Cartel Coordination and the Role of Payoff Asymmetries: Experimental Evidence on Partial Cartels

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Abstract

This paper provides evidence on the coordination to partial cartels in the presence of payoff asymmetries. Firms face a coordination challenge when a partial cartel is to be formed as every firm is better off if it is not inside the cartel but is a free-riding outsider. We introduce a two-stage mechanism with communication which facilitates the formation of a cartel and respectively allows the formation of a partial cartel. Although theory predicts three-firm cartels to occur we hardly find firms coordinating to these cartels when communication is possible. Instead, in the communication treatments firms coordinate to all-inclusive cartels which are always formed. Our control treatments emphasize that coordination problems occur when chat is absent. Strikingly, firms seem to care about payoff asymmetries, i.e., partial cartels are frequently rejected out-of-equilibrium if outside firms profit excessively from the formation of the cartel.

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1 Introduction

The emergence of partial cartels remains a highly debated phenomenon in the theory of collusion which, in spite of numerous contributions to the subject, still leaves a host of questions unanswered. The cartel stability literature provides important insight on the market conditions which are necessary for a partial cartel to emerge, but deliberately leaves the subject of coordination challenges within the partial cartel untouched. Evidence from antitrust cases such as the vitamin C cartel, the district heating pipe cartel or the sugar institute cartel suggests that cartel members had to coordinate their behavior in order to confront the disruptive effect of those firms operating outside the cartel.[1] The failure to adequately coordinate actions among the cartel members, in order to respond to the competitive pressure of the outside firm, may ultimately lead to the breakdown of the collusive agreement. This phenomenon has been observed in the vitamin C cartel and the heating pipe cartel.

A significant coordination challenge for a partial cartel may be generated by the fact that outside firms make excessive profits at the expense of the cartel members. As d'Aspremont et al. (1983) underline "...however by free-riding, fringe firms enjoy higher profits than cartel members." In fact when firms in our setup decide to say "no" to the cartel, this does not imply a renunciation at all for them. This raises the following research question: *Under which conditions do firms coordinate the formation of a partial cartel when a firm would be better off if it was the free-riding outsider?* We tackle this problem as we provide a stylized experiment to investigate the conditions on how firms coordinate the formation of a partial cartel. More precisely, we study a mechanism that facilitates the formation of a stable partial cartel *with* and *without* communication.

This paper departs from the cartel formation approach where a unanimous decision to communicate constitutes cartel formation.[2] Instead we analyze a cartel with an institutional structure as in Selten (1973) which adequately copes with the coordination challenge in the cartel formation process. Furthermore we allow firms to employ free-form communication as further coordination device (see Harrington et al., 2013).[3] We therefore use a modified version of a three-stage mechanism first experimentally introduced by Kosfeld, Okada, and Riedl (2009)(henceforth KOR, 2009) which works as follows: the formation process is split into two stages, where only those firms that attempt to establish a cartel in a first stage are allowed to form it in the second stage. Firms observe the number of potential cartel members and thus the cartel size in the second stage before they unanimously decide to form the cartel. Finally, all cartel members are

[1] In the vitamin C cartel, cartel members decided to purchase the excess supply of non-cartel members, in order to ensure that the quotas fixed by the cartel would be fulfilled. The heating pipe cartel opted for a collective boycott against the customers and suppliers of the outside-firm Powerpipe in order to drive it out of the market (both cases see Harrington, 2006 and Harrington and Skrzypacz, 2011). A similar strategy was observed in the sugar institute cartel case, where sugar refiners from Florida suggested that the cartel should either force the outside firm Hershey to stop its "unethical" behavior or convince it to join the cartel (see Genesove and Mullin, 1999).

[2] See, for instance, Apesteguia et al. (2007), Hinloopen and Soetevent (2008) and Bigoni et al. (2012). This literature is discussed comprehensively, in the next section.

[3] The study of Harrington et al. (2013) experimentally infers what modes of communication (non-binding price announcements vs. unrestricted written communication) are able to generate and sustain collusion.

automatically bound to a certain quantity decision while the outsiders play the best-response strategy. By contrast, if the cartel is not formed, all firms play their competitive best-response strategies.

Most importantly, as we are interested in the interaction of communication (as a coordination device) and the two-stage mechanism, we introduce an innovation to the KOR (2009) framework by allowing the firms to communicate before the mechanism starts. In our view, a communication option in the beginning of the game adequately reflects meetings of firms in a "smoked-filled room". The introduction of communication is crucial in the context of cartels (e.g., McCutcheon, 1997; Genesove and Mullin, 2001; Andersson and Wengström, 2007, and Harrington et al., 2013)[4] and may furthermore reveal what motives drive the firms' decisions in the presence of profit asymmetries between cartel insiders and outsiders. Although firms are not bound to a contract after the communication stage, it adds an interesting new feature. That is, when firms tried to free-ride in previous periods, former inside firms may use the chat to inform former free-riders that they would stop to collude when this might be abused. Therefore communication in our framework cannot be seen as cheap talk and should crucially impact on firms' decisions in the subsequent two stages. The combination of an institutional structure provided by the KOR (2009) mechanism and communication not only allows us to answer our research question but also 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 two-stage mechanism not only provides a clear partition between insiders and outsiders in the first stage, it furthermore allows potential participants to check which firms are inside and outside of the cartel, before its formation. Undesirable constellations may thus be rejected in the second stage. Making the agreement binding is a simplification of the cartel implementation challenge as it guarantees the cartel's stability and ensures that it will not be jeopardized by cheaters within the cartel. This approach provides assurance of the profits insiders and outsiders will make and generates the profit asymmetry which is the subject of the research question at stake. Combining the communication opportunity with the mechanism will thus lead to interesting insights whether chat affects firms willingness to form cartels under the mechanism. Furthermore it enables us to study whether potential cartel members honor partial cartels with outside firms. We are among the first to provide experimental evidence on the formation of a partial cartel.

The remainder of this article proceeds as follows. Section 2 links our approach to the relevant literature and presents our experimental design. Section 3 presents the theoretical predictions and the hypotheses we postulate. Sections 4 and 5 discuss the results, while Section 6 concludes.

[4]Ellingsen and Johannesson (2004) report the coordination enhancing effect of communication in a hold-up experiment.

2 Literature and Experimental Design

2.1 Related Literature

The predominant experimental literature on endogenous cartels mainly focuses on the disruptive effect of antitrust policies on the implementation of all-inclusive cartels. Apesteguia et al. (2007), Hinloopen and Soetevent (2008) and Bigoni et al. (2012) therefore leave out the endogenous cartel formation process and focus on the coordination of prices and the subsequent implementation of the cartel strategy. As opposed to the approach followed in this literature, we do not study antitrust policies in this paper, instead we analyze the conditions under which partial cartels may occur. Therefore, we tackle the cartel formation challenge and abstract from the cartel implementation challenge. We introduce a multi-stage mechanism that allows the firms to assess if the critical mass of firms willing to participate in a cartel is reached before the cartel is implemented. This guarantees the emergence of stable cartels and allows us to infer how firms coordinate the formation of a partial cartel *with* and *without* preceding communication opportunity.

