Strategic and Behavioral Aspects of (Anti-)Competitive Conduct in Oligopolies:

Four Essays in Industrial Organization

Inaugural-Dissertation

zur Erlangung des akademischen Grades eines Doktors

der Wirtschafts- und Sozialwissenschaften

(Dr. rer. pol.)

der Heinrich-Heine-Universität Düsseldorf

vorgelegt von: Dipl.-Volksw. Georg Clemens LL.M.

aus: Ebersberg

Erstgutachter:	Prof. Dr. Hans-Theo Normann
Zweitgutachter:	Prof. Dr. Christian Wey
Datum der letzten Prüfung:	29.01.2014

Preface

This thesis has strongly benefited from discussions with professors and colleagues, as well as presentations at various national and international conferences, seminars, and workshops. I am very grateful to my colleagues: Volker Benndorf, Gordon Klein, Claudia Möllers, Beatrice Pagel, Holger Rau and to all who supported my work. In particular, I would like to thank my supervisor Hans-Theo Normann for his excellent advice and support when writing this thesis. I also want to thank my second supervisor Christian Wey for constant input. Finally I would like to particularly thank my parents and my sisters for patiently supporting me during the whole time when writing this thesis.

Contents

Chapter 1

Introduction

This thesis analyzes the underlying strategic and behavioral motivation of firms' (anti) competitive conduct in oligopolistic markets. One of the major challenges antitrust authorities face is the reconciliation of competition and cooperation among firms in order to benefit from the economic advantages of both. Consequently national and supranational antitrust authorities have issued guidelines and notes which allow to assess the compatibility of firm's conduct such as horizontal co-operation or merger with the legal antitrust framework. The EU guidelines on horizontal co-operation agreements for instance cover cooperation among firms such as R&D Joint ventures which have been thoroughly analyzed by Katz (1986) and d'Aspremont and Jacquemin (1988). Kamien et al. (1992) show that firms which may cooperate in R&D and decide to collude in prices afterwards always have a strategic incentive to fully collude on both stages. This underlines the threat of a horizontal agreement that enables firms to implement a collusive strategy.

The standard assumption on collusive conduct is that firms always opt for collusion as long as the profits from collusion exceed the competitive profit. Yet, Armstrong and Huck (2010) and experimental evidence provided by Huck et al. (2001) and Huck et al. (2007) show that non-standard preferences may influence competitive conduct as well. The results suggest that firms might have concerns about relative profits rather than absolute profits. Consequently outcomes, where some firms free-ride on the strategic decisions of other firms may be rejected out-of-equilibrium because of behavioral motivations. These

behavioral motives may be particularly relevant in the context of cartel formation. The formation of a partial cartel induces a significant coordination challenge as outside firms free-ride on the cartel formation as they usually earn higher profits than the cartel members.

The first part of this thesis is composed of two chapters which analyze the strategic motivation for competitive and anti-competitive behavior of firms in an oligopolistic market. Chapter 2 infers investment strategies in a general purpose product of horizontally competing firms while chapter 3 analysis collusive strategies within a horizontal investment agreement.

Chapter 2 entitled **"General purpose products in a spatial price discrimination model"** analyzes the provision of a general purpose product by means of transport costs reduction in a spatial price discrimination model. General purpose products combine the characteristics of a variety of standard products, allowing firms to cope with the preferences of different consumers. As opposed to the case of mill-pricing, the privately and the socially optimal degrees of general purposeness of a product are equal with spatial price discrimination.

Chapter 3 entitled **"The Limits of Antitrust in the Assessment of Competitor Collaborations"** analyzes the welfare effects of a horizontal agreement in a spatial price discrimination model. In a circular city model à la Salop with price discrimination two out of three firms can opt for a horizontal cooperation. This yields a trade-off, which reduces the fix-cost of the collaborating firm while increasing the substitutability of the firms' products, by relocating the firms closer to each other. In contrast to previous results on competitor collaborations, we show that with price discrimination collaboration may be profitable in the absence of fixed costs reduction. In the latter case both, the consumer surplus and welfare decrease. We conclude that such horizontal agreements should raise more antitrust concerns in markets where firms can price discriminate.

In the second part of the thesis two chapters analyze the behavioral motivations of firms conduct in the context of two cartel coordination problems where non standard-preferences for profits may emerge.

Chapter 4 entitled **"Rebels without a Clue?-Experimental Evidence on Partial Cartels"** (co-authored with Holger Rau) provides experimental evidence on the formation of partial cartels. 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 three-stage mechanism with communication which facilitates the formation of a cartel and respectively allows the formation of a partial cartel. All-inclusive cartels are always formed. We find that partial cartels are frequently rejected out-of-equilibrium if outside firms profit excessively from the formation of the cartel.

Chapter 5 entitled **"The Disruptive Effect of Ringleader Discrimination on Cartel Formation-Experimental Evidence"** (co-authored with Holger Rau) experimentally analyzes the cartel coordination challenge induced by a leniency policy that discriminates cartel ringleaders. Ringleaders often take a leading role in the coordination and formation of a cartel. A discriminatory leniency policy which grants amnesty to all "whistleblowers" except for ringleaders may therefore reduce the incentive to become a ringleader and may disrupt cartel formation. We analyze discriminatory and non-discriminatory leniency policies in a multi-stage cartel formation experiment where multiple ringleaders may emerge. Although theory predicts that cartels will always be reported, whistleblowing rarely occurs. Paradoxically the discriminatory leniency policy induces more firms to become ringleaders, which ultimately facilitates coordination in the cartel.

Part I

Strategic Aspects of (Anti-)Competitive Conduct

Chapter 2

General Purpose Products in a Spatial Price Discrimination Model

2.1 Introduction

The spatial competition approach has emerged as a standard in the literature on product strategies in markets with monopolistic competition. The underlying reason is that product characteristics can be elegantly depicted in a geographical context. Location, for instance, may be interpreted as the level of product differentiation while transport costs level can represent the degree of general purposeness of a product. A firm that invests in the reduction of its transport costs increases the general purposeness of its product as it now combines characteristics that are initially incompatible. The provision of a general purpose product may thus provide a strategic advantage. This interpretation has been developed by von Ungern-Sternberg (1988) and used in subsequent models by Weitzman (1994), Dos Santos Ferreira and Thisse (1996) and Hendel and Neiva de Figueiredo (1997). The results obtained by von Ungern-Sternberg (1988) are in line with the literature on product differentiation[1] as the private degree of general purposeness chosen by

[1] See Hotelling (1929) and d'Aspremont et al. (1979) who show that the private and social product differentiation levels diverge and the excess entry theorem by Salop (1979), which however may not hold for concave transport costs (Matsumura and Okamura, 2006a) or in the case of an elastic demand (Gu and Wenzel, 2009).

firms exceeds the socially optimal degree.

However, the aforementioned results crucially depend on the contestable assumption that firms set mill-prices i.e. customers cover their transport costs. Thisse and Vives (1988) show in a spatial competition model that firms have strong unilateral incentives to price discriminate. They demonstrate that firms will end up with price discrimination if they cannot commit to set uniform mill-prices. Consequently this paper reassesses the findings obtained for the general purpose approach in the context of spatial price discrimination. With spatial price discrimination firms cover the transport costs of their customers, so that the corresponding general puposeness degree may differ from the general purposeness degree with mill-pricing.[2]

This model compares the privately and socially optimal degrees of general purposeness obtained by means of endogenously determined transport costs in a spatial price discrimination model. The results show that firms choose the socially optimal general purposeness degree of their products. This model therefore contributes to the literature on product strategies in spatial price discrimination models as it is the first to introduce general purpose products in this context. Furthermore, this approach copes with trends and established product strategies in a multitude of industries such as automobile and electronics. Car manufacturer in the European market opt for spatial price discrimination (see Verboven, 1996) and provide general purposeness cars such as the "Sport Utility Vehicle", which encompasses the attributes of a of an estate car and a Four-wheel-drive at the same time. In a similar fashion computer manufacturers sell general purpose computers that incorporate functions of special purpose computers, such as a high-performance-computer and a video game console at discriminatory prices (see McAfee, 2008). These examples highlight the practical relevance of general purpose products in markets with price discrimination.

[2]Matsumura and Okamura (2006b) confirm that spatial price discrimination significantly changes the result obtained with mill-pricing for the excess entry theorem.

2.2 The Model

We consider a circular-city model à la Salop (1979) where n firms sell different brands of the same product. Every firm is characterized by an address $x_i \in [0,1]$ and firms are located equidistantly from each other. There is a mass of consumers normalized to unity. Consumers are uniformly distributed over the circle and each consumer is characterized by an address $x \in [0,1]$ which corresponds to his most preferred brand. We assume that a consumer buys at most one unit of the product. If a consumer does not buy his most preferred brand, he has to bear linear transport costs proportional to the distance of the firm. The utility from consuming good i from firm i located at x_i of a consumer located at x corresponds to:

$$u(t_i, x) = v - t_i|x - x_i| - p_i(x) \tag{2.1}$$

Here v is a positive constant, where we assume that $v \geq 2t/n$.[3] A consumer who buys from firm i has to pay a price p_i. As in von Ungern-Sternberg (1988) it is assumed that t_i is a choice variable of the producer i. We assume that firms decide on both the unit transport costs and prices. Decreasing the unit transport costs to t_i requires the fixed cost $F = F(t_i)$, where the fix-cost are a decreasing function of transport costs with $F' < 0$ and $F'' > 0$. It is assumed that all firms face variable costs $c = 0$.

The timing is as follows: In the first stage all firms determine their unit transport costs simultaneously and independently from each other. In the second stage firms set their prices and are able to price discriminate and charge individual prices.[4] The game is solved by backward induction.

[3] The condition $v \geq 2t/n$ guarantees that no monopoly equilibrium exists.

[4] Note that the timing differs from von Ungern-Sternberg (1988). The underlying reason is that this timing reflects more adequately the strategic product behavior of firms outlined in the introduction where an investment decision in production facilities usually precedes pricing decisions.

2.3 The Oligopoly Equilibrium

We follow Thisse and Vives (1988) and assume that when firms price discriminate, they bear transport costs and have to cover them. Hence firm i would face the transport costs $T_i = t_i|x - x_i|$. As symmetry is assumed for all firms in the market, one can focus on the decisions of firm i located in 0. As we solve for a subgame-perfect Nash equilibrium, we start with the second stage where firms set their prices.[5]

A standard result in the literature on spatial price discrimination holds that firms compete à la Bertrand in every location.[6] Given this result, the firm with the lower transport costs in a market segment will be the only seller of the good and set prices that correspond to the transport costs of the rival. The market segment is delimited by the consumer located in $\bar{x}$ who is indifferent between consumption from firm 1 and consumption from firm 2 so that:

$$t_i(\bar{x}) = t_j\left(\frac{1}{n} - \bar{x}\right) \tag{2.2}$$

solving for $\bar{x}$ yields:

$$\bar{x} = \frac{t_j}{n(t_i + t_j)} \tag{2.3}$$

We thus formulate following proposition:

Proposition 1. *When firms set their prices independently and simultaneously, firm i located in $x_i = 0$ competing with $j \neq i$ sets following prices:*

$$p_i^*(x) = \begin{cases} t_j(\frac{1}{n} - x) \textit{ for } x \in [0, \frac{t_j}{n(t_i+t_j)}] \\ t_i(x) \textit{ for } x \in [\frac{t_j}{n(t_i+t_j)}, \frac{1}{n}] \end{cases} \tag{2.4}$$

$$p_i^*(x) = \begin{cases} t_j(x - 1 + \frac{1}{n}) \textit{ for } x \in [1 - \frac{t_j}{n(t_i+t_j)}, 1] \\ t_i(1 - x) \textit{ for } x \in [1 - \frac{1}{n}, 1 - \frac{t_j}{n(t_i+t_j)}] \end{cases} \tag{2.5}$$

[5] We again follow Thisse and Vives (1988) and assume the following tie-breaking rule: If firms propose the same utility to a consumer, he makes a socially optimal choice and buys from the closest firm.

[6] See Thisse and Vives (1988) and respectively Matsumura and Okamura (2006b).

We now turn to the transport costs choice t_i of firm i in the first stage. Given the second stage equilibrium prices firm i maximizes following profit function with respect to t_i:

$$\max_{t_i} \Pi_i = 2 \int_0^{\frac{t_j}{n(t_i+t_j)}} t_j \left(\frac{1}{n} - x \right) dx - 2 \int_0^{\frac{t_j}{n(t_i+t_j)}} t_i(x) dx - F(t_i) \tag{2.6}$$

Solving for a symmetric equilibrium, where $t_i = t_j = t^*$ the first-order condition yields:

$$\frac{\partial \Pi_i}{\partial t_i} = 0 \rightarrow F'(t^*) = -\frac{1}{4n^2} \tag{2.7}$$

given the optimal transport costs level we formulate following proposition:

Proposition 2. *In the symmetric equilibrium, the optimal transport costs level is given by:*

$$F'(t^*) = -\frac{1}{4n^2}$$

The transport costs level obtained here significantly differs from the result with mill-pricing. As von Ungern-Sternberg (1988) notes, firms only take into consideration the benefits of the marginal consumer. Hence the transport costs are reduced until the additional per unit fix cost corresponds to the benefits of the marginal consumer, who is located at a distance of $1/2n$. The transport costs level is unmistakably lower with mill-pricing than with price discrimination where firms cover the transport costs. Thus, they internalize the externalities of excessive transport costs reductions. In order to fully evaluate this result, we now turn to the analysis of the socially optimal level of transport costs.

2.4 Socially Optimal Level of Transport Costs

As in von Ungern-Sternberg (1988), we consider a social planner constrained to sell in n locations who maximizes the social surplus given by:

$$S(n) = 2n \int_0^{\frac{1}{2n}} (V - t(x)) dx - nF(t). \tag{2.8}$$

The first-order condition yields:

$$\frac{\partial S(n)}{\partial t} = 0 \rightarrow F'(t) = -\frac{1}{4n^2} \tag{2.9}$$

Proposition 3 states the result:

Proposition 3. *Privately chosen level of transport costs correspond to the socially optimal transport costs level*

This result stems from the special character of perfect price discrimination. Here, firms aim to maximize welfare in order to reap it off through their prices. As opposed to the mill-pricing case, firms bear the transport with price discrimination. Furthermore they can reduce these costs through a fix cost expenditure in our model. The social planner in von Ungern-Sternberg (1988) faces a very similar maximization problem as the firms in our model. This explains why the private transport costs level corresponds to the social transport costs level a social planner would choose. A more intuitive interpretation of this result suggests that the customer information that is necessary for price discrimination plays a crucial role here. As perfect price discrimination implies that firms have extensive information on consumers behavior, firms can easily deduce the degree of general purposeness that is optimal for their customers.

