refuse to implement a partial cartel although theory predicts such an outcome. It appears that firms prevent situation where the profit of a rival would be comparatively excessive. Hence, the refusal to participate in the cartel, by a potential outside firm 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 cooperation leading to a cartelization rate of 97% thus replicating the historic evidence from the U.S. So far, we opted for a purely descriptive approach which did not provide any recommendations for antitrust experts and cartel authorities. In a possible extension, a prescriptive approach may be followed that measures the efficiency of antitrust authorities in deterring endogenous cartelization and allowing to infer whether or not leniency programs facilitate or disrupt cooperation in the cartel context.

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