The theoretical literature on cartel stability determines the necessary market conditions that guarantee the emergence of stable cartels and their respective subsets of partial cartels. Accordingly the existence of partial cartels is established in a static setting for price-leadership (e.g., d'Aspremont et al., 1983; Donsimoni, 1985; d'Aspremont and Gabszewicz, 1986; Donsimoni et al., 1986), for quantity-leadership (e.g., Shaffer, 1995) and in a dynamic capacity-constrained price game (e.g., Bos and Harrington, 2010). Most of the papers, however, focus on the structure of the cartel, neglecting the coordination challenge firms face in the formation of these cartels.

A notable exception in this strand of literature is Selten (1973) who introduces institutional assumptions on the operation of a cartel characterized by a multi-stage coordination mechanism. At the first stage of this setup firms decide on the formation of a cartel. Afterwards, they bargain over the cartel's implementation via a quota scheme at the second stage.[5] The coordination challenge is therefore composed of a formation and a bargaining challenge since the cartel bargaining problem can only be solved and subsequently implemented if a sufficient number of firms decide to form the cartel beforehand. Selten (1973) infers the impact of market size on the stability of the collusive agreement, focusing on the bargaining solution which allows the implementation of the cartel. Our paper differs in this aspect as it abstracts from this implementation challenge. Instead it focuses on the formation challenge, analyzing how payoff asymmetries and the subsequent free-rider problem generated in partial cartels impact on coordination. Furthermore our paper assesses the impacts of communication on the coordination challenge. The aforementioned formation challenge has been tackled by the experimental literature on endogenous institutions in the context of public-good provision as, for instance, in KOR (2009).[6]

Here, an experimental analysis on the formation of an endogenous institution which sanctions

[5] In Selten (1973), the solution of the cartel bargaining stage implies that firms will stick to the agreement and not cheat on the cartel. Hence the successful coordination of the quotas guarantees that the cartel is implemented afterwards.

[6] Note that the theoretical model implemented experimentally in KOR (2009) developed in Okada (1993) is closely related to Selten (1973). As Okada (1993) underlines: "The prototype of our institutional arrangement can be found in Selten (1973) where cartel bargaining in the symmetric Cournot oligopoly is investigated by using a noncooperative game model similar to ours."

free-riding in the context of a public good game is provided. In a three-stage decision game, the first stage of the KOR (2009) experiment consists of a vote to participate in an institution, as in Selten (1973). In the second stage all subjects that decided to participate at the first stage learn about the number of potential participants. The institution is established if and only if *all* first-stage participants unanimously opt for the formation of the institution at the second stage. If established, the institution sanctions those that have refused to contribute their entire endowment at the third stage, ensuring cooperation within the institution. The outsiders may contribute whatever they want to the public good. We apply this three-stage mechanism to a Cournot market, where the first and second stages are equivalent to KOR (2009). Afterwards we depart from their framework as the cartel automatically chooses the joint-profit-maximizing Cournot quantity for all its members, whereas the outsiders always play best-response. Hence we assume that the cartel may be able to prevent cartel members from cheating. Here, one might raise the objection that joint profit maximization does not satisfy the incentive compatibility constraint of a firm that wants to maximize its own profit. However, evidence from several cartel cases as presented in Levenstein and Suslow (2006) confirm the theoretical finding revealed by Bernheim and Whinston (1985) which shows that a joint-profit maximizing strategy may be sustained in a cartel.

Levenstein and Suslow (2006) group the problems cartels have to overcome in three categories: coordination of the behavior to a collusive agreement, cheating on the collusive agreement and market entry. As our research focuses on the first category, namely coordination, our analysis abstracts from the second and third categories. On the one hand this approach therefore introduces a technical simplification of the cartelization challenge. Our framework guarantees after the two stags that the potential payoff asymmetries generated by outside firms are not jeopardized by cartel members that decide to cheat on the cartel agreement. Hence the effect of cheating within the cartel is neglected in our framework. On the other hand the effect of cheating may be neglectable in the context of explicit collusion as empirical evidence provided by Levenstein and Suslow (2006) suggests.[7] Furthermore, Bernheim and Whinston (1985) show that the implementation of a joint-sales agency incentivizes competing firms through an indirect mechanism to opt for the joint-profit-maximizing output. Experimental evidence by Cooper and Kühn (2014) highlights that the implementation of an effective retaliation mechanism that punishes cheating efficiently induces full cooperation in an infinitely repeated coordination game. Hence our setup does not literally require enforceable cartel contracts or a binding agreement to guarantee that cartel members maximize joint profits.

As the coordination of the cartel formation process in our experiment is composed of a two-stage mechanism with a preceding communication phase, we contribute to the literature on the pro-collusive effect of communication. Economic theory by Crawford and Sobel (1982) and Farrell and Rabin (1996) underlines that coordination may be facilitated by communication, which is furthermore experimentally confirmed (e.g., Cooper et al., 1989; Cooper et al., 1992; Charness and Dufwenberg, 2006). Recent papers in the experimental antitrust literature by Andersson

[7]Note however that Levenstein and Suslow (2006) find that market entry is one of the biggest challenges cartels face.

and Wengström (2007), Fonseca and Normann (2012), and Cooper and Kühn (2014), who thoroughly analyze the impact of communication on cartelization, confirm its pro-collusive effect. We contribute to this literature as we analyze how communication impacts on the formation of partial cartels. The communication device is of particular importance here, as it may allow us to study whether firms actively use it to enforce collusion by threatening potential free riders for being not cooperative in future periods. The latter indeed leads to the fact that communication in our game is not cheap talk as we apply a repeated game where firms meet for ten periods. Firms may therefore punish firms lying in the chat.[8] The communication option also allows us to to understand the underlying motivations of colluding firms, i.e., whether firms may care about payoff asymmetries between inside/outside firms in partial cartels. We therefore evaluate communication following the approaches used in Andersson and Wengström (2007) and Kimbrough et al. (2008) in order to infer whether or not payoff asymmetries influence the formation of partial cartels.

2.2 Experimental Design

In our experiments we implemented four different treatments: *Standard Endogenous Cartels with Chat* (SECC), *Standard Endogenous Cartels* (SEC), *Modified Endogenous Cartels with Chat* (MECC), *Modified Endogenous Cartels* (MEC).