2.5 Conclusion

This work provides evidence on the provision of general purpose products in an oligopolistic spatial price discrimination model. As spatial price discrimination is the norm in a multitude of industries such as automotive or electronics, an assessment of the relevant product strategies is necessary. The paper shows that the degree of general purposeness of a product determined endogenously is socially optimal. An intuitive explanation to this result is that the consumers' information used to set discriminatory prices allow firms to take into consideration the choices of the consumers when the degree of general purposeness is set. Even though this approach focuses on the case of perfect price discrimination,

it is possible to formulate following insight: a shift from mill-pricing to a certain degree of price discrimination is already welfare enhancing, as the general purposeness degree converges to the socially optimal level when prices converge to full price discrimination.

References

[1] d'Aspremont, C., Gabszewicz, J. J., Thisse, J.-F., 1979. On Hotelling's "Stability in Competition". Econometrica 47, 1045-1050.

[2] Dos Santos Ferreira, R., Thisse, J.-F., 1996. Horizontal and vertical differentiation: the Launhardt model. International Journal of Industrial Organization 14, 485-506.

[3] Gu, Y., Wenzel, T., 2009. A note on the excess entry theorem in spatial models with elastic demand. International Journal of Industrial Organization 27, 567-571.

[4] Hendel, I., Neiva de Figueiredo, J., 1997. Product differentiation and endogenous disutility. International Journal of Industrial Organization 16, 63-79.

[5] Hotelling, H., 1929. Stability in competition. Economic Journal 39, 41-57.

[6] Matsumura, T., Okamura, M., 2006a. A note on the excess entry theorem in spatial markets. International Journal of Industrial Organization 24, 1071-1076.

[7] Matsumura, T., Okamura, M., 2006b. Equilibrium number of firms and economic welfare in a spatial price discrimination model. Economics Letters 90, 396-401.

[8] McAfee, P., 2008. Price discrimination. ABA's Issues in Competition Law and Policy. ABA Section of Antitrust Law, Chicago, pp. 465-484.

[9] Salop, S., 1979. Monopolistic competition with outside goods. Bell Journal of Economics 10, 141-156.

[10] Thisse, J.-F., Vives, X., 1988. On the strategic choice of spatial price policy. American Economic Review 78, 122-137.

[11] von Ungern-Sternberg, T., 1988. Monopolistic competition and general purpose products. Review of Economic Studies 55, 231-246.

[12] Verboven, F., 1996. International price discrimination in the European car market. Rand Journal of Economics 27, 240-268.

[13] Weitzman, M., 1994. Monopolistic competition with endogenous specialization. Review of Economic Studies 61, 45-56.

Chapter 3

The Limits of Antitrust in the Assessment of Competitor Collaborations

3.1 Introduction

Collaborations of a horizontal nature are among the most delicate issues dealt with by antitrust laws. While horizontal collaborations allow firms to combine their resources an thereby to achieve efficiencies, they may facilitate collusive behavior such as price-fixing or product curtailment at the same time. Hence a comprehensive welfare assessment which considers the possible pro-collusive effects of collaboration between competing firms is necessary before its implementation. The E.U. and U.S. American antitrust authorities have issued guidelines which allow to evaluate the compatibility of horizontal collaborations with article 101 TFEU and section 1 of the Sherman Act respectively. While the U.S. American Antitrust authorities follow a rule of reason which balances pro- and anti-competitive effects, the European approach first requires that a horizontal agreement does not have the object to restrict competition ("object restrictions"). Should the agreement have the effect of restricting competition ("effect restrictions") without

eliminating it, exemption is possible if the generated efficiencies are passed on to the consumers. The prerogative is in line with the consumer surplus standard which is favored over the total welfare standard by European antitrust authorities.

This paper assess the welfare impact of a horizontal collaboration between competing firms in a market with price discrimination. Recent examples of large scale collaborations include Ford and Mazda who operate a common production plant in Michigan ("Auto Alliance International plant"), EADS (through its subsidiary Cassidian) and Rheinmetall who jointly develop and produce military drones and Deutsche Telekom AG and O2 who cooperatively operate broadband internet infrastructure. These collaborations all take place in industries where firms opt for price discrimination such as automobile (see Verboven, 2006), telecommunications (see Armstrong and Vickers, 1993 among others) and defense[1]. Further empirical evidence moreover suggests that delivered prices are the norm in international trade (see Greenhut, 1995). Accordingly more insight on the welfare impact of competitor collaboration in the context of spatial price discrimination especially with regards to possible pro-collusive effect is necessary.

So far the literature on horizontal agreements initiated by Katz (1986) and d'Aspremont and Jacquemin (1988) has mostly focused on cooperative R&D and Research joint-ventures[2]. A general approach on horizontal agreements which encompasses the characteristics of the different types of collaborations is provided in Ghosh and Morita (2012). Here, a collaboration that yields a reduction of fix-cost expenditures at the expense of an increased product substitutability is analyzed in a spatial competition model with three firms. Ghosh and Morita (2012) focus on the pricing decision of the non-participating rival and the respective product decision if firms collaborate in production. It is shown, that a competitor collaboration can increase consumer surplus and total welfare.

We model competitor collaboration as in Ghosh and Morita (2012) where the competing firms first decide whether or not they want to collaborate. In the second stage

[1]Note that the collaboration between EADS and Rheinmetall allows to implement a product customization strategy which implies price discrimination, as outlined by Eaton and Schmitt (1994).

[2]Subsequent models on R&D joint-ventures such as Fershtman and Gandal (1994) and Lambertini et al. (2003) furthermore analyze to what extend, these joint-ventures facilitate or disrupt collusion.

firms compete by setting prices. Some crucial extensions are introduced in our approach. First, we analyze competitor collaboration in a spatial price discrimination model following Thisse and Vives (1988) who show that firms rather opt for delivered prices than mill-pricing. Second, we analyze whether or not competitor collaboration may ultimately facilitate tacit collusion. The results obtained allow to infer to what extend collaboration is incompatible with article 101 TFEU or exemptable under article 101(3) TFEU. We thus fill a gap in the literature as we are the first to analyze the pro-collusive effects of a competitor collaboration in a spatial price discrimination model.

The remainder of this article is organized as follows. Section 2 introduces the model. Section 3 analyzes the incentives to form a competitor collaboration. The welfare effects of the collaboration are outlined in Section 4. Section 5 concludes.

3.2 The Model

We consider a "circular city" model à la Salop (1979) where three firms sell different brands of the same product. There is a mass of consumers normalized to unity and uniformly distributed over a circle of circumference 1. Each consumer is characterized by an address $x \in [0,1]$ which corresponds to his most preferred brand. We assume that a consumer buys at most one unit of the product. If a consumer does not buy his most preferred brand, he has to bear quadratic transportation costs proportional to the distance of the firm. The utility of buying at firm i located at x_i :

$$u(x_i, x) = v - t|x - x_i|^2 - p_i(x) \tag{3.1}$$

Here v is a positive constant, where we assume that $v \geq 2t/36$.[3] A consumer who buys from firm i has to pay a price p_i.

The three firms are initially located equidistantly on a circle of circumference 1 where x_i and p_i denote the location and price of firm i. The initial locations of the firms are

[3]The condition $v \geq 2t/36$ guarantees that no monopoly equilibrium exists.

$x_1 = 0$, $x_2 = \frac{1}{3}$ and $x_3 = \frac{2}{3}$, where the initial distance between the firms $i, j \in (1, 2, 3)$, with $i \neq j$ denoted by the subscript "0" corresponds to $d^0_{i,j} \equiv \mid x^0_i - x^0_j \mid = \frac{1}{3}$. All firms face production cost $cq_i + F_i$, where c_i denote the marginal cost of production, which we normalize to zero, while F_i denote the fix-cost of production.

The trade-off generated by the production collaboration is captured by a symmetric relocation which reduces the distance between two firms by $\frac{z}{3}$ with $z \in [0, 1)$. Hence the production collaboration between two firms increases the substitutability between their respective brands. We assume that the firms' decision to form a production collaboration yields a trade off as in Ghosh and Morita (2012). The initial fix cost investment corresponds to $F_1 = F_2 = F$ while collaboration yields $F_1 = F_2 = F(1 - \phi)$ with $0 < \phi < 1$, where ϕF corresponds to the cost savings resulting from the production collaboration.

There are two stages in the game. In stage 1, firm 2 and firm 3 decide simultaneously whether or not to form a production collaboration, while firm 1 cannot form a production collaboration. If the formation of the production collaboration is disclaimed, firms stay at their initial locations $x_1 = 0$, $x_2 = \frac{1}{3}$ and $x_3 = \frac{2}{3}$ so that their fix cost are $F_1 = F_2 = F_3 = F$. If firms 2 and firm 3 agree to induce the production collaboration they face reduced fix cost $F_2 = F_3 = (1 - \phi)F$ and are symmetrically relocated at $x_2 = \frac{1}{3} + \frac{z}{6}$ and $x_3 = \frac{2}{3} - \frac{z}{6}$. In stage 2 each firm i chooses its profit maximizing price p_i, where it takes the price p_j of the firm $j \neq i$ as given. We assume that firms opt for price discrimination. We solve this game by backward induction for a subgame-perfect Nash equilibrium. All proofs are provided in the Appendix.

3.3 Competitor Collaboration with a Competitive Outsider

3.3.1 Prices and Equilibrium Profits

We follow Thisse and Vives (1988) by assuming that when firms price discriminate, they bear transport costs and have to cover them. Hence firm i would face the transport costs

$T = t|x - x_i|^2$.[4] When firms set their prices independently and simultaneously, firm i located in $x_i = 0$ competing with $j \neq i$ sets following prices:

$$p_i^*(x) = \begin{cases} t_j(\frac{1}{n} - x) \text{ for } x \in [0, \frac{t_j}{n(t_i+t_j)}] \\ t_i(x) \text{ for } x \in [\frac{t_j}{n(t_i+t_j)}, \frac{1}{n}] \end{cases} \tag{3.2}$$

$$p_i^*(x) = \begin{cases} t_j(x - 1 + \frac{1}{n}) \text{ for } x \in [1 - \frac{t_j}{n(t_i+t_j)}, 1] \\ t_i(1 - x) \text{ for } x \in [1 - \frac{1}{n}, 1 - \frac{t_j}{n(t_i+t_j)}] \end{cases} \tag{3.3}$$

Given the equilibrium prices, we may now determine the equilibrium profits of the collaborating firms 2 and 3 in the case of collaboration:

$$\Pi_2^{CC} = \int_{\frac{1}{6}+\frac{z}{12}}^{\frac{1}{3}+\frac{z}{6}} t(x)^2 - t(\frac{1}{3} + \frac{z}{6} - x)^2 dx + \int_{\frac{1}{3}+\frac{z}{6}}^{\frac{1}{2}} t(\frac{2}{3} - \frac{z}{6} - x)^2 - t(x - \frac{1}{3} - \frac{z}{6})^2 dx \tag{3.4}$$

which yields:

$$\Pi_2^{CC} = \Pi_3^{CC} = \frac{t}{54} - \frac{tz}{72} + \frac{5tz^2}{144} - \frac{7tz^3}{864}. \tag{3.5}$$

The profits of firm 1 which does not collaborate correspond to:

$$\Pi_1^{CC} = \int_0^{\frac{1}{6}+\frac{z}{12}} t(\frac{1}{3} + \frac{z}{6} - x) - t(x)^2 dx + \int_{\frac{5}{6}}^1 + \frac{z}{12} t(\frac{2}{3} - \frac{z}{6} - x) - t(1 - x)^2 dx. \tag{3.6}$$

which yields:

$$\Pi_1^{CC} = \frac{t}{54} + \frac{zt}{36} + \frac{z^2 t}{72} + \frac{z^3 t}{432}. \tag{3.7}$$

[4] We again follow Thisse and Vives (1988) and assume the following tie-breaking rule: If firms propose the same utility to a consumer, he makes a socially optimal choice and buys from the closest firm.

If no collaboration takes place the respective profits of all firms correspond to:

$$\Pi_1^C = \Pi_2^C = \Pi_3^C = \frac{t}{54}. \tag{3.8}$$

3.3.2 The Impact of Collaboration on Collaborating Firms

Proposition 1. *: In the equilibrium of the collaboration subgame, there exists a threshold value $z' \in [0,1]$ such that the profits of a collaborating firm i where $i = 2,3$ are decreasing in z for all $z < z'$ and increasing in z for all $z > z'$.*

Collaboration has two opposing effects in this model. On the one hand it increases the substitutability between the products provided by the collaborating firms, which has a detrimental impact on the profits for a higher degree of substitutability, i.e higher values of z. On the other hand, the collaboration increases the substitutability between the products of the collaborating and the non-collaborating firm. This increase has a positive effect on the profits of the collaborating firms (see Fig. 1).

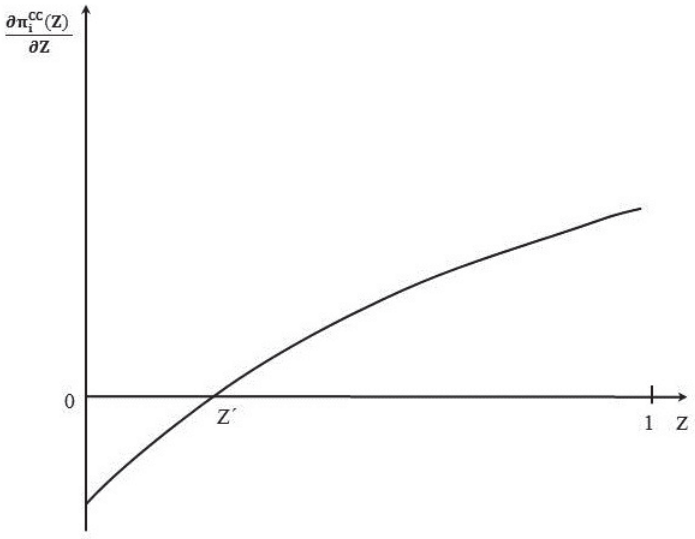


Figure 3.1: The effect of collaboration on profits

Since the reduced distance between the collaborating firms z, exceeds the increased distance between the collaborating and non-collaborating firm $\frac{z}{2}$, the initial impact of col-

laboration on the profits of the collaborators is negative. This holds as long as $z < z'$. As opposed to the mill-pricing case (see Ghosh and Morita (2012)) this effect is reversed with spatial price discrimination for values of $z > z'$. This stems from the fact that with spatial price discrimination the increased competition with the collaborating firm has no downward pressure on the general price level as it is the case with mill-pricing. While the prices of the collaborators generally decrease with higher values of z in the mill-pricing case, prices increase for the consumers located between the collaborating and non-collaborating firms with spatial price discrimination. Ultimately, higher profits in the market segments where the collaborators and non-collaborators compete overcompensate the reduced profits in the other market segment. Hence the detrimental effect of production collaboration on profits is reversed for $z > z'$.