TABLE 1 Treatments

		communication	
		chat	no chat
payoff structure	Standard Endog. Cartels	**SECC**	**SEC**
	Modified Endog. Cartels	**MECC**	**MEC**

SECC and SEC are our control treatments which also serve as starting points. Here, we first infer how firms coordinate the formation of a stable cartel. The treatment SEC is without chat and allows us to infer the role of communication on coordinating the formation of a stable all-inclusive cartel. Our main focus are the treatments with modified payoffs, i.e., in the MECC treatment we introduce a crucial modification of the payoff structure for a partial cartel in the standard treatment. The latter facilitates the emergence of a partial cartel (see next section for a detailed theoretical description of the game). Again we introduce a treatment MEC without chat,

[8] Recall that firms may threaten other firms to stop collusion when they realize that these firms try to abuse the cooperation.

which allows us to evaluate the role of communication on the coordination and implementation of a stable partial cartel. The treatments with standard payoffs provide useful benchmark cases to infer the effects of potential payoff asymmetries in the presence of partial cartels (we will discuss this below, when we introduce the payoff schemes of our treatments). The reason is that theory predicts partial cartels to occur in MECC and MEC, whereas all-inclusive cartels are predicted in SECC and SEC.[9] Therefore the benchmark treatments enable us to compare how firms coordinate the formation of a stable all-inclusive cartel and a stable partial cartel. Thus we can infer whether firms form partial cartels and whether this leads to a coordination challenge. The variation of chat/no chat and modified/standard payoffs allows us to study the research question, i.e, under which conditions may firms coordinate to partial cartels. Table 2 provides an overview of the payoffs generated in a symmetric Cournot game with four firms for every cartel constellation.[10] In the table, cartel members' payoffs are determined following the assumption that they maximize the joint profits. Furthermore, we assume that the outsiders play their best-response strategies which determines their payoffs. In the following we explain our mechanism.

TABLE 2 Payoffs in the Treatments

Composition		**Payoffs in SECC/SEC**		**Payoffs in MECC/MEC**	
# insiders	# outsiders	insider(s)	outsider(s)	insider(s)	outsider(s)
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

Note: The table illustrates subjects' payoff dependent on their role (insider/outsider) and the total sum of insiders/outsiders. It also depicts how the combination of chat and the modified mechanism works. Payoffs are presented in *Taler* which is a synonym for *ECU* (Experimental Currency Unit). The payoffs were rounded to integers, and we always assume the subjects to play their best-responses.

In **stage zero** of SECC and MECC firms of one market were given the possibility to participate in an unrestricted chat. This took place in a chat window for a total of 60 seconds. After that the window automatically closed and stage one started immediately.[11]

[9] See Section 3.

[10] We modify the payoffs for a three-firm cartel from 59 to 70 Taler in the modified treatments in order to analyze the formation of partial cartels. Although this modification is exogenous it allows us to compare the formation process of a partial and an all-inclusive cartel in a symmetric four-firms Cournot market. Furthermore, the increase of payoffs within a three-firm cartel may also be justified in the context of association formation as in Bloch (2010) where synergies within a partial cartel yield a comparable increase in payoffs.

[11] Stage zero lasted for 90 seconds in the first period as subjects first had to find out how to use the chat option. Afterwards the time was reduced to 60 seconds. Firms remained anonymous during the chat and were given neutral names like "firm 1-4" which did not change.

In **stage one** all subjects in a market simultaneously had to state whether they wanted to join a cartel.[12] Subjects simply had to click on a "yes-" or "no-" button. If a participant stated in stage one that she was willing to form a cartel she became a *possible insider*. Participants who stated in stage one that they did not want to form a cartel became *ultimate outsiders*.

In **stage two** everybody was informed of the total number of possible insiders and ultimate outsiders. Note that both types of subjects (possible insiders as well as ultimate outsiders) were given information on the total number of participants willing to establish a cartel. In stage two, only possible insiders were allowed to decide whether they definitely wanted to form a cartel. Beforehand, they were asked if they ultimately wanted to stick to the cartel. The possible payoff of being a cartel member was presented to them as well as the possible payoff of being an outsider. Additional information about the resulting payoffs of the ultimate outsiders was also given. Once 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 subjects clicked the "no-" button, the agreement was rejected and no cartel was established. The cartel agreement became binding if and only if *all* possible insiders in stage two selected the "yes-" button to confirm that they ultimately wanted to join the cartel.[13] Otherwise they became direct competitors and received the Cournot Nash equilibrium profits of a standard four-firm Cournot market. Ultimate outsiders did not have to make any choice in stage two and were only informed of the number of possible insiders.

Finally subjects' payoffs were automatically determined (stage 3). Every subject was informed of whether a cartel had been formed or not. Additionally, they obtained information about their own payoffs and those of the other participants which resulted from the occurrence or non-occurrence of the cartel. Figure 1 gives an overview of the mechanism's stages.

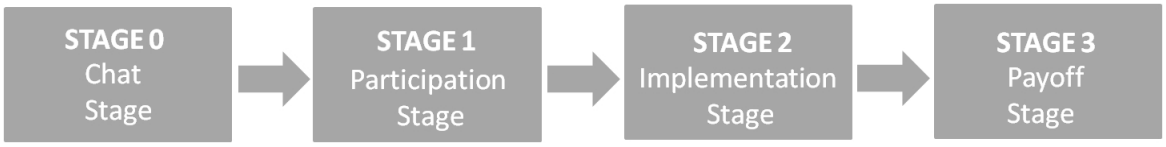

Figure 1: Cartel-formation stages

We used a fixed matching protocol where every group interacted for 10 periods, i.e., the two-stage game was repeated for 10 periods.[14] For the SECC treatment we generated data of three matching groups and for the MECC treatment we generated data of four matching

[12] The treatments were neutrally framed using the German word "Marktabsprache" which means "market agreement."

[13] Note, if unanimity had not been required the firms would have again faced a coordination problem within the cartel in stage two. Hence, for the sake of operability we implemented unanimity.

[14] We opt for fixed matching as this replicates a real market with recurrent interaction.

groups. In the SEC and MEC treatment we each have data of seven match groups.[15] The experiment was conducted at the *DICE Lab* of the University of Duesseldorf in February and April 2011. In total, 84 subjects from the University of Duesseldorf from various fields took part in the experiment. The profits achieved by the participants were converted at an exchange rate of 1 Taler = 0.02€. On average they earned 16.96€. The experiments were programed in z-Tree (Fischbacher, 2007) and our subjects were recruited with the online recruitment system ORSEE (Greiner, 2004) .

3 Theoretical predicitions and hypotheses

3.1 Underlying theory: the Cournot game

We consider a symmetric Cournot market where $n = 4$ firms sell a homogeneous product. The linear demand function for the product corresponds to $P(Q_i) = 50 - \sum_{i=1}^{4} Q_i$. Firms face marginal cost of production $c = 10$. In the case of oligopolistic Cournot competition the profits of the firms correspond to:

$$\Pi = \left(\frac{40}{4+1}\right)^2 = 64. \tag{1}$$

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

$$\Pi(m) = \frac{(40)^2}{(4-m+2)^2 m}. \tag{2}$$

whereas the outsiders' profits are given by:[16]

$$\Pi(m) = \frac{(40)^2}{(4-m+2)^2}. \tag{3}$$

A complete overview of the standard Cournot payoffs depending on the cartel outcomes is provided in columns 3 and 4 of Table 2 (see Experimental-Design section).
The cartel-stability conditions outlined in d'Aspremont et al. (1983) state that all cartel members must prefer to be inside the cartel (internal stability) while outside firms must always prefer to be outside the cartel (external stability) in equilibrium. Absent of our mechanism we never observe a stable cartel as the "internal stability" criteria given by

$$\frac{(40)^2}{(4-m+2)^2} < \frac{(40)^2}{(4-m+2)^2 m}. \tag{4}$$

[15] Note, we conducted more data in our treatments without communication as we observed more heterogeneity in these treatments.

[16] Note that this strategy induces the outside firm to be very aggressive, as every outside firm will have exactly the same market share as the cartel.

holds for no value $m > 1$.

Our mechanism copes with the cartel stability issues that may jeopardize the formation of a stable cartel. As the mechanism automatically binds the cartel members to the joint maximizing strategy, possible cartel insiders at the second stage decide to form the cartel if and only if the cartel payoffs exceed the competition payoffs without a cartel. Therefore the internal-stability criteria in our mechanism corresponds to

$$\frac{(40)^2}{(4-m+2)^2 m} > 64. \tag{5}$$

Hence, internal cartel stability is guaranteed if and only if $m = 4$.[17]

In the first stage firms decide to be either a possible insider or an ultimate outsider. As the $m = 4$ firms cartel is the only stable cartel, free-riding on the cartel always fails. There is no second stage equilibrium with outside firms, so that the $m = 4$ cartel is also externally stable. Hence all firms announce their willingness to join the cartel in the first stage, where a cartel with $m = 4$ firms is a subgame-perfect equilibrium. Proposition 1 states our result:

Proposition 1: *With standard Cournot payoffs, the cartel with $m = 4$ members is a strict subgame perfect Nash equilibrium. As four-firm cartels will always be implemented at the second stage, all firms decide to be insiders of the cartel at the first stage.*

We now turn to the analysis of the case with the modified payoffs for a three-firm cartel. The payoffs are outlined in columns 5 and 6 of Table 2 (see Experimental-Design section).

The modification of firms' payoffs changes the outcome of the game as follows: given our mechanism, the potential cartel members implement the cartel at the second stage if the following condition is satisfied:

$$\frac{(40)^2}{(4-m+2)^2 m} > 64 \tag{6}$$

Now, this not only holds for $m = 4$ but also for $m = 3$ as the insiders' payoffs correspond to 70.[18]

At the first stage, a firm may increase its payoffs from 100 to 178 if it becomes an ultimate outsider. The cartel with $m = 3$ is internally stable, as no firm will revoke its decision to participate in the cartel with three firms. It is externally stable, as the outside firm would reduce its payoffs if it announced its willingness to join the cartel at the first stage instead. This is not the case for the all-inclusive cartel with four firms, as one firm would be better off by becoming an ultimate outsider at the first stage. We thus formulate the following proposition:

[17] Note that Equations four and five are the essence of Salant et al. (1983).

[18] Note that the $m = 3$ cartel is also externally stable, i.e., no outside firm will rather be inside the cartel than outside the cartel as $178 > 100$.

Proposition 2: *In the case of modified Cournot payoffs we obtain four strict subgame-perfect equilibria yielding stable cartels each with $m = 3$ cartel members and every firm as the only outsider in each of the equilibra.*

Proposition 2 highlights that in the modified version of the game another interesting coordination challenge occurs, i.e., firms have to coordinate on which firm should be the unique outsider.[19] Thus, we also obtain a symmetric Nash equilibrium in mixed strategies where firms opt for the possible insider position with a probability of $p = \frac{3}{16}$ as the decision is simultaneous at the first stage. Given this result the emergence of a three-firm cartel is observed with a probability of $p = 0.214$, while a four-firm cartel emerges with a probability of $p = 0.0012$. However, it suffices for our purposes to focus on a partial cartel encompassing three firms. Note that our theoretical predictions are outlined for a static framework although our experimental treatments are repeated for 10 periods. As we do not obtain multiple equilibria, we do not expect the finite repetition of the game to yield diverging results. Nonetheless, our result section includes a learning section in order to infer whether the finite repetition of the game may influence the obtained results.

3.2 Hypotheses

Given the theoretical predictions in the previous subsection we derive our hypotheses. Propositions 1 and 2, predict that the mechanism always yields cartels. Proposition 1 states that the four-firm cartel is the only cartel, i.e., only all-inclusive cartels will be formed in SECC. Proposition 2 predicts that in the case of modified Cournot payoffs only the cartel composition with $m = 3$ cartel members and one outside firm is stable. Thus, only partial cartels will occur with modified payoffs. Following this line of reasoning we expect significantly more partial cartels in MECC than in SECC. From a theoretical point of view there is no difference between the communication and the no-communication case. This leads to Hypotheses 1a and 1b.

Hypothesis 1
(a) In MECC, significantly more partial cartels will be established than in SECC.
(b) In MEC, significantly more partial cartels will be established than in SEC.

Our main research question targets on the acceptance of partial cartels in the presence of asymmetric payoffs. Therefore we focus on MECC and MEC and study how communication in the case of partial cartels influences the decision to form the collusive agreement. The notion of Proposition 2 also implies that partial cartels encompassing three firms will always be accepted by inside firms at the second stage of the mechanism. Theory again

[19] In this regard the experiment can give interesting insights how firms will cope with that.

predicts no difference for the case with and without communication. We can therefore formulate Hypotheses 2a and 2b.

Hypothesis 2
(a) In MECC, firms intending to form a cartel will always accept partial cartels with threee members.
(b) In MEC, firms intending to form a cartel will always accept partial cartels with threee members.

4 Results

In the following paragraphs the hypotheses are tested. Therefore we start reporting the frequency of established cartels. Afterwards we study the determinants of cartel formation, i.e, the incentives to attempt cartels in the different Treatments. In a next step we analyze firms' willingness to accept partial cartels in the presence of payoff asymmetries. Finally, we investigate firms' learning behavior. The data includes one MECC group which decided to play a taking-turns strategy[20] coordinating the formation of a three-firm cartel which encompassed the outside firm in its collusive agreement. As this decision constitutes a collusive agreement the group is also treated as a four-firm cartel.[21] The non-parametric tests are always conducted at the match group level of the treatments.

4.1 Frequency of established cartels

To test Hypothesis 1a and 1b the analysis starts with a summary statistic reporting the frequency of established cartels in the Treatments.

Table 3 gives an overview of the average frequency of established cartel compositions over all periods in the four treatments. It presents data of four (MECC), three (SECC), and seven (MEC and SEC) independent observations of the match-group level in the treatments.

[20] Although playing taking-turns strategies does lower total firm profits (see footnote 19), the observation of firms applying this strategy once ore emphasizes the coordination challenge determined by Proposition 2. Similar taking-turns strategies have been observed in Fonseca and Normann (2012).

[21] The chat protocol revealed that this group played the taking-turns strategy between periods 4 and 7. Hence, the four-firm data comprises this group's choices of periods 4-7. Note that when firms play this taking-turns strategy their joint profits are 388, while coordination to the all-inclusive cartel yields joint profits of 400.