Given the effect of z on the profits we may now infer the exact conditions which guarantee the emergence of production collaborations between firm 2 and 3. These conditions are outlined in Proposition 2.

Proposition 2. *Firms 2 and 3 decide to collaborate on stage 1 iff:*

(i) $z \in [\bar{z}, 1)$*, where* $\bar{z}$ *is the threshold value for which* $\Pi_i^{CC} \geq \Pi_i^C$ *for* $i = 2, 3$*.*

(ii) There exists a value γ *such that firm 2 and firm 3 decide to collaborate iff* $\phi F \geq |\gamma|$*, where* $\gamma = min(\Pi_i^{CC} - \Pi_i^C)$ *in* $z \in (0, \bar{z})$*.*

Figure 2 outlines the difference in profits with and without collaboration.

As the profits with collaboration increase for $z \in (z', 1)$, the latter may exceed the profits without collaboration. This case holds for values of $z \in [\bar{z}, 1)$, where firms always opt for collaboration irrespective of the fix cost savings ϕF. If $z \in (0, \bar{z})$ the profits without collaboration exceed the profits with collaboration. Here, the fix cost savings have to compensate for the profit reduction induced by collaboration which reaches its maximum at γ. Thus, collaboration takes place for values of $z \in (0, \bar{z})$ if $\phi F \geq |\gamma|$.

The effect of the collaboration in the case of spatial price discrimination thus fundamentally differs from the mill-pricing case. While collaboration in the mill-pricing case

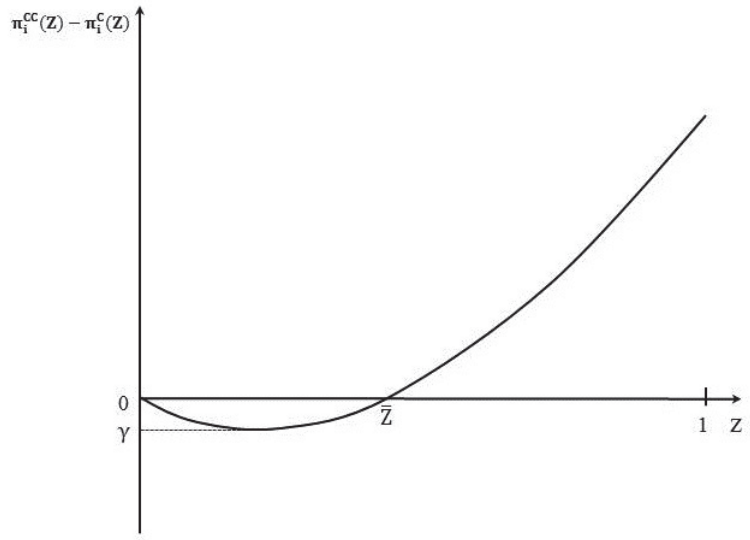


Figure 3.2: Differences between profits with and without collaboration

is conditional on the fix cost savings, this restriction is alleviated for spatial price discrimination.

3.3.3 The Impact of Collaboration on Non-Collaborating Firms

The production collaboration has a direct impact on the non-collaborating firm as outlined in Proposition 3.

Proposition 3. *The profits of the non-collaborating firm 1 strictly increase in z.*

The effect of collaboration on the non-collaborating firm is straightforward. The relocation of the collaborating firms reduces the competitive pressure on the non-collaborating firm. Furthermore there is no downward pressure on the price set by the non-collaborating firm resulting from the intensified competition between the collaborators as in the mill-pricing case. When firms opt for spatial price discrimination, prices in the market segments where collaboration takes place do not impact prices in the other market segment. Hence there are no negative externalities emerging from the intensified competition between the collaborators on the non-collaborating firm who always profit from collaboration.

3.4 Antitrust Assessment of a Competitor Collaboration

In order to infer whether a competitor collaboration is compatible with the respective antitrust laws, we start our analysis with an assessment of the possible pro-collusive effect of the collaboration before analyzing the impact of collaboration on consumer surplus. We use the approach introduced by Chang (1991) and Ross (1992) which analyzes collusion in an infinitely repeated game with differentiated products.

3.4.1 Supergame Collusion with Competitor Collaboration

We assume that the three firms interact in an infinitely repeated game. As we analyze whether collaboration facilitates collusion the assessment is made for the case with and without collaboration where the case without collaboration serves as a benchmark. If firms tacitly collude, it is assumed that they agree to set a price that correspond to the reservation price v. Hence $p_1^K = p_2^K = p_3^K = v$. This strategy yields an equal division the market areas for every brand, so that firm 1 sells in the market segment $[\frac{5}{6} - \frac{z}{12}, \frac{1}{6} + \frac{z}{12})$ only, while firm 2 sells in the segment $[\frac{1}{6} + \frac{z}{12}, \frac{1}{2})$ and firm 3 restricts its sales to the segment $[\frac{1}{2}, \frac{5}{6} - \frac{z}{12})$. Firms choose the Nash equilibrium prices as in section 3.1 in the case of competition. A firm i defects from the collusive agreement by setting a price $p_i^D = v - \varepsilon$, which allows to take over the market shares of its direct rivals.

Given the pricing strategies of the firms we now determine the profits of the collaborating firms and firm 1 in the case of collusion:

$$\Pi_1^K = \int_0^{\frac{1}{6}+\frac{z}{12}} v - t(x)^2 dx + \int_{\frac{5}{6}-\frac{z}{12}}^1 v - t(1-x)^2 dx. \tag{3.9}$$

which yields:

$$\Pi_1^K = \frac{1}{6} v(2+z) - \frac{t(2+z)^3}{2592}. \tag{3.10}$$

The collusive profits of firm 2 correspond to:

$$\Pi_2^K = \int_{\frac{1}{6}+\frac{z}{12}}^{\frac{1}{3}+\frac{z}{6}} v - t(\frac{1}{3} + \frac{z}{6} - x)^2 dx + \int_{\frac{1}{3}+\frac{z}{6}}^{\frac{1}{2}} v - t(x - \frac{1}{3} - \frac{z}{6})^2 dx. \tag{3.11}$$

as firms 2 and 3 are symmetric we obtain

$$\Pi_2^K = \Pi_3^K = \frac{v(4-z)}{12} + \frac{t(-4+z)(4-2z+7z^2)}{5184} \tag{3.12}$$

The deviation profits of firm 1 correspond to:

$$\Pi_1^D = \int_0^{\frac{1}{3}+\frac{z}{6}} v - t(x)^2 dx + \int_{\frac{2}{3}-\frac{z}{6}}^1 v - t(1-x)^2 dx. \tag{3.13}$$

we obtain the deviation profits of firms 2 and 3, which correspond to:

$$\Pi_2^D = \Pi_3^D = \int_0^{\frac{1}{3}+\frac{z}{6}} v - t(\frac{1}{3} + \frac{z}{6} - x)^2 dx + \int_{\frac{1}{3}+\frac{z}{6}}^{\frac{2}{3}-\frac{z}{6}} v - t(x - \frac{1}{3} - \frac{z}{6})^2 dx. \tag{3.14}$$

which yields:

$$\Pi_2^D = \Pi_3^D = \frac{v(4-z)}{6} + \frac{t(-4+z)(4-2z+7z^2)}{648} \tag{3.15}$$

Given the profits obtained in section 3.1, we observe that cheating is always profitable for every firm in a one-stage setting as $\Pi_1^D > \Pi_1^K$ and $\Pi_2^D > \Pi_2^K$, while collusion is always better than competition($\Pi_1^K > \Pi_1^C$ and $\Pi_2^K > \Pi_2^C$). A firm i adopts a grim trigger strategy where it decides to set a price $p_i^K = v$ which yields an equal division of the market area where a specific brand is sold. If a firm $j \neq i$ deviates from the collusive agreement by setting a price $p_j^D = v - \varepsilon$, firm i chooses to set the Nash equilibrium price p_i^C. All firms have a discount factor δ, so that the deviation payoffs in this repeated game of firm i correspond to $\Pi_i^D + \frac{\delta}{(1-\delta)}\Pi_i^C$, while the collusion payoffs are $\frac{\Pi_i^K}{1-\delta}$. Hence firms prefer to

collude if:

$$\frac{\Pi^K}{1-\delta} \geq \Pi^D + \frac{\delta}{(1-\delta)}\Pi^C \tag{3.16}$$

We thus obtain a critical discount factor δ:

$$\bar{\delta} = \frac{\Pi^D - \Pi^K}{\Pi^D - \Pi^C} \tag{3.17}$$

As long as the discount factor of the firms exceed the critical discount factor obtained above, collusion is sustainable. The critical discount factor therefore serves as a measurement of the stability of a collusive agreement.

3.4.2 Competitor Collaboration and Tacit Collusion

As we analyze a production collaboration in a circular city model, we infer whether or not the collaboration increases the stability of a possible collusive agreement between the three firms. If a collaboration ultimately eliminates competition by rendering the collusive agreement fully stable, the collaboration is deemed to be incompatible with antitrust laws. Otherwise, the increased stability of the collusive agreement needs to be counterbalanced with efficiencies generated by the collaboration which need to be passed on to consumers.

Proposition 4. *Collaboration does not stabilize a collusive agreement as the critical discount factors with and without collaboration are equal, i.e* $\bar{\delta}^{CC} = \bar{\delta}^{C} = \frac{1}{2}$.

Our result are in line with Gupta and Venkatu (2002) who show that in a spatial differentiation model à la Hotelling (1929) the critical discount factor is independent of the degree of product differentiation. In this model we introduce a collaboration which yields a symmetric relocation of the two collaborating firms in a three-firm circular city model à la Salop (1979) as in Ghosh and Morita (2012). Furthermore we assume that firms can opt for spatial price discrimination which may explain the stark contrast to the results

obtained for mill-pricing (see Chang, 1991). With mill-pricing the horizontal product differentiation has two countervailing effects on profits. While greater substitutability increases the collusive profits, it also increases one-time defection profits at the same time. In the mill-pricing case the latter effect dominates the former which explains why the stability of the collusive agreement decreases with increasing substitutability. However, for spatial price discrimination, the two effects remain proportional irrespective of the degree of substitutability between the products of the firms. This result reflects why the stability of the collusive agreement does not change for varying degrees of substitutability.

3.5 Welfare Effects of a Competitor Collaboration

The former section outlines that the competitor collaboration does not increase the stability of a collusive agreement. Per assumption, the competitor collaboration cannot be categorized as an explicit collusion as it allows a fix-cost reduction without facilitating price or quantity fixing as for instance in Selten (1973). Hence the collaboration has not the object("object restriction") to restrict competition. Furthermore the competitor collaboration has not the effect ("effect restriction") of restricting competition, as the stability of a tacit collusive agreement does not increase. Yet, a comprehensive welfare assessment needs to encompass the impact of collaboration on consumer surplus. The following proposition outlines theses effects:

Proposition 5. *Let $CS^{CC}(z)$ and CS^{C} be the aggregate consumer surplus in the equilibrium of the collaboration subgame and the non-collaboration subgame respectively. For all $z \in [0,1]$ we have $CS^{C} \geq CS^{CC}(z)$.*

The collaboration increases the competitive pressure in the market area where the collaborating firms 2 and 3 directly compete. In the mill-pricing case, this directly induces a general price decrease which impacts on the other market areas, where the collaborating firms compete with the non-collaborating firm. This is not the case for spatial price dis-

crimination where the prices set in different market areas are not interdependent. While the relocation of the collaborating firms increases the competitive pressure in the market area where both directly compete it alleviates competition in the market areas where they face the non-collaborating firm. The second effect overcompensates the former so that the aggregated consumer surplus is always lower if firms decide to collaborate. The effect of z on the aggregated consumer surplus is formulated in following corollary:

Corollary 1. *Aggregated consumer surplus $CS^{CC}(z)$ in the equilibrium of the competitor collaboration is decreasing in z.*

The corollary follows from proposition 3. Higher values of z increase competition between the collaborating firms on the one hand. On the other hand, the competitive pressure is reduced in the market areas where the collaborating firms compete with the non-collaborating firm. The latter effect dominates once again the former which explains why consumer surplus monotonically decreases in z.

The presented effects of a competitor collaboration reflect the limits of antitrust in the assessment of possible detrimental effects by a competitor collaboration. The competitor collaboration does neither facilitate overt collusion nor tacit collusion which rules out a comprehensive assessment under the respective antitrust laws. This is due to the fact that the reduction in consumer surplus is attributed to the increased substitutability induced by the collaboration. Antitrust mainly focuses on price and quantity fixing which have a detrimental effect on consumer surplus but deliberately leaves out possible harm resulting from product differentiation.

Given the profits and the consumer surplus obtained so far, we now focus on the general welfare effects of the collaboration. The results are formulated in the following proposition:

Proposition 6. *Let $W^{CC}(z)$ and W^{C} be welfare in the equilibrium of the collaboration subgame and the non-collaboration subgame respectively. For all $z \in [0,1]$ we have $W^{C} \geq W^{CC}(z)$.*

While collaboration might have a positive impact on the firms profit, the detrimental effect of collaboration on consumer surplus is never compensated. We furthermore observe that welfare decreases for higher values of z. As the variable z is exogenously determined in this model, a characterization of the industries for which higher values of z which are most lethal to consumer surplus. High values of z induce an increased substitutability between the products of the collaborating firms. It is unlikely to observe such values in industries with strong brands such as automobile. However, in other industries with weaker brands such as electronics or in markets for new technologies where the product distinctiveness is not clearly discernible collaborations may yield high values of z which are particularly harmful to consumer surplus.

3.6 Conclusion

This paper analysis the welfare effects of a competitor collaboration between two competing firms in a spatial price discrimination model. Here, a competitor collaboration yields a trade-off between a fix-cost reduction and an increase in product substitutability between two collaborating firms. While non-collaborating firms always profit from collaboration the incentive to form a collaboration crucially depends on the degree of substitutability. If the degree of substitutability deceeds a certain threshold value, the fix-cost reduction has to overcompensate the losses resulting from the increased competitive pressure between collaborators. For a degree of substitutability in excess of the threshold value firms always opt for collaboration. While firms may generally profit from collaboration, consumer surplus decreases for increasing product substitutability. This result builds a stark contrast to the findings of Ghosh and Morita (2012) who show that consumers profit from a competitor collaboration.

Although collaboration increases the profits of the firms at the expense of the consumers, it is not deemed incompatible with antitrust laws. The welfare detrimental effects are a side effect of the general product substitutability shift induced by the collaboration. As the collaboration neither has the objective of curtailing output or fixing prices nor

the effect of facilitating collusive behavior, it does not raise any direct antitrust concerns. Yet, firms may strategically coordinate the collaboration by inducing its formation among those firms that most likely will generate high degrees of substitutability. As the profits of the collaborating and non-collaborating firms alike increase for higher degrees of substitutability all firms would favor its implementation. In spite of the detrimental effects for consumers antitrust laws may not adequately prevent such strategies as they do not constitute a collusive agreement on prices or output.