TABLE 3 Frequency of established Cartel Compositions

	no cartel	2-firm cartels	3-firm cartels	4-firm cartels	**total cartels**
MECC (n=4)	0.175	-	-	0.825	**0.825**
SECC (n=3)	0.033	-	-	0.967	**0.967**
MEC (n=7)	0.800	0.014	0.114	0.071	**0.200**
SEC (n=7)	0.743	-	0.014	0.243	**0.257**

Note: The table gives an overview of the frequency of the established cartel compositions in the different treatments. Here, the MECC group which played the taking-turns strategy between periods 4-7 is counted as a 4-firm cartel. The table furthermore includes the frequency of total established cartels.

We find a high degree of cartelization in MECC (in 83% of the cases). Moreover all cartels are all-inclusive cartels. This contradicts Proposition 2. A similar pattern can be found in SECC where we find a substantial cartelization rate of 97%. Again all cartels are all-inclusive cartels, which gives strong support for Proposition 1. As we find no single partial cartel in MECC, we conclude that the fraction of partial cartels is not significantly higher as compared to SECC. We thus have to reject Hypothesis 1a. The latter finding is remarkable as it is in strong contrast to theory which predicts that the three-firm cartel is the only stable cartel in MECC. However, we do not find any partial cartel in the modified treatment with chat.

Turning to Hypothesis 1b we now focus on established cartels in the treatments without chat (MEC and SEC). The fraction of established cartels is small in MEC (20%). Here, we find 13% partial and 7% all-inclusive cartels. In SEC slightly more cartels (26%) are established. The lion's share (24%) are four-firm cartels. It turns out that we find significantly more partial cartels in MEC than SEC (Mann-Whitney test, $p = 0.040$) which supports Hypothesis 1b. The latter finding is interesting as it emphasizes that the communication option leads to different results regarding partial cartelization.

Figure 2 summarizes the fraction of established all-inclusive and partial cartels in the treatments, provided cartels were formed. The Figure reports two-tailed Mann-Whitney test significance levels. The Figure again confirms our findings, i.e., in the communication treatments exclusively all-inclusive cartels are formed. By contrast, there is no significant difference between partial and all-inclusive cartels in MEC. In the standard treatment without chat firms form significantly more all-inclusive cartels than partial cartels.

Finally, the data shows that the communication option has a pro-collusive effect, i.e., significantly more cartels are established in the modified (MECC vs. MEC, two-tailed Mann-Whitney test, $p = 0.006$) and standard treatments (SECC vs. SEC, two-tailed Mann-Whitney test, $p = 0.016$). The pro-collusive effects we find in the communication treatments confirm the results of Cooper and Kühn (2014), Fonseca and Normann (2012), and Harrington et al. (2013). We also find that the fraction of established cartels is

moderately higher in SECC compared to the case with modified payoffs in MECC (Two-tailed Mann-Whitney test, $p = 0.078$).[22] This indicates that the coordination challenge may be enhanced under modified payoffs which may facilitate partial cartels.

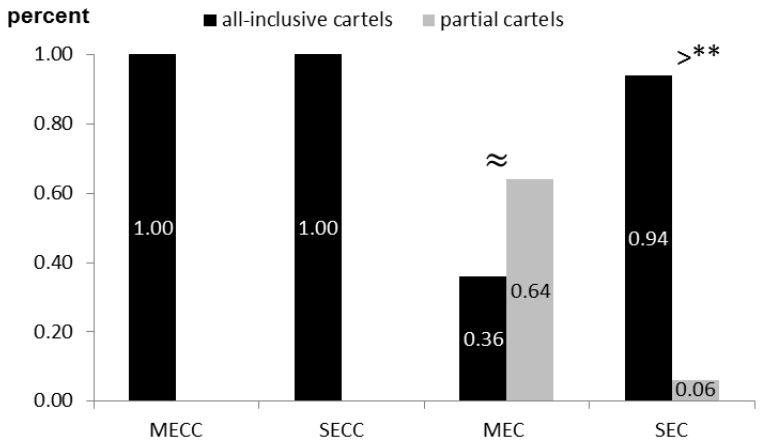

Figure 2: Fraction of all-inclusive and partial cartels

Note: Two-tailed Mann-Whitney tests were used to test for significant differences. In this Figure ***, **, and * indicate significance at the 1%, 5%, and 10% levels. Tests were applied at the match-group level. For the tests we had three match groups in MEC and SEC where cartels were formed.

The analysis has shown that the communication option leads to different outcomes as compared to the case without chat. We find that in SECC and MECC significantly more cartels are established. Supporting theory we find that communication has (almost) no effect on established cartel compositions when comparing SEC and SECC (see Figure 2). In contrast to theoretical predictions this is not the case for the modified treatments, here, communication leads to exclusively all-inclusive cartels. Whereas, partial cartels can be found in the absence of chat. We can therefore establish our first result regarding established cartels:

Result 1 (Established Cartels)
(a) In MECC and SECC we find a high fraction of established cartels.
(b) No partial cartels occur in MECC and SECC. At the same time three-firm cartels are implemented in the modified treatment without chat.
(c) The communication option leads to significantly more established cartels.

4.2 Stage-1 Results: Attempted Cartels

The previous section revealed that no partial cartel was formed in the treatments with communication. Furthermore, we only find few partial cartels in MEC and the total fraction of cartels was small. To get a better understanding on firm coordination to partial and all-inclusive cartels we now infer the incentives to form a cartel in our treatments.

[22] We do not observe a statistical significant difference between SEC and MEC.

Figure 3 presents the average fraction of firms willing to form a cartel at the first stage in our four treatments.[23] The diagram depicts the fractions of 1-4 firms willing to form a cartel at the first stage of our mechanism.