The compatibility assessment of competitor collaborations with European antitrust laws is of particular relevance in the light of the EU Council Regulation (EC) No 1/2003. The regulation outlines that the central scheme which puts the antitrust authorities in charge of assessing the compatibility of a horizontal agreements with article 101 TFEU is to be replaced by a directly applicable exception system where the burden of proof lies with the applicants. This paradigm shift in the framework on the assessment of horizontal agreement limits the antitrust discretion to ex post interventions after the implementation of collaborations. Our results suggest that such an assessment should not be limited solely to possible price and quantity arrangements but should also encompass product characteristics. Although this paper holds for the case of perfect price discrimination and may not substitute a detailed assessment which is required to prove the compatibility of the collaboration with antitrust laws, one may draw following conclusion: A comprehensive antitrust assessment needs to take into consideration possible shifts in the product characteristics induced by the competitor collaboration in order to provide a comprehensive picture of its welfare implications.

Appendix

Proof of Proposition 1: The F.O.C with respect to z yields $\frac{\partial \Pi_i^{PC}}{\partial z} = -\frac{tz}{72} + \frac{5tz^2}{144} - \frac{7tz^3}{864}$ for $i = 2, 3$. There exists a unique number $z' \in [0, 1]$ ($z' \simeq 0.21$)so that $\frac{\partial \Pi_2^{PC}}{\partial z} > (=, <)0$ $\iff z > (=, <)z'$.

Proof of Proposition 2: As the profits are increasing in z for $z \geq z'$, it has to be evaluated if there is an incentive to opt for collaboration irrespective of any fix-cost savings. The threshold value for which $\Pi_i^{PC} - \Pi_i^{NC} = -\frac{tz}{72} + \frac{5tz^2}{144} - \frac{7tz^3}{864} \geq 0$ corresponds to $\hat{z} = 0.446$. Hence firm 2 and firm 3 have an incentive to form a collaboration for $z \in [0.446, 1)$ which proves (i). For values of $z \in (0, 0.446)$, firm 2 and firm 3 decide to collaborate as long as the fix-cost savings overcompensate the profit reduction. Following the proof of Proposition 1 we know that $\Pi_i^{PC} - \Pi_i^{NC}$ has a minimum value at z' for $z \in (0, 1)$ which corresponds to γ(where $\gamma \simeq -0.001t$). Hence collaboration takes place if $\Pi_i^{PC} - \Pi_i^{NC} = \gamma + \phi F = 0(\gamma \simeq 0.001t)$.

Proof of Proposition 3: The F.O.C with respect to z yields $\frac{\partial \Pi_1^{PC}}{\partial z} = \frac{t}{36} + \frac{zt}{36} + \frac{z^2 t}{144} > 0$. Thus firm 1 always profits from collaboration.

Proof of Proposition 4: The critical discount factor without collaboration corresponds to:

$$\bar{\delta}^C = \frac{\frac{2V}{3} - \frac{2t}{81} - \frac{V}{3} + \frac{t}{324}}{\frac{2V}{3} - \frac{2t}{81} - \frac{t}{108}} = \frac{1}{2}$$

In the case of collaboration the critical discount factor of firm 1 is:

$$\bar{\delta}_1^{PC} = \frac{\frac{V}{3}(2+z) - \frac{t}{324}(2+z)^3 - \frac{V}{6}(2+z) + \frac{t}{2592}(2+z)^3}{\frac{V}{3}(2+z) - \frac{t}{324}(2+z)^3 - \frac{t}{54} - \frac{tz}{36} - \frac{tz^2}{72} - \frac{tz^3}{432}} = \frac{1}{2}$$

while the critical discount factor for the collaborating firms 2 and 3 corresponds to:

$$\bar{\delta}_2^{PC} = \bar{\delta}_3^{PC} = \frac{\frac{1}{12}(4V - zV) + \frac{7t(-4+z)(4-2z+tz^2)}{5184}}{\frac{1}{6}(4V - zV) + \frac{7t(-4+z)(4-2z+tz^2)}{2592}} = \frac{1}{2}$$

Hence $\bar{\delta}^C = \bar{\delta}_1^{PC} = \bar{\delta}_2^{PC}$=$\frac{1}{2}$.

Proof of Proposition 5: The total consumer surplus can be subdivided in three groups of customers for every firm. The consumer surplus of firm 1 customers corresponds to $CS_1^{CC} = \int_0^{\frac{1}{6}+\frac{z}{12}} V - t(\frac{1}{3}+\frac{z}{6}-x)^2dx + \int_{\frac{5}{6}-\frac{z}{12}}^1 V - t(x-\frac{2}{3}+\frac{z}{6})^2dx = \frac{1}{6}V(2+z) - \frac{7t(2+z)^3}{2592}$. Consumers who buy from firm 2 obtain consumer surplus $CS_2^{CC} = \int_{\frac{1}{6}+\frac{z}{12}}^{\frac{1}{3}+\frac{z}{6}} V - t(x)^2dx + \int_{\frac{1}{3}+\frac{z}{6}}^{\frac{1}{2}} V - t(\frac{2}{3} - \frac{z}{6} - x)^2dx$=$\frac{(-4+z)\left(-432V+7t\left(4-2z+7z^2\right)\right)}{5184}$. As $CS_2^{CC} = CS_3^{CC}$ we obtain an aggregated surplus of $CS^{CC} = V + \frac{1}{432}\left(7t\left(-4-6z^2+z^3\right)\right)$, where $\frac{\partial CS^{CC}}{\partial z} < 0$ for $z \in (0,1)$.

Proof of Corollary to Proposition 5:The proof follows from Proposition 5.

Proof of Proposition 6: Without collaboration total welfare corresponds to $W^C = 6\int_0^{\frac{1}{6}} V - t(x)^2dx = V - \frac{t}{108}$. If firms opt for collaboration total welfare corresponds to $W^{CC} = 2(\int_0^{\frac{1}{6}+\frac{z}{12}} V - t(x)^2dx + \int_{\frac{1}{6}+\frac{z}{12}}^{\frac{1}{3}+\frac{z}{6}} V - (\frac{1}{3} + \frac{z}{6} - x)^2dx + \int_{\frac{1}{3}+\frac{z}{6}}^{\frac{1}{2}} V - (\frac{1}{3} + \frac{z}{6} - x)^2dx) = V - \frac{t}{108} - \frac{z^2t}{72} + \frac{tz^3}{432}$. For $z \in (0,1)$ we obtain $W^{CC} - W^C < 0$.

References

[1] Armstrong, M., Vickers, J., 1993. Competitive Price Discrimination, Rand Journal of Economics, 32, 579-605.

[2] Chang, M., 1991. The effects of product differentiation on collusive pricing, International Journal of Industrial Organization 9, 453-469.

[3] d'Aspremont, C., Gabszewicz, J. J. and Thisse, J.-F., 1979. On Hotelling's "Stability in Competition". Econometrica 47, 1045-1050.

[4] Eaton, B. C., Schmitt N. 1994. Flexible manufacturing and market structure. American Economic Review, 84, 875-888.

[5] Fershtman, C. and Gandal, N., 1994. Disadvantageous semicollusion. International Journal of Industrial Organization 12, 141-154.

[6] Ghosh, A. and Morita H. 2012. Competitor collaboration and product distinctiveness, International Journal of Industrial Organization 30, 137-152.

[7] Greenhut, M.L. 1995. Spatial pricing in the United States, West Germany and Japan. Economica 48, 79-86.

[8] Gupta, B. and Venkatu, G., 2002. Tacit Collusion in a Spatial Model with delivered Pricing 76, 49-64.

[9] Hotelling, H. 1929. Stability in Competition, Economic Journal 39, 41-57.

[10] Katz, Michael L. 1986. An analysis of cooperative research and development. RAND Journal of Economics, 17, 527-543.

[11] Lambertini, L., Poddar, S. and Sasaki, D., 2003. RJVs in product innovation and cartel stability, Review of Economic Design 7, 465-477.

[12] Ross, T., 1992. Cartel stability and product differentiation, International Journal of Industrial Organization, 10, 1-13.

[13] Salop, S. 1979, Monopolisitc Competition with Outside Goods, Bell Journal of Economics 10, 141-156.

[14] Selten, R., 1973. A simple Model of imperfect competition, where 4 are few and 6 are many. International Journal of Game Theory 2, 141-201.

[15] Thisse, J.-F. and Vives, X., 1988. On the strategic choice of spatial price policy. American Economic Review 78, 122-137.

[16] Verboven, F., 1996. International price discrimination in the European car market. Rand Journal of Economics 27, 240-268.

Part II

Behavioral Aspects of Anti-competitive Conduct

Chapter 4

Rebels without a Clue? Experimental Evidence on Partial Cartels*

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

Albert Camus

4.1 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

*The research of this chapter is part of a joint project with Holger Rau.

[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

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 the outside firms have many points in common with the rebel, as "saying no" to the cartel does not imply a renunciation at all for them. This raises the following research question: *How 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 an experimental analysis on how firms coordinate the formation of a partial cartel. Therefore, a mechanism that facilitates the formation of a stable partial cartel is designed which allows us to infer the formulated coordination challenge.

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. 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. The third stage binds all cartel members to a quantity decision while the outsiders play the best-response strategy. By contrast, if the cartel is not formed, all firms play their compet-

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.

itive best-response strategies. We introduce an innovation to the KOR (2009) framework by allowing the firms to communicate before the mechanism starts.

This 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. The introduction of communication is crucial in the context of cartels (see McCutcheon (1997) and Genesove and Mullin (2001) among others) and may furthermore reveal what motives drive the firms' decisions in the presence of profit asymmetries between cartel insiders and outsiders. 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." 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. Section 4 and 5 discuss the results, while Section 6 concludes.

4.2 Literature and Experimental Design

4.2.1 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. This approach allows us to infer the role of defection and "whistleblowing" of cartel members that file for leniency on the implementation of cartels. The formation of the cartel is deliberately simplified, since a one-stage decision to activate a communication device corresponds to the entire cartel formation process. Moreover, only all-inclusive cartels can be formed and partial cartels are ruled out per se, which neglects possible cartel stability concerns.[3] As opposed to the approach followed in this literature, 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.

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 and Donsimoni et al., 1986) 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.

[3] Apesteguia et al. (2007) and Hinloopen and Soetevent (2008) abstract from stability concerns as one of their requirements is that all firms decide to activate communication in order to establish a cartel. Bigoni et al. (2012) analyze a duopolistic market, which rules out the emergence of stability problems.

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. Here, firms that decide on the formation of a cartel at the first stage bargain over its implementation via a quota scheme at the second stage.[4] 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. This 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).[5]

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

[4] 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.

[5] 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."

first and second stages are equivalent to KOR (2009). At the third stage, we depart from their framework as the cartel 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. Stage three guarantees 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.[6] 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 (2011) 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

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

a three-stage mechanism with a chat option, 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 and Charness and Dufwenberg, 2006). Recent papers in the experimental antitrust literature by Cooper and Kühn (2009) and Normann and Fonseca (2012), 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 understand the underlying motivations of colluding firms. We therefore evaluate communication following the approaches used in Andersson and Wengtsröm (2007) and Kimbrough et al. (2008) in order to infer whether or not payoff asymmetries influence the formation of partial cartels.

4.2.2 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).

		Communication	
		chat	no chat
Payoff structure	Standard Endogenous Cartels	**SECC**	**SEC**
	Modified Endogenous Cartels	**MECC**	**MEC**

Table 4.1: *Treatments*

SECC, serves as a starting point. 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. Both SECC and SEC are our baseline treatments. The MECC treatment introduces a crucial modification of the payoff structure for a partial cartel in the standard treatment, which 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, which allows us to evaluate the role of communication on the implementation of a stable partial cartel. Note that the MECC treatment and the SECC treatments are implemented for exactly the same market constellations, which let us compare how firms coordinate the formation of a stable all-inclusive cartel and a stable partial cartel. Thus we can infer if there is a coordination challenge when partial cartels are formed and answer our research question.

Table 4.2 provides an overview of the payoffs generated in a symmetric Cournot game with four firms for every cartel constellation.[7] 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 4.2 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

[7] 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.

Taler which is a synonym for *ECU* (Experimental Currency Unit). The payoffs were rounded to integers, and that 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 chat in a window for a total of 60 seconds. After that the window automatically closed and stage one started immediately.[8]

In **stage one** all subjects in a market simultaneously had to state whether they wanted to join a cartel.[9] 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.[10] Otherwise they became direct competitors and received the Cournot Nash equilibrium profits of a standard four-firm Cournot market. Ultimate outsiders did not

[8] 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.

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

[10] 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.

have to make any choice in stage two and were only informed of the amount of possible insiders.

In **stage three** the subjects' payoffs were determined. 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 4.1 gives an overview of the mechanism's stages.

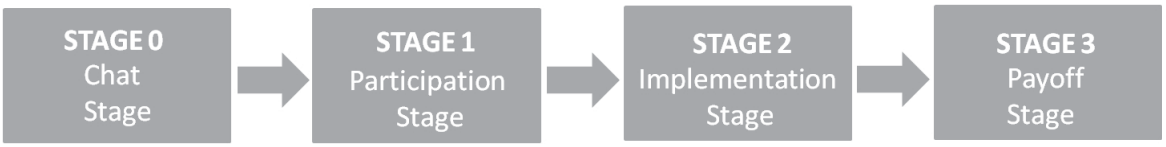


Figure 4.1: Cartel-formation stages

We used a fixed matching protocol where every group interacted for 10 rounds, i.e., the three-stage game was repeated for 10 periods.[11] We ran two sessions of our SEC treatment with a total of seven matching groups. Additionally, two sessions of MEC with seven matching groups were conducted. We carried out one session of SECC (with three matching groups) and one session of MECC (with four matching groups). 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).