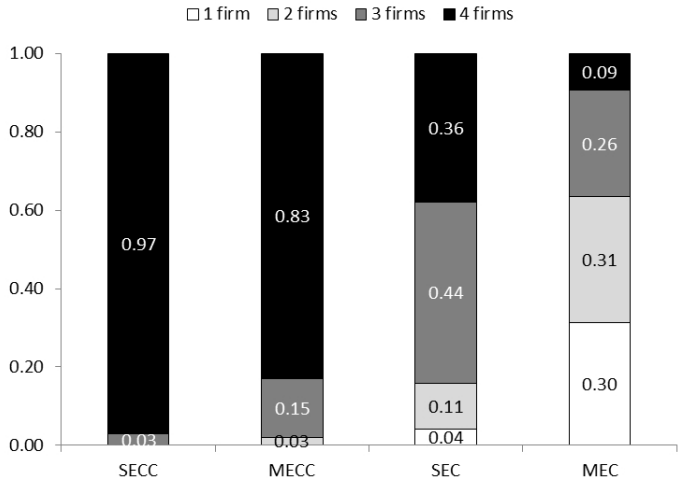

Figure 3: Fractions of firms willing to form a cartel

It can clearly be seen that in SECC (97%) and MECC (83%) firms almost always coordinate to the all-inclusive cartel. The opposite is true when focusing on MEC, i.e, only 9% of the firms try to coordinate to the four-firm cartel. Moreover, 36% of SEC firms try to form the all-inclusive cartel. The fraction of four firms attempting to form a cartel is significantly smaller in MEC as compared to all other treatments.[24] It is also significantly smaller in SEC when compared to the communication cases.[25] A closer look on the SEC and MEC data reveals that a large fraction of the cases with less than four firms is due to coordination failures. In SEC this accounts to all cases with less than four firms (64%). Whereas, in MEC this is the true for all examples with less than three firms. Here, we find a similar fraction of coordination failures (61%) as compared to SEC. In addition, we find that 26% firms coordinate to the three firm cartel. Thus, 87% of MEC firms coordinate to cartels with less than four members.[26] This emphasizes that the incentives in MEC may lead to a small number of firms willing to form cartels. The reason is that the high outsider payoff of 178 may serve as a focal point, i.e., each firm may try to be the only outsider in the partial cartel earning 178. The aforementioned results document that firms do a bad job when playing this coordination game. By contrast, communication seems to substantially enhance coordination in SECC, i.e., nearly all firms coordinate to the stable all-inclusive cartel. Interestingly, the same holds for MECC, where theory predicts

[23] Note that again we count the MECC group which played the taking turns strategy, as a group playing the collusive strategy of four firms which take part in the cartel.

[24] Two-tailed Mann-Whitney tests: $p = 0.013$ (SECC); $p = 0.006$ (MECC); $p = 0.042$ (SEC).

[25] Two-tailed Mann-Whitney tests: $p = 0.016$ (SECC); $p = 0.017$ (MECC).

[26] Note, the case where only one firm is willing to form a cartel is an exception which cannot be labeled as case where firms coordinate to cartels.

that partial cartels occur. The latter finding suggests that communication may help firms to coordinate and to enhance cooperation. That is, firms may manage to coordinate to the all-inclusive cartel, by encouraging selfish free riders not to coordinate to the partial cartel with asymmetric payoffs.

Result 2 (Attempted Cartels)
(a) In MECC and SECC firms almost always attempt the four-firm cartel.
(b) In the communication treatments significantly more four-firm cartels are attempted as compared to the cases without communication.
(c) In MEC the high outside payoffs of partial cartels seem to trigger coordination failures as most firms try to be the only outsider.

4.3 Stage-2 Results: Firms' willingness to accept cartels

The previous section revealed another interesting finding in MEC, i.e, 26% of the firms try to coordinate to the stable partial cartel. However, the results highlight that we only observe 20% (including 7% four-firm cartels) of established cartels in MEC. Thus, it will be exciting to analyze how firms react to payoff asymmetries when partial cartels with three firms can be formed.

Table 4 reports the implementation and rejection rates of cartel compositions conditioned on the number of possible insiders.

TABLE 4 Firms' acceptance of possible cartel compositions

	Possible Insiders				Possible Insiders		
Treatment	2	3	4	**Treatment**	2	3	4
MECC				*MEC*			
Implementation	0.00	0.00	1.00	Implementation	0.05	0.44	0.83
Rejection	1.00	1.00	0.00	Rejection	0.95	0.56	0.17
Observations	1	6	33	Observations	22	18	6
SECC				*SEC*			
Implementation	–	0.00	1.00	Implementation	0.00	0.03	0.68
Rejection	–	1.00	0.00	Rejection	1.00	0.97	0.32
Observations	0	1	29	Observations	8	31	25

Note: The table gives an overview of the implementation and rejection rates of cartels conditioned on the number of possible insiders at stage 2. Possible insiders are firms who stated their willingness to form a cartel at stage 1.

In what follows we conduct one-sample t-tests to test for statistical significance of acceptance and rejection rates. The tests are based on the match-group levels. Table 4 shows

that in MECC and SECC firms always implement the four-firm cartel. At the same time partial cartels with three members are always rejected in the communication treatments. The finding is striking as the three-firm cartel is an equilibrium in MECC. We therefore have to reject Hypothesis 2a, i.e., firms in MECC do never accept partial cartels with three members. It is remarkable that possible insiders here renounce to earn 70 when rejecting the three-firm cartel.

Focusing on the modified case without communication, we find the same phenomenon, i.e., only 44% of the partial cartels are accepted. A one sample t-test rejects the hypothesis that the rejection rate (56%) of three-firm cartels is zero (t(6)=2.914, $p = 0.027$). The finding that firms in MEC reject 56% of the three-firm cartels is striking as theory predicts that these cartels will be accepted. We therefore have to reject Hypothesis 2b. Furthermore firms in MEC reject the vast majority (95%) of two-firm cartels.[27] By contrast, MEC firms accept 83% of the all-inclusive cartels.[28] The result that two-firm cartels are almost always rejected is obviously the consequence of coordination failures of firms at the first stage. That is, cartels in MEC are never efficient when less than three firms attempt to form a cartel. Therefore, rational firm behavior would suggest that these cartels are not implemented at the second stage. However, firms not implementing the three-firm cartel in MEC and MECC cannot only be explained by coordination failures at stage 1, i.e, Proposition 2 predicts the three-firm cartel to be stable. The reason is, that inside firms implementing the three-firm cartel would be better off as opposed to the case when cartels are rejected.

In SEC, firms again always reject all constellations with less than four firms. There is only one exception in SEC where the three-firm cartel composition is accepted.[29] The majority of all-inclusive cartels (68%) is implemented in SEC.[30]

The fact that we have found substantial rejections of three-firm cartels in MEC and MECC might be explained by fairness models like Fehr and Schmidt (1999). Here it may be argued that inside firms dislike payoff asymmetries where one outside firm would get 178 Taler, while the insiders get 70 Taler each. Thus our results contribute to Armstrong and Huck (2010) who summarize the behavioral economics literature in the IO context. The authors highlight in their article that many people are strongly sensitive to relative pay which is also documented in the happiness literature (Clark et al., 2008). Moreover, Armstrong and Huck (2010) point out that CEOs may also care about relative payoffs as

[27] A one sample t-test, testing whether this fraction is larger than 50% cannot be rejected (t(6)=-9.500, $p = 1.000$).

[28] A one-sample t-test, testing whether this fraction is larger than 50% cannot be rejected (t(2)=2.000, $p = 0.908$).

[29] Note that this does not constitute a rational behavior, as firms in the three-firm cartel only earn 59 Taler in contrast to the Cournot-competition case where each firm yields 64 Taler.

[30] It is surprising that firms in SEC do not always implement all-inclusive cartels. A closer look in the dynamics of different SEC groups suggests that some firms may use rejection to punish firms for being not cooperative in prior periods.

managers explicitly or implicitly have placed incentives on them which may induce them to focus on relative performance. In the light of this, our results may provide evidence on the consequences of payoff asymmetries when CEOs care about relative payoffs. When payoff asymmetries exist, intrinsically motivated CEOs may avoid the coordination to partial cartels. Furthermore our findings are in line with Huck et al. (2001) and Huck et al. (2007).[31]

Result 3 (Acceptance of Partial Cartels)
(a) In MECC all partial cartels are rejected. At the same time a high fraction of three-firm cartels is rejected in MEC.
(b) A similar pattern can be observed in SECC and SEC where almost all three-firm cartels are rejected.
(c) Firms in the modified treatments obviously care about relative profits as they renounce the higher payoff of establishing the partial cartel.