4.3 Theoretical Predicitions and Hypotheses

4.3.1 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

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

face marginal cost of production $c = 10$. In the case of oligopolistic Cournot competition the profits of the firms correspond to:

$$\Pi = \left(\frac{40}{4+1}\right)^2 = 64. \tag{4.1}$$

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

$$\Pi(m) = \frac{(40)^2}{(4-m+2)^2 m}. \tag{4.2}$$

whereas the outsiders' profits are given by:[12]

$$\Pi(m) = \frac{(40)^2}{(4-m+2)^2}. \tag{4.3}$$

A complete overview of the standard Cournot payoffs depending on the cartel outcomes is provided in the following table:

TABLE 4.3 Standard Cournot Payoffs

Composition		**Firms' Payoffs**	
# insider(s)	# outsider(s)	insider(s)	outsider(s)
0	4	na	64
1	3	64	64
2	2	50	100
3	1	59	178
4	0	100	na

Note: The table illustrates firms' standard Cournot payoffs dependent on different cartel compositions

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

[12] 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.

mechanism we never observe a stable cartel as the "internal stability" criteria given by

$$\frac{(40)^2}{(4-m+2)^2} < \frac{(40)^2}{(4-m+2)^2 m}. \tag{4.4}$$

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 third stage 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

$$\frac{(40)^2}{(4-m+2)^2 m} > 64. \tag{4.5}$$

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

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.*

We now turn to the analysis of the case with the modified payoffs for a three-firm cartel. The payoffs are outlined in the following table:

TABLE 4.4 Modified Cournot Payoffs

Composition		**Firms' Payoffs**	
# insider(s)	# outsider(s)	insider(s)	outsider(s)
0	4	na	64
1	3	64	64
2	2	50	100
3	1	**70**	178
4	0	100	na

Note: The table illustrates firms' modified Cournot payoffs dependent on different cartel compositions

This 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:

$$\frac{(40)^2}{(4-m+2)^2 m} > 64 \tag{4.6}$$

Now, this not only holds for $m = 4$ but also for $m = 3$ as the insiders' payoffs correspond to 70.[13]

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:

[13]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.*

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 rounds. 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.

Given the theoretical predictions in the previous subsection we derive our hypotheses. Propositions 1 and 2, predict that the mechanism should yield cartels. Following Proposition 1 which states that the four-firm cartel is the only cartel, we expect the all-inclusive cartel to be the most frequent cartel composition in SECC. In line with our theoretical predictions there should be no difference between the communication and the no-communication case. Thus most cartels in SEC should also be all-inclusive cartels. This concludes Hypotheses 1a and 1b.

Hypothesis 1

(a) In SECC, most cartels will be all-inclusive cartels.

(b) In SEC, most cartels will be all-inclusive cartels.

In the case of modified Cournot payoffs, proposition 2 emphasizes that only the cartel composition with $m = 3$ cartel members and one outside firm is stable. Thus, we expect that in MECC most cartels will be partial three-firm cartels. Following the theoretical predictions, this should be the same in MEC. We can therefore establish Hypotheses 2a and 2b.

Hypothesis 2

(a) Most cartels in MECC will be partial three-firm cartels.

(b) Most cartels in MEC will be partial three-firm cartels.

Our research question focuses on the formation of partial cartels. Consequently we analyze how payoff asymmetries in the case of partial cartels influence the decision to form the collusive agreement. Proposition 2 suggests that possible inside firms accept partial cartelization with three cartel members and one outside firm. This yields Hypothesis 3.

Hypothesis 3

Possible cartel members should accept partial cartelization with one outsider at the second stage of the mechanism.

4.4 Results

In the following paragraphs the hypotheses are tested. The analysis starts with a summary statistic reporting Stage-3 outcomes. Subsequently, the analysis focuses on attempted cartels, afterwards we present our main results focusing on established cartel compositions and firms' willingness to accept. The data contains one MECC group which decided to play a taking-turns strategy[14] 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.[15]

Table 4.5 gives an overview of the average frequency of established cartel compositions in all periods of the four treatments.

[14] Similar taking-turns strategies have been observed in Fonseca and Normann (2012).

[15] 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 4.5 Frequency of Stage-3 Outcomes

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

Note: The table gives an overview of Stage-3 outcomes 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.

Our results suggest that most cartels are established in SECC (97%) and MECC (83%), whereas there are 26% cartels in SEC and 20% cartels in MEC. The table furthermore emphasizes that cartels are most often all-inclusive. This is true for SECC, MECC and SEC. The only exception is the MEC treatment where firms seem to have faced a coordination problem.

4.4.1 Stage-1 Results: Attempted Cartels

Table 4.6 presents the fraction of total attempted full and partial cartels. It also consolidates the cases where only three firms (one ultimate outsider) and two firms (two ultimate outsiders) attempted to form the cartel. The table only accounts for the cases where at least two firms opted to form a cartel at stage 1.

TABLE 4.6 Fraction of Attempted Full and Partial Cartels

	total (attem.) full cartels	one-sided p-value	**total (attem.) partial cartels**	one ultimate outsider	two ultimate outsiders
SECC	**0.967**	$>$* 0.051	**0.033**	0.033	-
SEC	**0.357**	$\approx$ 0.223	**0.557**	0.443	0.114
MECC	**0.825**	$>$** 0.029	**0.175**	0.150	0.250
MEC	**0.086**	$<$*** 0.009	**0.571**	0.257	0.314

Note: One-sided Wilcoxon matched-pairs tests were used to test for significant differences. In this table ***, **, and * indicate significance at the 1%, 5%, and 10% levels. Tests were applied at the match-group level. We had four match groups in SECC and three match groups in MECC and seven match groups in SEC and MEC. Here, total attempted full cartels depict the rates of attempted cartels where all firms were part of the possible cartel agreement. The case where one group in the MECC treatment was playing the taking-turns strategy between periods 4-7 is also included in this category. Note, we also count this case as an attempt to a full cartel agreement since this corresponds to a collusive strategy including all four firms.

It turns out that in SECC significantly more full-firm cartels (96.7%) than partial cartels (3%) are attempted. Focusing on the no-communication case (SEC) no significant difference can be found between the fraction of attempted full and partial cartels.

In MECC we obtain a significantly higher rate of attempted full cartels (82.5%) than partial cartels (17.5%). In MEC the opposite is true: significantly more firms attempt the formation of partial cartels (57.1%) than full cartels (8.6%). This may be a fist indication that the communication possibility persuades the firms to coordinate to the all-inclusive cartel in the modified treatment. By contrast, absent of the chat opportunity firms in MEC try to coordinate to the partial cartel.

4.4.2 Stage-2 Results: Established Cartel Compositions

In order to test Hypotheses 1 and 2 we analyze which cartel compositions most often occurred in all of our treatments. Table 4.7 presents our main results regarding cartel coordination, i.e., it gives a comparison of established full and partial cartels. The table summarizes the fractions of established four-firm, three-firm, and two-firm cartels.

First, we observe that our mechanism facilitates the formation of cartels in all of the four treatments. A closer look at the benchmark treatments reveals that in SECC only stable four-firm cartels emerge. This confirms Hypothesis 1a.

TABLE 4.7 Fraction of Full and Partial Cartels (provided a cartel was established)

	total full cartels	one-sided p-value	**total partial cartels**	3-firm cartels	2-firm cartels
SECC	**1.000**	-	-	-	-
SEC	**0.944**	$>$ ** 0.034	**0.056**	0.056	-
MECC	**1.000**	-	-	-	-
MEC	**0.357**	$\approx$ 0.159	**0.642**	0.571	0.071

Note: One-sided Wilcoxon matched-pairs tests were used to test for significant differences. In this table ***, **, and * indicate significance at the 1%, 5%, and 10% levels. Tests were applied at the match-group level. We had four match groups in SECC and three match groups in MECC and seven match groups in SEC and MEC. Here, total full cartels depict the rates of established cartels where all firms were part of the cartel. The case where one group in the MECC treatment was playing the taking-turns strategy between periods 4-7 is also included in this category. Note, we also count this case as a full cartel agreement since this corresponds to a collusive strategy including all four firms. The table also controls for established partial cartels focusing on the cases were only three (3-firm cartels) and two firms (2-firm cartels) were part of the cartel. The table only accounts for the cases where at least two firms opted to form a cartel at stage 1.

The same is true in the absence of the communication option where significantly more full cartels than partial cartels are formed. That is, the lion's share of SEC cartels (94.4%)

is composed of stable all-inclusive cartels. Thus we also accept Hypothesis 1b.

Result 1

In line with predictions, literally all cartels formed are all-inclusive cartels in SECC. In SEC significantly more four-firm cartels than partial cartels are established.

Focusing on the treatments with modified Cournot payoffs, it turns out that 100% of cartels in MECC are composed of four firms. In contrast to our theoretical predictions, firms do not form partial three-firm cartels. Instead they always coordinate the formation of all-inclusive cartels. We thus have to reject Hypothesis 2a. In the modified treatment without chat (MEC) there are more partial cartels (64.2%) than full cartels (35.7%). To infer whether the stable three-firm cartel is the most frequent cartel composition we have to compare the fraction of three-firm cartels with the fraction of two- and four-firm cartels. It turns out that we neither observe significantly more three-firm cartels (57.1%) than two-firm cartels (7.1%) (one-sided Wilcoxon matched-pairs test, $p - value = 0.121$) nor do we observe significantly more three-firm cartels than four-firm cartels (35.7%) (one-sided Wilcoxon matched-pairs test, $p - value = 0.191$). We therefore have to reject Hypothesis 2b.

Result 2

In MECC no partial cartels are established. Likewise, there is no statistical evidence that the partial cartel is the most frequent cartel in MEC.

4.4.3 Stage-2 Results: Acceptance of Cartel Compositions

This subsection tests Hypothesis 3 and therefore infers how potential payoff asymmetries within a stable three-firm cartel influence its formation. There is a discrepancy between the results obtained in subsection 4.1 and 4.2 as not all stable partial cartels attempted in the MEC treatment are established afterwards. In this regard this subsection analyzes whether firms form the three-firm cartel at the second stage in MECC and MEC. Table

4.8 therefore illustrates the inside firms' willingness to accept different potential cartel compositions at the second stage.

TABLE 4.8 Rate of Accepted Cartel Composition

	4 Insider 0 Outsider			3 Insiders 1 Outsider		
	accept	p-value	reject	accept	p-value	reject
SECC	1.000	-	-	-	-	1.000
SEC	0.680	$\approx$ 0.140	0.320	0.032	$<***$ 0.006	0.968
MECC	1.000	-	-	-	-	1.000
MEC	0.833	$>*$	0.167	0.444	$\approx$ 0.269	0.556

Note: One-sided Wilcoxon matched-pairs tests were used to test for treatment effects. In this table ***, **, and * indicate significance at the 1%, 5%, and 10% levels. Tests were applied at the match-group level. We had four match groups in SECC and three match groups in MECC and seven match groups in SEC and MEC. The number of "Insiders" is the amount of participants who were willing to potentially form a cartel at the first stage of the mechanism. The number of "Outsiders" is the amount of participants who were not willing to form a cartel at the first stage. The table only includes the cases where at least two firms opted to form a cartel at stage 1.

It can be seen that in SECC and MECC the four-firm cartel is always accepted. In SEC most all-inclusive cartels are formed. This is also true for MEC where significant more four-firms are accepted.

Focusing on partial cartel compositions with one outsider it turns out that in SECC and SEC all cases are rejected. There is only one exception in SEC where the three-firm cartel composition is accepted.[16] Strikingly, all partial cartel compositions with three-firms are rejected in MECC. Similarly, in MEC most potential cartel constellations with three inside firms and one outside firm are not formed (56%). Although there is no significant

[16]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.

difference between rejected and accepted three-firm cartels in MEC, the frequent rejections of partial cartels in MECC and MEC stand in contrast to our theoretical predictions which suggest that all three-firm cartels should be accepted.

A possible explanation might be given by fairness models like Fehr and Schmidt (1999) which suggests that every inside firm dislikes payoff asymmetries where one outside firm would get 178 Taler, while the insiders get 70 Taler each. Contrary to Hypothesis 3 we find that partial three-firm cartels are only accepted in 44% of the MEC cases and never in MECC. Thus our results contribute to Huck and Armstrong (2010) who summarize the behavioral economics literature in the IO context. Furthermore our findings are in line with Huck et al. (2001) and Huck et al. (2007). 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. Therefore we have to reject Hypothesis 3.

Result 3

Firms do not implement any partial three-firm cartel in MECC. Furthermore most of the three-firm cartels are rejected in MEC.

4.4.4 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 reveal that in SECC and MECC solely all-inclusive cartels emerge. At the second stage it turns out that firms in all treatments frequently refrain from implementing partial cartels with three insiders. By contrast all four-firm cartels in SECC and MECC are accepted, which contradicts our theoretical predictions for the MECC case.

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 4.2 depicts the development of the fraction of attempted full cartels.

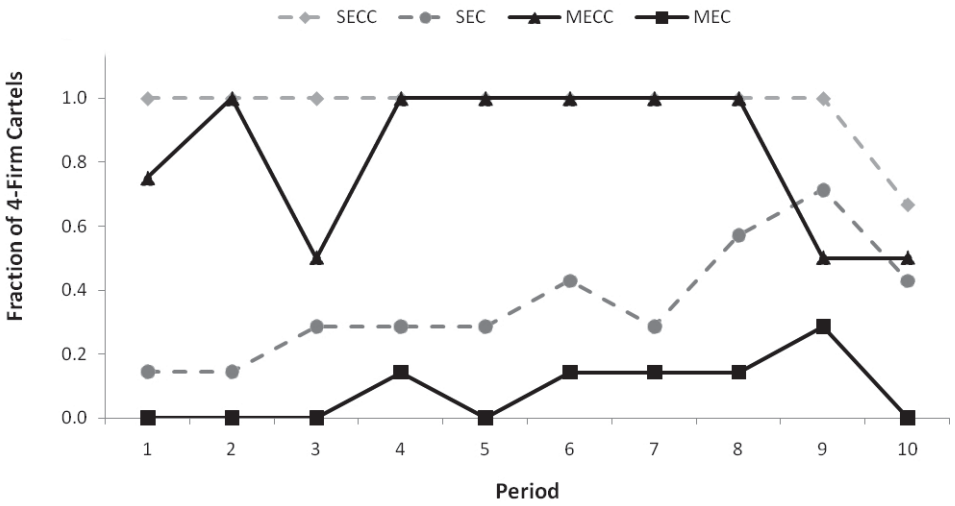


Figure 4.2: Development of the Fraction of Attempted Full Cartels

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.

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, $p - value = 0.316$).

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 nearly all firms in SECC and MECC from the beginning attempt to establish the four-firm cartel, whereas in MEC and SEC only few firms attempt it. To account for the substantial differences in the chat treatments we therefore analyze the effects of communication in the subsequent section.

4.5 Analysis of the Chat Protocols

As opposed to Proposition 2 our main results revealed no significant difference between the fraction of established three-firm and four-firm cartels in MEC. Strikingly, this was further emphasized when adding a chat option, i.e., no partial cartel emerged at all 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 "cheap-talk agreement" whenever firms proposed an agreement on the cartel and this was not rejected by other firms.[17] Table 4.9 depicts the average messages sent and the percentage of cheap-talk 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

[17] 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 our framework chat is merely cheap talk as a cartel can only be implemented by the three-stage mechanism.