4.4 Stage-1: Learning Behavior

In this section we briefly analyze whether firms in our four treatments are prone to learning behavior when focusing on stage-1 decisions. Our results in SECC and MECC reveal that firms use the communication device to coordinate solely on all-inclusive cartels. At the second stage it turns out that firms in all treatments frequently refrain from implementing partial cartels with three insiders. By contrast, in MECC we exclusively find all-inclusive cartels which contradicts our theoretical predictions.

We therefore analyze whether firms strategically reject the formation of three-firm cartels in order to incentivize outsiders to attempt all-inclusive cartels in subsequent periods. Hence, this section infers whether the fraction of attempted all-inclusive cartels changes over time. Figure 2 depicts the development of the fraction of attempted full cartels. In MECC we observe a weak learning effect at the beginning: firms quickly anticipate to attempt the four-firm cartel after period 3. However, there is no significant difference when comparing the average attempted all-inclusive cartels in periods 1-5 (3.8) to periods 6-10 (3.8)(one-sided Wilcoxon matched-pairs test, $p - value = 0.353$). The main reason is that firms in MECC are prone to an end-game effect which starts in period 8. By contrast in MEC no learning can be found, i.e., on average 2.06 four-firm cartels are attempted between periods 1-5 compared to 2.03 in periods 6-10 (one-sided Wilcoxon matched-pairs test, $p - value = 0.316$).

[31] Huck et al. (2001) observe in an experimental Stackelberg setting that Stackelberg followers sanction Stackelberg leaders by increasing their quantities. Similarly Huck et al. (2007) show in a merger experiment based on Salant et al. (1983), that merged firms prevent free-riding behavior of non-merging outside firms.

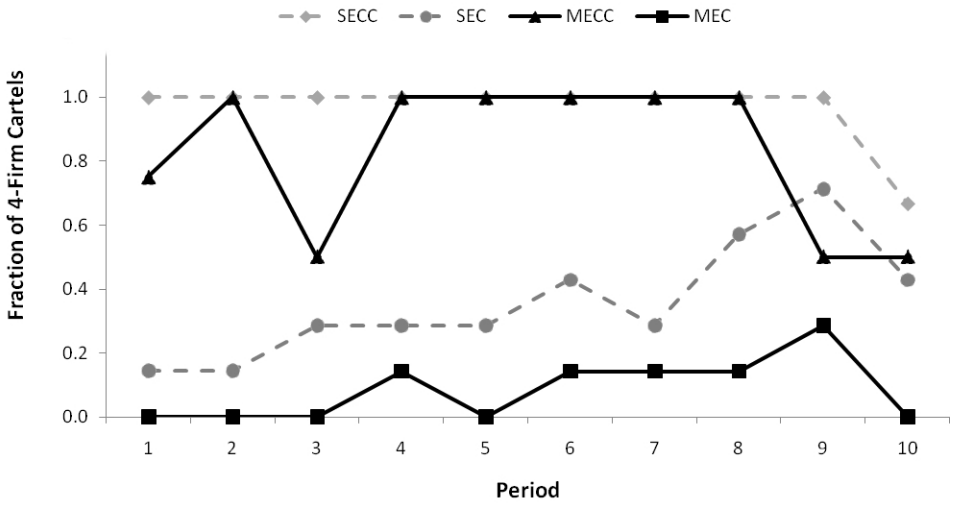

Figure 4: Development of the Fraction of Attempted Full Cartels

Note: The diagram depicts the development of attempted full cartels. The cases where one group in MECC played the taking-turns strategy between periods 4-7 are also counted as attempted full cartels.

The Figure illustrates that there is no learning behavior in the SECC treatment at all. The only exception is the last period where an end-game effect can be observed. By contrast in SEC it turns out that firms learn over time and anticipate that they have to attempt the all-inclusive cartel. That is, there is a significant increase of the average fraction of attempted four-firm cartels (2.71) in periods 1-5 compared to periods 6-10 (3.3) (one-sided Wilcoxon matched-pairs test, $p - value = 0.037$).

The section emphasizes that in the beginning nearly all firms in SECC and MECC attempt to establish the four-firm cartel, whereas in MEC and SEC only few firms attempt it. To learn more about the substantial treatment differences between the non-communication and chat treatments we therefore analyze the chat protocols in the subsequent section.

5 Analysis of the Chat Protocols

As opposed to Proposition 2 we find no significant difference between the fraction of established three-firm and four-firm cartels in MEC. Strikingly, this was further emphasized with communication, i.e., no partial cartel emerged in MECC. To account for these differences we analyze the chat protocols to infer whether firms discuss stage-1 and stage-2 behavior. We analyze the frequency of messages sent by firms over time. Furthermore the chat protocols are evaluated in order to infer the underlying motivations in the cartel-formation process.

In this regard we first follow an approach similar to Andersson and Wengström (2007). The authors account for the number of messages sent and the percentage of "collusive agreements" in the markets. A collusive agreement is defined as any case where subjects in their setting proposed a price by sending a message which was not rejected by other

subjects. In our setting we account for a "collusive agreement" whenever firms proposed an agreement on the cartel and this was not rejected by other firms.[32] Table 7 depicts the average messages sent and the percentage of chat agreements. The table provides evidence that in both treatments most messages are sent in the first period. On average subjects send more messages in MECC (14) than in SECC (9). In both treatments there is a strong decrease of messages sent after the first period. Strikingly, this decrease is pronounced in SECC (33%) in contrast to MECC (15%).

Table 5 Average Number of Messages Sent and Fraction of Entered Contracts

	period										
	1	2	3	4	5	6	7	8	9	10	avg.
avg. number of messages sent											
SECC	18	12	11	8	10	9	11	6	6	9	9
MECC	20	17	13	16	10	14	14	13	11	14	14
collusive agreements (in %)											
SECC	100	67	33	33	0	33	0	33	33	33	29
MECC	100	100	100	75	50	50	75	50	75	100	75

Note: The table depicts the average number of messages sent and the percentage of collusive agreements. Following Andersson and Wengström (2007), we define a collusive agreement in a market whenever at least one subject proposed reaching a market agreement by sending a message and this was not rejected by any of the other subjects

Focusing on collusive agreements it can be observed that in both treatments the implementation of the market agreement is discussed in period 1 of all markets. Starting with period 2 there is a sharp decrease of collusive agreements in SECC, whereas it remains constantly high in MECC. This emphasizes that the incentives of the modified-payoff structure seem to trigger more discussions on cartel-formation strategies among firms than in SECC. To shed more light on these strategies we infer the contents of representative chat protocols. In this regard we follow Kimbrough et al. (2008) and Fonseca and Normann (2012) who have shown that quoting chat protocols of experiments may be very helpful for further revealing promising information about subjects' strategies.

We now give a representative first period example, emphasizing how firms in Market 1 of SECC decided to reach a collusive agreement:

Market 1, period 1: SECC

```
firm 2:  does everybody take part ?!
firm 1:  yes, sure
firm 3:  absolutely
firm 4:  I recommend, that everybody always takes part.  This will guarantee that everybody
```

[32] As opposed to Andersson and Wengström (2007) the agreement to form a cartel in a chat does not constitute a collusive agreement per se. In their setup chat is costly, whereas it is free in our setup. In our framework although chat does not bind firms to the collusive strategies it cannot be seen as cheap-talk agreement. The reason is that our game is repeated and firms lying in the cheat can be easily punished by other firms in future periods.

earns 20€ ...
firm 4: yeah
firm 3: :)
firm 2: yes

These type of conversations took place in all three SECC markets and in all four MECC markets of period 1. It demonstrates that subjects in both treatments immediately made use of the chat option at the beginning. The chat protocols reveal that subjects in SECC quickly started to talk about subjects which had no relation to the experiment.[33] This suggests that the high cooperation rates in SECC periods arise as a result of the early discussion of formation strategies. Another example for the discussion of coordination issues is given by the chat protocols of market 2 and 3 in SECC:

Market 3, period 4: SECC
firm 2: if somebody would get 178, all other participants would be worse off
firm 4: everything would be more complicated, but after 2 periods you would have more than 200
firm 4: 178+59
firm 1: however, the best thing for all is that everybody takes part
firm 3: yes!

Focusing on the modified treatment it turns out that there are 100% of collusive agreements until period 3. In MECC there are high incentives to become the only outsider. This may explain the high number of collusive agreements compelling all the firms to cooperate. There is also evidence that firms in MECC use the chat to rebuke other firms for not taking part in the market agreement. This is illustrated by the next example:

Market 2, period 4: MECC
firm 1: What's that? Who did that?
..
firm 2: nobody did it...
firm 1: if somebody clicks no, then everybody will click no. This in turn leads to the smallest payoff for all of us
firm 2: this is bad for everybody
firm 3: yes, you cannot avoid it. That's the bad thing..
firm 1: everybody would be worse off. Thus, we now should all take part

As already outlined in the previous sections, one of our MECC group (market 3) used the chat opportunity to agree to a taking-turns strategy starting from period 4. We therefore present the chat protocol of this group to demonstrate how these firms coordinated:

Market 3, period 4: MECC
firm 2: all of us should uniquely not take part
firm 2: then everybody would get 178 once
firm 2: who wants to be the first to do that?
..
firm 1: I will not take part!

[33] They talked about their field of study and sports, for instance.

```
firm 2:  firm 1!
firm 3:  yes, you!
firm 4:  ok firm 1, go ahead!
```

In period 8 they realized that this behavior did not help to increase their joint payoff. Thus, the firms immediately quit playing this strategy:

Market 3, period 8: MECC

```
firm 1:  the idea was stupid
firm 2:  which idea?
firm 1:  with this idea everybody earned on average less than 100 Taler
firm 1:  this turns out when you get 3 times 70 and once 178
firm 4:  true
firm 2:  ok, I see your point.  Then it was stupid.
firms 3:  yes!
```

The analysis of the chat data shows that the communication opportunity yields similar results as in Andersson and Wengström's (2007) high cost treatment.[34] Although chat is costless in our experiment, it turns out that the combination of chat with the two-stage mechanism is an efficient instrument to reach collusive agreements. In MECC where a high frequency of non-decreasing collusive agreements can be found, it turns out that chat was an important instrument to sustain cooperation over time. This may explain why solely all-inclusive cartels emerged in contrast to MEC where most cartels were established as three-firm cartels.

Result 4 *In both treatments firms in all markets immediately propose the market agreement. In MECC firms permanently use collusive agreements to stabilize long-term cooperation over time, whereas in SECC there is a sharp decrease of this behavior right after the first period.*

6 Discussion

Our paper is among the first experiments to analyze the coordination challenge faced in the formation of a partial cartel. In this regard we study the interaction of communication and a two-stage mechanism to form cartels. Our results highlight the important role of high outsider payoffs and payoff asymmetries when partial cartels are possible. The modified treatments without communication attract firms trying to be outsiders. We find that the latter frequently leads to coordination failures, i.e., cases with less than three firms willing to form a cartel. Furthermore, payoff asymmetries when three firms are willing to form the cartel seem to exacerbate the coordination to partial cartels. That is, potential cartel members prefer to revoke the decision to form the cartel if outsiders

[34] Andersson and Wengström (2007) outline in their Bertrand-oligopoly experiment, that chat is most effective when the cost of activating are high.

excessively profit at its expense. Hence, our findings suggest that relative profits matter in the formation of a partial cartel. We therefore find confirmation for Armstrong and Huck (2010) who argue that people caring about relative payoffs is an established finding in the literature. Introducing communication leads to different results. First, established results regarding a pro-collusive effect of chat are confirmed (Fonseca and Normann, 2012; Cooper and Kühn, 2014),i.e, substantial more cartels are formed in MECC and SECC. Furthermore the enhancing effect of communication also confirms the results of Ellingsen and Johannesson (2004) who study a hold-up experiment. The high cartelization rates emphasize that firms use the chat option as coordination device to avoid that firms stay a away from cartels. Second, the findings highlight that most cartels established with communication in MECC and SECC are all-inclusive cartels.

Although the paper points out that firms face a particular coordination challenge in the formation of a partial cartel, it does not question the emergence of partial cartels. It rather provides insight on the payoff structures that may preclude the formation of partial cartels. Put differently, our framework models the outsider as an aggressive maverick which takes over a significant market share after the emergence of the partial cartel. However, most of the partial cartels that have emerged in recent decades faced competition from outside firms operating at the fringe of the market (therefore also labeled as fringe firms). The respective fringe firms initially behaved non-aggressively and had a limited disruptive effect on the formation of a cartel. This behavior not only guaranteed the profitability of the cartel for the insiders, but also mitigated the disruptive effect of excessive payoff asymmetries we outlined here. Non-aggressive market behavior by competing fringe firms may therefore be a necessary condition for the emergence of a partial cartel.

So far this approach has abstracted from the analysis of antitrust policies, as our suggested research question necessitates a positive approach of the coordination challenge. The normative approach analyzing the efficiency of antitrust policies has to include cartel defection, which limits the applicability of our framework in this context. However, our experimental approach is not only limited to analyze the impact of payoff asymmetries in the coordination process of a partial cartel. It may also infer coordination challenges resulting from antitrust policies. In this regard the results of the communication treatment emphasized the important role of chat to overcome the coordination problems firms face when attempting to form cartels. Discriminatory leniency policies, for instance, which preclude fine reductions for cartel ringleaders may generate payoff-asymmetries within a cartel. Thus firms may be disincentivized to take a leading role in the formation of a cartel. A coordination challenge in the formation of cartels may therefore arise and may thus necessitate more theoretical and experimental evidence in this area.

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