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 4.9 Average Messages Sent and Fraction of Entered Contracts

	period										
	1	2	3	4	5	6	7	8	9	10	avg.
avg. 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
cheap-talk 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 average messages sent and the percentage of cheap-talk agreements. Following Andersson and Wengström (2007), we define a cheap-talk 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 cheap-talk 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 cheap-talk 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 Kombrough et al. (1998) 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 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.[18] 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 rounds 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 cheap-talk agreements until period 3. In MECC there are high incentives to become the only outsider. This may explain the high amount of cheap-talk 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:

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

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!
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.Andersson and

Wengström (2007) outline in their Bertrand-oligopoly experiment, that chat is most effective when the cost of activating are high. Although chat is costless in our experiment, it turns out that the combination of chat with the three-stage mechanism is an efficient instrument to reach collusive agreements. In MECC where a high frequency of non-decreasing cheap-talk 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 cheap-talk agreements to stabilize long-term cooperation over time, whereas in SECC there is a sharp decrease of this behavior right after the first period.*

4.6 Conclusion

Our paper is among the first experiments to analyze the coordination challenge faced in the formation of a partial cartel. The results show that payoff asymmetries in partial cartels between insiders and free-riding outsiders may disrupt its formation process. That is, potential cartel members prefer to revoke the decision to form the cartel if outsiders excessively profit at its expense. As the outside firm's refusal to participate in the cartel ultimately *does imply a renunciation* for itself, the latter ends up being a "rebel without a clue." Hence, our findings suggest that relative profits matter in the formation of a partial cartel. We therefore find confirmation for Armstrong and Huck (2010).

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 car-

tels. 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 analyzing the impact of payoff asymmetries in the coordination process of a partial cartel. It may also infer coordination challenges resulting from antitrust policies. Discriminatory leniency policies, for instance, which preclude fine reductions for cartel ringleaders may generate payoff-asymmetries within a cartel. Thus firms may be disincentivize to taking 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.

Appendix

Experimental Instructions

General Information

Welcome to this decision experiment. Please read the instructions carefully. You will find a questionnaire at the end of these instructions in order to double check if you understand the instructions. Please answer those questions. When you answered them correctly, the experiment will start. During the experiment you can earn chips depending on your and the decisions of the other participants. At the end of the experiment, the gained chips are exchanged at a rate of

1 Taler = 2 Cent

and paid out to you. In order to do so, please wait in your booth until you are called forward to collect your earnings. Please bring all documents, which were given to you, to the payout after the experiment.

Please note that from now on and during the entire experiment, you must not talk to any other participant. We are forced to call of the experiment, should it happen. If there are any questions, please raise your hand and we will come to you to answer your question.

The experiment consists out of **10 rounds**. In these rounds, you are taking up the role of a company, which is active on a market with three other companies, so that there are in total four companies in the market. The constitution of the market is set at the beginning of the experiment. During the experiment, the constitution of the market will not change. Hence you are acting in a four- company market every round, which exists of exactly the same companies. During the experiment you will not be able to gain information about

the identity of the other companies. This is also the case after the experiment. The other companies are also unable to gain any personal information about you. Hence, the entire experiment is completely anonymous.

Detailed Information on the Experiment

The experiment consists of **10 rounds** in total. All rounds are identical and are divided into **three parts (phases)**.

In each round each company faces the following situation: In the **first phase** of a round, all companies within a market can communicate with each other via a chat window. Afterwards, each company decides whether to take part in the market agreement. In the **second phase**, the companies have to decide whether this agreement is compulsory. In the **third phase**, the decisions of a company are realized. However, the abnormal profits of a company depend on their decisions in phase 1 and 2.

We will now explain to you, how your earnings in each round, depend on the decisions, which are implemented in the third phase. For simplification, we will call the earnings gained in the third phase **"round earnings"**. Your earnings will - independently of your decision to collude or not collude –depend on the number of firms colluding participants and non- colluding participants. A more specific explanation in terms of how your "round earnings" are composed in each case can be found in the table below.

The table illustrates all possible outcomes of colluding participants and non-participating firms. It depicts which earnings can be obtained, conditional on the different constellations of participating and non-participating firms.

Payoff Table for the modified Treatment

Participants of the Markt Agreement	Nonparticipants of the Market Agreement	Participants Payoff (EVERY participant obtains the respective payoff under the assumption that the agreement is implemented)	Nonparticipants Payoff (EVERY nonparticipant obtains the respective payoff under the assumption that the agreement is implemented)
0	4	There are no participants	64 Taler
1	3	64 Taler	64 Taler
2	2	50 Taler	100 Taler
3	1	70 Taler	178 Taler
4	0	100 Taler	There are no nonparticipants

Example 1: Assume you are taking part in the market agreement. So does company 1. Hence there are two participants. Furthermore, there are 4-2=2 non- participants. This event is shown by row 3 in table 1. Assuming this collusion is happening at the end of phase 2, there will be a payout of 50 chips for you. The other participant will **also** earn 50 chips. The non- participants will earn 100 chips **each**.

Example 2: Assume **you do not take part** in the collusion and 2 other companies also decide not to take part in it. Hence there are 3 non- participants. Furthermore, there are 4-3=1 participant. This event is shown by row 2. Assuming this collusion is happening at the end of phase 2, there will be a payout of 64 chips for you. All other non- participants will also earn 64 chips each. The only participant will also earn 64 chips. We will explain now to you the decisions, you have to make in the various phases.

Phase 1

In the first phase, you have to decide whether **to take part in a market agreement**. In the experiment, you will do that by using a computer screen and mouse.

In the **first round**, a chat window will pop- up for **90 seconds** in the first phase. From the **second** to the **10th round**, this chat window will only pop- up for 60 seconds in each

first phase. You are able to communicate with the three other companies in your market via this chat window. You only need to type in the text you want to communicate in the bottom bar. Your own text as well as the text of the other companies will appear in the window above the bottom bar. After 90 seconds, this chat window will disappear automatically in round 1 (this will be the case in round 2-10 after 60 seconds). After the chat window has closed automatically, you are not able to communicate anymore in this round and you make your decision by using the mouse in the decision window. You hit the "yes" button if you want to and the "no" button if you do not want to participate in the market- agreement (collusion). When you have made your decision you only need to click on the "ok" button. As soon as every participant has made his or her decision, the next phase will start. Apart from the decision window, there are three more windows. The windows always show the same information in each phase. You will find the "information window" in the top- left corner. You can get information about the round and the phase, in which you are at the moment. Your total earnings are shown below that. The big window at the bottom of your screen is the "history- window". If there is a "-1", it means that there are no information yet available about your phase. At the end of each round all information is available, so that there will not be a "-1" in this array. Further information about this window is provided at the end of the instructions.

Phase 2

In this phase, you will find out how many firms are intending to participate in a market agreement, which would be binding in phase 3 if implemented. There are two possibilities in phase 2:

First case: In the first phase you announced your willingness to participate in the market agreement.

Hence, you would now need to decide if you really want to commit to it in phase 3. This

works out as follows:

The total number of potential participants of the collusion is presented to you. Furthermore you will find information, how many companies are definitely not taking part in it. Additionally, you are provided with information about the earnings, which you and the other participants would get if the collusion happens. You can also see how much the non-participants would earn. Finally you would get information about the earnings of all companies if a collusion does not happen. You now need to decide if you still want to take part in a collusion.

Only if all of the companies that announced their willingness to form a market agreement in phase 1 and confirm that a market agreement will be formed in phase 2, this commitment becomes binding.

If even **one** of these companies, that announced in phase 1 to form a market agreement, now rejects the formation of a market agreement the commitment is not binding anymore and no market agreement is reached.

If the commitment becomes binding, then all companies that have announced and confirmed to form a market agreement, are bound to the agreement in phase 3. Hence these companies automatically commit to the market agreement in phase 3 and are hence participants of the agreement.

If the agreement is binding, then all companies that have announced and confirmed to form a market agreement, are bound to the agreement in phase 3. Hence these companies automatically commit to the market agreement in phase 3 and are participants of the agreement.

If the agreement is non- binding, then all companies that have announced to form a market agreement will automatically behave as non-participants of the agreement in phase 3.

Phase 2 ends, once you have announced whether to commit or not.

Second case: You announced in the first phase that you do not intend to to form

a market agreement.

When you announced that you do not intend to form a market agreement in phase 1, there is no decision to be made in phase 2. You will only be given information about how many companies intend to commit. Furthermore you find out how many companies are definitely not participating in the market agreement. In that case, you simply need to click on the button "read".

Note: Only the companies that have announced in phase 1 to form a market agreement may decide in phase 2, if their commitment is binding.

Phase 3

In this phase you will find out if the market- agreement becomes binding. Furthermore the total number of companies that decided to finally commit to the market agreement is revealed. Please note that these two possible events can occur:

Case 1: The commitments are binding and the market agreement takes place

When the commitments are binding and if you are among the players who decided to commit to the market agreement, the computer will assess you as a participant. This assessment has direct consequences on your payment. However if you are among the companies, which decided not to participate, the computer will assess you as a non-participant. This assessment has also direct consequences on your payoff. A screen appears that indicates your earnings and the earnings of the other companies. Do not forget to press"read" when you are done reading.

Case 2: The commitments are not binding

If the commitment is not binding, then all companies are assessed as non-participants. This assessment has direct consequences on your payoff. The screen indicates that there is no market agreement. Furthermore the earnings of all non- participants appear. Do not forget to press "read" when you are done reading. At the end of phase 3 a new round

begins. The same procedure takes place starting at phase 1.

Example: Assume you are company A and decide to commit to the market agreement in phase 1. Additionally company B and C decide to commit as well. Company D decides not to commit. If the market- agreement is binding after phase 2, you receive a payoff of 70 Taler - so does B and C (4th row in the table). D receives 178 Taler. However if B, C or you decide to make the agreement non- binding in phase 2, the entire market agreement is non-binding. After determining the payoffs in phase 3, B, C and you receive 64 Taler, the payoff of D decreases from 178 to 64.

After the end of each round, the history window will be refreshed. Your decisions and the one of the other companies is documented as follows:

Round=Round.

Potential Participant=Your announcement in Phase 1, to be willing to participate in the market agreement.

Total number of potential participants=total number of potential participants, who announced their willingness to participate in the market agreement in Phase 1.

Decision=Your final decision to form the market agreement in Phase 2.

Binding(Yes/No)=Information regarding the implementation of a market agreement

Number of participant=Exact number of firms participating in the market agreement

Number of nonparticipant=Exact number of firms not participating in the market agreement

Earnings participants/nonparticipants=Your earnings resulting from participation/non-participation in the market agreement

Payoff of the current round=Your payoff in the current round

Check-up questionnaire

We kindly ask you to answer the following questions. The questions are only designed to check if you understand the instructions correctly. All questions are based on random examples. For simplicity, we sign the four group member with the letters “A”, “B”, “C” and “D”. If there are any questions, please raise your hand. Check-up questions 1/2

a) Assume you are company A and you claim in phase 1 that you will not participate in a market- agreement. Additionally the companies B,C and D claim to collude.

- Which companies may decide in phase 2 if they compulsory collude?
- Assume the collusion (market- agreement) takes place, what are the earnings in phase 3?
- Assume the collusion does not take place, what are the earnings in phase 3?

b) Only one participant (which decided to collude in phase 1) commits to the market-agreement in phase 2.

- Does the collusion take place? (Yes/No)?

c) Assume now that phase 3 begins and the computer assesses the participants and non-participants of a possible collusion.

- Who is finally assessed as a non- participant?
- Who is finally assessed as a participant?
- What are the earnings in phase 3?

Check-up question 2/2

a) Assume you are company A and you intend in phase 1 to collude. Additionally, company B,C and D claim that they also intend to collude.

- Which companies may decide in phase 2 if they compulsory collude?
- Assume the collusion (market- agreement) takes place, what are the earning in phase 3?
- Assume the collusion does not take place, what are the earning in phase 3?

b) All participants of the collusion (which decided to collude in phase 1 (all companies in

this case)) commit to the collusion in phase 2.

- Does the collusion take place? (Yes/No)?

c) Assume now that phase 3 begins and the computer assesses the participants and non-participants of a possible collusion.

- Who is finally assessed as a non- participant?

- Who is finally assessed as a participant?

- What are the earnings in phase 3?

References

[1] Andersson, O., Wengström, E., 2007. Do antitrust laws facilitate collusion: experimental evidence on costly communication in duopolies. The Scandinavian Journal of Economics 109, 321-339.

[2] Armstrong, M., Huck, S., 2010. Behavioral Economics as Applied to Firms: A Primer. CESifo Working Paper.

[3] Apesteguia, J., Dufwenberg, M., Selten, R., 2007. Blowing the whistle. Economic Theory 31, 143-166.

[4] Bigoni, M., Fridolffson, S.-O., le Coq, C. Spagnolo G., 2012. Fines, leniency and rewards in antitrust: An Experiment. Forthcoming in RAND Journal of Economics.

[5] Bolton, G.E., Ockenfels, A., 2000. ERC: A theory of equity, reciprocity, and competition. American Economic Review 90, 166-193.

[6] Bos, I., Harrington, J.E., 2010. Endogenous cartel formation with heterogeneous firms. RAND Journal of Economics 41, 92-117.

[7] Cooper, R., Dejong, D.V., Forsythe, R., Ross, T.W., 1989. Communication in the battle of the sexes game: Some experimental results. RAND Journal of Economics 20, 568-587.

[8] Cooper, D. J., Kühn, K.-U., 2011. Communication, renegotiation, and the scope for

collusion. Unpublished manuscript, Florida State University.

[9] d'Aspremont, C., Jacquemin, A., Gabszewicz, J.J., Weymark, J.A., 1983. On the stability of collusive price leadership. Canadian Journal of Economics 16, 17-25.

[10] Davis D.D, Holt, C.A., 1998. Conspiracies and secret discounts in laboratory markets. The Economic Journal 108, 736-756.

[11] Ertan, A., Page, T., Putterman, L., 2005. Who to punish? Individual decisions and majority rule in mitigating the free rider problem. European Economic Review 53, 495-511.

[12] Fehr, E., Gächter, S., 1998. Reciprocity and economics: The economic implications of *Homo Reciprocans*. European Economic Review 42, 845-859.

[13] Fehr, E., Schmidt, K., 1999. A theory of fairness, competition, and cooperation. Quarterly Journal of Economics 114, 817-868.

[14] Fischbacher, U. (2007). z-Tree: Zurich Toolbox for Readymade Economic Experiments - Experimenter's Manual. Experimental Economics 10, 171-178.

[15] Fonseca, M., Normann, H.-T., 2012. Explicit vs. Tacit Collusion - The Impact of Communication in Oligopoly Experiments. Forthcoming in European Economic Review.

[16] Genesove, D., Mullin, W.P., 2001. Rules communication, and collusion: Narrative evidence from the Sugar institute cartel. American Economic Review 91, 379-398.

[17] Genesove, D., Mullin, W.P., 1999. The sugar institute learns to organize information exchange. In: Lamoreaux, N.R., Raff, D.M.G., Temin, P. (Eds.), Learning by doing in markets, firms, and countries. University of Chicago Press, Chicago.

[18] Genesove, D., Mullin, W.P., 1998. Testing static oligopoly models: Conduct and cost in the sugar industry, 1890-1914. RAND Journal of Economics 29, 355-377.

[19] Greiner, B., 2004. An online recruitment system for economic experiments. In: Kremer, K., Macho, V. (Eds.), Forschung und wissenschaftliches Rechnen. 2003, GWDG Bericht 63. Ges. für Wiss. Datenverarbeitung, Göttingen, 79-93.

[20] Gürerk, Ö., Irlenbusch, B., Rockenbach, B., 2006. The competitive advantage of sanctioning institutions. Science 312, 108-111.

[21] Harrington, J.E., Skrzypacz, A., 2011. Private monitoring and communication in cartels: Explaining recent collusive practices. American Economic Review 101, 2425-2449.

[22] Hinloopen, J., Soetevent, A.R. 2008. Laboratory evidence on the effectiveness of corporate leniency programs. RAND Journal of Economics 39, 607-616.

[23] Huck, S., Konrad, K.A., Müller, W. Normann, H.-T., 2007. The merger paradox and why aspiration levels let it fail in the laboratory, Economic Journal 117, 1073-1095.

[24] Huck, S., Müller, W., Normann, H.-T., 2001. Stackelberg beats Cournot - On collusion and efficiency in experimental markets. Economic Journal 111, 749-765.

[25] Huck, S., Normann, H.-T., Oechssler, J., 2004. Two are few and four are many: Number effects in experimental oligopolies. Journal of Economic Behavior & Organization 53, 435-446.

[26] Kosfeld, M., Okada, A., Riedl, A., 2009. Institution formation in public goods games. American Economic Review, 99, 1335-1355.

[27] Levenstein, M.C., Suslow, V., 2006. What Determines Cartel Success? Journal of Economic Literature, 44, 43-95.

[28] McCutcheon, B., 1997. Do meetings in smoke-filled rooms facilitate collusion? Journal of Political Economy, 105, 330?350

[29] Salant, S.W., Switzer, S., Reynolds, R.J., 1983. Losses from horizontal merger: The effects of an exogenous change in Industry Structure on Cournot-Nash equilibrium. Quarterly Journal of Economics 98, 185-199.

[30] Selten, R., 1973. A simple Model of imperfect competition, where 4 are few and 6 are many. International Journal of Game Theory 2, 141-201.

[31] Shaffer, S., 1995. Stable cartels with a Cournot fringe. Southern Economic Journal 55, 231-246.

[32] Sutter, M., Haigner, S., Kocher, M.G., 2010. Choosing the stick or the carrot?: Endogenous institutional choice in social dilemma situations. Review of Economic Studies 77, 1540-1566.

Chapter 5

Do Discriminatory Leniency Policies Disrupt Cartel Formation?- Experimental Evidence

5.1 Introduction

Over the last two decades corporate leniency programs have emerged as real "game-changers" in the fight against hard-core cartels. The provision of amnesty to a cartel member that reports the cartel to an antitrust authority has ultimately proven to be an antitrust tool of utmost efficacy.[1] The possibility to apply for leniency does however not extend to all firms within a cartel. Ringleaders, which are identified as the firms that instigate and organize the cartel.[2] are excluded from leniency applications in most jurisdictions. A leniency policy that excludes ringleaders is therefore classified as discriminatory.

[1] As it has been pointed in U.S. Department of Justice (2001): "Over the past five years, the Amnesty Program has been responsible for detecting and prosecuting more antitrust violations than all of [the Antitrust Division's] search warrants, consensual-monitored audio or video tapes, and cooperating informants combined. It is, unquestionably, the single greatest investigative tool available to anti-cartel enforcers."

[2] See Davies and De (2013) who outline the organizational activities of ringleaders within a cartel.

Discriminatory leniency policies have a twofold disruptive effect on cartels. The first effect is the elicitation of confessions in an existing cartel. Cartels such as Lysine, Vitamins or Belgian brewers have been uncovered following insider information reported by cartel members.[3] The second disruptive effect is the deterrence of cartel formation by leniency. In this respect the discrimination of cartel ringleaders is of significant importance. As leniency is denied to ringleaders, the formation of cartels is potentially mitigated, since the role as a ringleader comes at the cost of amnesty. This generates a significant coordination problem in the formation of a cartel as every firm would be better-off if the other was the ringleader. The discrimination of ringleaders, however also has the potential to stabilize cartels.[4] By becoming a ringleader within the cartel, a firm can signal its commitment. As leniency creates distrust among cartel members who may all betray each other, renouncing the right to report the cartel as a ringleader may re-inject trust.

Although it remains unclear whether the stabilizing or destabilizing effect prevails, empirical evidence reported in Davies and De (2013) suggests that ringleader discrimination has not fully prevented the emergence of ringleaders. Astonishingly, the E.U. Commission has identified more than one ringleader in most of the ringleader cases, where the respective firms shared duties such as the organization of meetings. Despite the fact that this phenomenon might only be driven by organizational issues, the decision by multiple firms to become ringleaders could also have trust-enforcing motives. An increasing number of ringleaders reduces the number of potential "whistleblowers" and therefore facilitates cartel formation.

This paper analyzes whether or not cartel formation is disrupted by a discriminatory policy. The coordination problem generated by a discriminatory leniency policy yields the following research question: Does ringleader discrimination prevent the emergence of ringleader(s) and thereby cartel formation?

[3] See European Commission 2002

[4] This duality of a discriminating leniency policy has first been addressed in Leslie (2006)

Our experimental approach allows an adequate investigation of the effect of ringleader discrimination on cartel formation. Although economic experiments have their limitations, since firms' behavior is deducted from the decisions of subjects in the lab, their advantages are undeniable. Experiments can generate data for different legislation and policies especially with regard to coordination issues which are generally not observable in the field. More importantly, experiments allow the inference of behavioral aspects of conduct in cartels, such as trust, which cannot be deducted from field data or from theory.[5]

This experiment compares the impact of different antitrust policies on cartelization. We implement a cartel formation game where the cartel is established in a multi-stage decision game preceded by a communication stage. The experiment abstracts from pricing decisions as cartel members are always bound to the joint-profit-maximizing strategy while outside firms play best-response. This allows us to leave aside the possible influence of price coordination challenges on cartel formation which in this experiment only depends on whistleblowing. We introduce a benchmark treatment *Antitrust Authority* (AA) without leniency and two leniency treatments *Leniency* (LEN) and *Ringleader Discrimination* (RD). While cartel formation is sanctioned in all three treatments, leniency is only available in *LEN*. In RD only non-ringleaders are eligible to report the cartel. The introduction of LEN enables us to infer the general effect of leniency on cartel formation when comparing with AA. More importantly, introducing the RD treatment allows us to disentangle the effects of a discriminatory and non-discriminatory leniency policy on the emergence of ringleaders and cartel formation.

Many of the characteristics of cartels with ringleaders, which have been left untouched by the literature, are included in our experimental approach. First and foremost, we allow for multiple ringleaders in order to reflect the empirical evidence reported by Davies and De (2013). Our ringleaders not only instigate a cartel by switching on a chat device

[5] See Armstrong and Huck (2010) for an overview of the behavioral literature as applied to firms' conduct in markets.

that allows unlimited communication but may also facilitate collusion.[6] As opposed to former experiments by Bigoni et al. (2012), Hesch (2012), and Wandschneider (2012), the emergence of a ringleader is not deterministic in our setting. This is in line with the observation by Bos and Wandschneider (2011) who find that cartels do not necessarily have to include a ringleader in order to coordinate the cartel implementation. Thus, our framework allows us to assess whether there would be a ringleader under a leniency policy which discriminates against ringleaders and, if so, if he would emerge as the only ringleader.

Our findings can be summarized as follows: a non-discriminatory leniency policy reduces the number of formed cartels compared to a system without leniency where ringleader discrimination achieves the highest cartel formation rates. Cartels are rarely reported under both leniency policies, where the lowest number of reports is observed in the ringleader discrimination case. Most strikingly, we observe the highest number of ringleaders with ringleader discrimination. The results are of particular importance for antitrust policy as they show that the discriminatory leniency may facilitate cartel formation. In this regard the emergence of multiple ringleaders may generate trust among cartel members showing that firms can overcome the coordination challenge induced by the discriminatory leniency policy.

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. Section 4 discusses the results, while section 5 concludes.

[6]This follows from Cooper and Kühn (2009) and Fonseca and Normann (2012) who show that unlimited communication facilitates collusion in cartels.

5.2 Literature Review and Design

5.2.1 Literature Review

The number of articles on leniency policies has significantly increased over the last decade encompassing theoretical, empirical, and experimental contributions to the literature. The theoretical and empirical literature provides ambiguous results regarding the efficiency of leniency. Motta and Polo (2003), show that a leniency program may incentivize firms to collude more since the fine reduction induced by the leniency program makes collusion more attractive. In a similar line Spagnolo (2004) and Aubert et al. (2006) have shown that a reward system where whistleblowers obtain a bonus payment for reporting the cartel is superior to a leniency policy which reduces the fine. Empirical contributions by Miller (2009) and Brenner (2009) evaluate the efficiency of the U.S. and E.U. leniency programs showing that the former (Miller, 2009) enhances cartel detection while the latter fails to destabilize cartels (Brenner, 2009). Both the theoretical and experimental literature provide important insight into the effect of whistleblowing in existing and in detected cartels. However, neither the theoretical nor the empirical literature can explain how firms face challenges induced by a leniency policy on cartels that are yet to be formed. Here, the experimental literature on leniency initiated by Apesteguia et al. (2007) may fill a gap.

Apesteguia et al. (2007) provide the first experimental analysis of leniency programs. In a discretized one-shot Bertrand game similar to Dufwenberg and Gneezy (2000), Apesteguia et al. (2007) analyze the formation of three-firm cartels and the pricing decision under different antitrust policies. Here, a cartel was formed in a unanimous decision which implied unrestricted communication, while prices were fixed independently in the preceding stage. Subsequently, the cartel could be reported by cartel members if leniency was available or be detected by an antitrust authority. Apesteguia et al. (2007) find that leniency not only deters cartel formation but also undermines price coordination

as cartel prices are significantly lower under leniency. The experimental framework is designed as a one-shot repetition which may overestimate the positive effect of leniency. In fact, leniency has no consequence with one-shot interactions as it leaves out the possibility to sanction whistleblowers by refusing to collude in future periods. Consequently, Hinloopen and Soetevent (2008) and Bigoni et al. (2012) extend the framework of Apesteguia et al. (2007) to a dynamic setting with repeated interaction among the firms.

In Hinloopen and Soetevent (2008) the results obtained by Apesteguia et al. (2007) regarding the disruptive effect of leniency are confirmed, as leniency deters cartel formation and reduces prices alike. Further intriguing changes are introduced by Bigoni et al. (2012) where the right to report the cartel before and after its implementation is the most important one.[7] This modification allows us to disentangle defection and punishment and ensures that leniency does not become a mere punishment tool for defecting firms. As opposed to Apesteguia et al. (2007) and Hinloopen and Soetevent (2008), Bigoni et al. (2012) find that leniency increases prices. Yet, the deterring effect of leniency on cartel formation found in Apesteguia et al. (2007) and Hinloopen and Soetevent (2008) is confirmed in Bigoni et al. (2012). Experimental evidence hence fills a gap as it clarifies the picture of the effect leniency has on the coordination of cartel formation. We are in line with this approach as we also investigate the effect leniency has on the formation of cartels. Note however that our approach focuses on the effect of a discriminatory leniency policy where ringleaders are excluded from the leniency program, and therefore contributes to the literature on ringleader discrimination.

Ringleader discrimination has only recently caught the attention of economic research. Bos and Wandschneider (2013) infer the impact of a ringleader discrimination policy in a theoretical model based on Bos and Harrington (2010). It is shown that a discriminatory leniency policy may yield higher cartel prices as compared to a non-discriminatory pol-

[7] Note that Bigoni et al. (2012) furthermore analyze leniency in a duopolistic differentiated Bertrand market and use a fixed fine, as opposed to Apesteguia et al. (2007) and Hinloopen and Soetevent (2008).

icy.[8] A different approach is suggested by Herre et al. (2012) who model the ringleader as the cartel member with the highest amount on relevant information for the antitrust authority. In a theoretical framework based on Motta and Polo (2003) it is shown that, depending on the amount of information a ringleader has, ringleader discrimination may or may not be desirable. So far the theoretical literature has fallen short of a clear-cut evaluation of ringleader discrimination. Hence, experimental evidence may provide additional evidence to clarify the picture.

Ringleader discrimination has only recently caught the attention of experimental research. The experiment by Bigoni et al. (2012) includes a leniency treatment with ringleader discrimination. The results suggest that the policy does not decrease cartel deterrence and that cartels become more harmful since prices increase. However, the scope of these results is limited as Bigoni et al. (2012) exclusively analyze duopolies. Hesch (2012) and Wandschneider (2012) extend the analysis to a triopoly. In an experimental framework based on Hinloopen and Soetevent (2008), Hesch (2012) finds that ringleader discrimination facilitates cartel formation and increases prices for a low detection probability while the opposite holds for a high detection probability. Wandschneider (2012) confirms the result that ringleader discrimination does not deter cartel formation although cartel prices are lower with ringleader discrimination.

The experimental literature on discriminatory leniency policies has so far mainly focused on the implementation of the cartel prices, and has deliberately simplified cartel formation. In all experiments presented above the entire cartel formation process corresponds to a unanimous decision to activate a communication device. Consequently Bigoni et al. (2012) model the ringleader as the firm that is first to activate the communication device. This approach guarantees that the ringleader plays a crucial role in the cartel

[8] This is the case if the cartel fails to implement the joint-profit-maximizing strategy, if there is a non-linear relation between the fines and the individual cartel gains of a firm and if the distribution of the firm size within the cartel is sufficiently heterogeneous.

formation process. Yet it only leaves one potential whistleblower as the cartel is formed in a duopoly. Hence the coordination challenge induced by a potential "run to the court house" cannot be inferred here. In Hesch (2012), the ringleader is randomly picked by the computer which per-se excludes coordination problems in the formation of a cartel. Wandschneider (2012) models the ringleader as the firm that proposes the cartel price which is ultimately confirmed by the other cartel members. This approach has a minor flaw as the designated ringleader cannot renounce his position if his price is accepted by the other members. Hence the decision to become a ringleader is not fully deliberate.[9]

In all of the above mentioned experiments the presence of a ringleader is a necessary requisite for the emergence of a cartel. Furthermore, the existence of multiple ringleaders is ruled out. This stems from the fact that the experimental ringleader literature simplifies the cartel formation process so as to provide a comprehensive cartel experiment. We depart from this approach as we rather focus on the cartel formation process and less on the price coordination decision within a cartel. We therefore introduce a modified version of the setup introduced by Kosfeld et al. (2009) which analyzes the formation of endogenous public good institutions. This approach allows us to infer the role of ringleader discrimination on coordination in the formation of a cartel and to abstract from the pricing decisions. It furthermore enables the emergence of multiple ringleaders without necessarily requiring the presence of a ringleader in the formation process of a cartel.

Kosfeld et al. (2009) provide an experimental analysis on the formation of an endogenous institution which sanctions free-riding in the context of a public good game. Here a three-stage-decision game is implemented where in the first stage subjects have to vote whether to participate in an institution (see Selten, 1973). In the second stage all subjects that decided to participate at the first stage learn about the number of potential partici-

[9]Note, however, that a firm could avoid becoming the ringleader by choosing a price that will always be rejected by the other. Yet, this would in turn drive the results as low prices in the ringleader treatment would be obtained "by design."

pants. 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. Since the baseline model for Kosfeld et al. (2009) (see Okada, 1993) is closely related to Selten (1973), its applicability to a cartel formation case is undeniable.[10]

In a companion paper (Clemens and Rau, 2013) the three-stage-decision game introduced by Kosfeld et al. (2009) is modified to analyze the emergence of partial cartels in a Cournot market. The cartel is formed at the first and second stages, equivalently to Kosfeld et al. (2009), where the cartel works like an institution with cartel members being the insider and non-participants being the outside firms. At the third stage, the cartel chooses the joint-profit-maximizing Cournot quantity for all its members, whereas the outsiders always play best-response. Firms are given the possibility to use a communication device before voting to implement the cartel. The results suggest that partial cartels are rejected out-of-equilibrium if outside firms profit excessively from the formation of a cartel at the expense of insiders. The communication stage plays a significant role in this framework as it yields an increase of the cartel formation rates from 26% to 97% as compared to the cases without communication. This insight is used in our experiment as the role of the ringleader is tied to the activation of the communication device.

Our experiment uses the same experimental framework as Clemens and Rau (2013) but includes a stage where firms can apply for leniency and an additional stage where an antitrust authority may detect the cartel. Furthermore, firms do not communicate automatically but have to choose to activate the communication device, where at least one positive

[10] 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."

vote is needed to activate chat. Yet, there may be more than one firm willing to activate the chat. This is of particular importance as those firms that activate communication are treated as ringleaders. Hence, we allow for the emergence of multiple ringleaders as but do not require the presence of a ringleader to ensure the formation of a cartel. One important advantage of this approach is that the activation of the communication device does not automatically lead to the formation of a cartel as in Apesetguia et al. (2007) but is only optional. However, cartel formation is significantly enhanced with communication, a result which is in line with Cooper and Kühn (2009) and Fonseca and Normann (2012).

Tying the role of a cartel ringleader to the activation of a communication copes with recent empirical findings from several E.U. cartel cases. Davies and De (2013) show that a ringleader has an organizational duty which helps to overcome the classical coordination issue cartels face. One of the main tasks identified as a ringleader duty by Davies and De (2013) is the formation, instigation, and approaching of potential cartel members. Although this may not be the only task a ringleader has to fulfill cartel instigation by ringleaders is observed in 14 out of 19 cases by Davies and De (2013). Our experiment therefore builds on the literature on discriminatory and non-discriminatory leniency policies. Yet it provides additional insight, being one of the first experiments to tackle the incurring coordination challenge induced by a discriminatory leniency policy on the emergence of one or more ringleaders.

5.2.2 Experimental Design

In our experiments we implemented three different treatments: *Antitrust (AA)*, *Leniency (LEN)* and *Ringleader Discrimination (RD)*.

Our *AA* treatment allows us to assess the formation of a cartel that can be detected with a probability of 15% by an antitrust authority yielding a 10% fine. *AA* does not include a possibility to report the cartel and therefore serves as a benchmark against which

the general effects of leniency policies on the formation of cartels can be measured. Consequently, *AA* is only composed of the communication stage, three subsequent cartel formation stages, and finally a cartel detection stage.

We implement two further treatments where leniency is possible. The *LEN* treatment introduces a non-discriminatory leniency policy that allows a cartel member to report the cartel to the antitrust authority after its formation and implementation. All cartel members are equally eligible to apply for leniency in the *LEN* treatment. The treatment is composed of the same five stages as in *AA* but adds a further stage if a cartel was formed which precedes the detection stage. The *LEN* treatment allows us to infer the general effects of whistleblowing on cartel formation and serves as a benchmark.
A crucial modification is provided in the *RD* treatment. Here, firms that decide to activate the communication device for the entire group become ringleaders and are denied the right to apply for leniency. The stages in the *RD* treatment are the same as in *LEN* with the exception that those firms that activate the chat are excluded from leniency in the whistleblowing stage. This approach follows Bigoni et al. (2012) and is motivated by the insight that it is communication that largely facilitates the formation of cartels. The *RD* treatment allows us to analyze the emergence of ringleaders and the formation of cartels if a discriminatory leniency policy is implemented

Table 5.1 provides an overview of the payoffs generated in a symmetric Cournot game with four firms for the different possible cartel constellations. Cartel members' payoffs are determined following the assumption that they maximize the joint profits while the outsiders play their best-response strategies which determines their payoffs. The terms in brackets indicate the fine a cartel member faces if the cartel is reported or uncovered, where we deduct the fine from the respective payoffs.

Composition		**Firms' Payoffs**	
# Insiders	# Outsiders	Insider	Outsider
0	4	na (na)	64
1	3	64 (na)	64
2	2	50 (-35)	100
3	1	59 (-34)	178
4	0	100 (-40)	na

Table 5.1: Cournot payoffs with cartel detection and cartel compositions (The terms in brackets indicate the fine a cartel member faces if the cartel is reported or uncovered.)

In the following we explain our mechanism. The decisions taken by the subjects are subdivided into six stages which can be summarized as follows:

- **Stage one:** Decision to activate the communication device.
- **Stage two:** Decision to participate in a market agreement.
- **Stage three:** Decision by the potential participants to make the market agreement binding.
- **Stage four:** Announcement on the formation of the cartel and the number of cartel insiders. If no cartel was formed, the round ended in this stage.
- **Stage five:** Decision to reveal the cartel (Leniency) to the authority (only in *LEN* and *RD* and only if a cartel was formed).
- **Stage six:** Investigation by the antitrust authority (only if a cartel was formed).

We now explain in detail every single stage and the respective decisions every

In **stage one** all firms were given the possibility to activate a chat window for a total of 60 seconds. If one or more firms decided to activate chat, the chat window was activated for all firms in the market. If no firm decided to activate the chat, it was not activated.

The decisions of the firms were made simultaneously and were communicated to the entire market before the chat window started (or not). If the chat window was activated it automatically closed after 60 seconds and stage one started immediately. Firms remained anonymous during the chat and were given neutral names like “firm 1-4” which did not change over the course of the experiment.

In **stage two** all subjects in a market had to decide whether or not they would like to participate in a market agreement[11] by either clicking “yes-” or “no-”. Those participants that clicked “yes” became *possible insiders* while those participants that clicked “no” became *ultimate outsiders*.

In **stage three** the total number of possible insiders and ultimate outsiders was reported to all firms. While ultimate outsiders had no decision to make at stage three, possible insiders had to decide whether they want to implement the cartel. As the payoffs were conditional on the number of insiders and outsiders, possible insiders were presented the payoffs of insiders and outsiders if the cartel was implemented, as well as the payoffs if no cartel was implemented. The cartel was only formed if all possible participants decided to implement the cartel requiring full unanimity by the firms.Otherwise the formation of the cartel was revoked and all firms became direct competitors and received the Cournot Nash equilibrium profits.

The cartel members were bound to the cartel strategy while outsiders always played best-response. Note that our approach abstracts from pricing decisions and neglects the possibility of defecting within the cartel. This simplification is deliberate, as we focus on the cartel formation challenge induced by potential whistle-blowing. The failure to agree on a price in the pricing stage or defection from the cartel price may as well deter cartel formation. Abstracting from the pricing decision is therefore necessary to fully focus on the impact of a leniency policy that induces cartel members to blow the whistle on cartel

[11] The treatments were neutrally framed using the German word “Marktabsprache” which means “market agreement.”

formation.

In **stage four** subjects were informed regarding the cartel formation. If no cartel was formed the game ended in this period and the players received Cournot payoffs (each 64).

Stage five only took place in the *LEN* and *RD* treatments and it only started if a cartel was established. In the *LEN* treatment a sequence of the four firms was randomly established by the computer, which determined in which order the firms could report the cartel. This random sequence guaranteed that all firms were designated as a potential whistleblower with the same likelihood and reflected equal chances of winning the run to the court house in the case of symmetry. If the first firm in the sequence decided to report the cartel, all firms except the whistleblower were sanctioned by the antitrust authority, yielding a fee corresponding to 10% of the revenues (see terms in brackets in Table 5.1). Otherwise the right to report the cartel was handed over to the next firm of the random sequence, until the cartel was either reported or the last firm in the sequence refused to report the cartel.

If no firm decided to report the cartel, the cartel was not revealed at this stage. A modification was introduced in the *RD* treatment which denied those firms who activated the communication device in stage one the right to report the cartel. Accordingly, these firms were excluded from the random sequence of possible whistleblowers.[12]

In **stage six** the antitrust authority started the investigation if a cartel was formed in both stages two and three and not reported in stage five of the *LEN* and *RD* treatment. The antitrust authority had a 15% chance to uncover the cartel. If the cartel was uncovered, a fine of 10% of the revenue was imposed on all cartel members (see terms in brackets in Table 5.1). Otherwise the cartel remained uncovered and the profits of the cartel members remained unaffected.

[12]Note that this approach is in line with the E.U. leniency program which sanctions multiple ringleaders in a cartel if they "took steps to coerce other undertakings to participate in the cartel." This is not the case in the U.S. and in Canada where discriminatory leniency policies are applied only if there is a single ringleader (see OECD, 2002).

5.2.3 Experimental Procedures

We used a fixed matching protocol with four firms in a market playing the multi-stage game repeatedly for 16 periods.[13] We conducted three sessions of every treatment, where every session was composed of 12 participants forming three matching groups of four firms each. Thus, our data involves 27 independent matching groups, i.e., we have nine independent matching groups in *AA*, *LEN*, *RD*. The experiment was conducted at the *DICE Lab* of the University of Düsseldorf in May and June 2013 with 108 subjects from various fields. The profits achieved by the participants were converted at an exchange rate of 1 Taler $= 0.01$€. On average, every participant earned 15.81€ and an additional show-up fee of 4€. The experiments were programmed in z-Tree (Fischbacher, 2007) and our subjects were recruited with the online recruitment system ORSEE (Greiner, 2004).

5.3 Predictions and Hypotheses

5.3.1 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 $P = 100 - \sum_{i=1}^{4} Q_i$. Firms face marginal cost of production $c = 60$.

A complete overview of the Cournot payoffs and antitrust fines depending on the respective cartel outcomes is provided in Table 5.1. Stages two, three, and four ensure that a stable cartel with four firms emerges in equilibrium. We now determine the equilibrium strategies for the *AA*, the *LEN*, and the *RD* treatments using backward induction.

[13] Following Clemens and Rau (2013) a fixed-matching protocol was used in order to resemble repeated interaction between the same firms in oligopolistic markets.

5.3.2 Antitrust Treatment: Equilibrium Strategies

Given our experimental design outlined above we start our analysis by determining the equilibrium strategies in the *AA* treatment. The only stable cartel is the all-inclusive cartel which encompasses the four firms. This is guaranteed in stage three, as possible cartel members are first informed of the size of a cartel if it was implemented. Hence possible cartel members can reject any out-of-equilibrium strategy, guaranteeing an all-inclusive cartel is implemented. We thus limit our analysis to this cartel. The expected payoffs of a firm i which participates in the four-firm, all-inclusive cartel corresponds to:

$$E(\pi_i^4) = 0.15 \times 60 + 0.85 \times 100 = 94$$

Comparing the payoffs of the firms for an all-inclusive cartel and in the case of Cournot competition ($94 > 64$) we conclude that risk-neutral firms choose to form an all-inclusive cartel.

Proposition 1: The cartel formation in the *AA* treatment has a unique strict subgame perfect equilibrium, where an all-inclusive cartel is formed.

In this case the decision to activate the communication device at the first stage does not influence the payoffs and is therefore obsolete regarding the formulation of our Proposition.

5.3.3 Leniency Treatment: Equilibrium Strategies

Our *LEN* treatment differs slightly from the *AA* treatment with regards to stage five. All former stages up to stage four are equal in *AA* and *LEN*. In stage five, all cartel members are given the possibility to report the collusive agreement. Since revelation guarantees a firm that it will obtain the collusive profit, it always decides to report the cartel. Hence the

decision to report the cartel or not corresponds to a prisoner's dilemma game.[14] The first firm in the randomly determined sequence at stage five consequently reports the cartel. The chance of being the first firm in the sequence corresponds to 25% yielding profits of 100, while another firm is picked out as the first potential whistleblower with a converse probability of 75% yielding payoffs of 60. Hence, the expected payoffs of forming a cartel corresponds to:

$$E(\pi_i^4) = 0.75 \times 60 + 0.25 \times 100 = 70$$

Comparing the payoffs of the firms in the case of an all-inclusive cartel and in the case of Cournot competition ($70 > 64$) we conclude that firms choose to form the all-inclusive cartel.

Proposition 2: The cartel formation game in the *LEN* treatment has a unique strict subgame perfect equilibrium, where an all-inclusive cartel is formed and always reported.

5.3.4 Ringleader Treatment: Equilibrium Strategies

The *RD* treatment introduces a modification to the *LEN* treatment, with regard to the eligibility of becoming a whistleblower at stage five. A firm that activates the communication device renounces its right to report the cartel to the authority and is therefore excluded from the random sequence determined at stage five. Assuming that all firms decide to activate the communication device, all firms would obtain the profits generated in the *AA* treatment, i.e., a payoff of 94. If a firm decided not to activate the communication device and to therefore become the only possible whistleblower, its profit would increase

[14] As Leslie (2006) points out: "The prisoner's dilemma is usually a game theoretical model used to explain behavior having nothing to do with prosecutors or prisoners. But in the case of cartel investigations, the language of the model maps the reality of our inquiry."

from 94 to 100, while the profits of the other firms would be 60. As this payoff is inferior to the competitive payoff (64) firms prefer not to form a cartel at all than to activate communication and form a cartel thereafter. We thus postulate the following corollary:

Corollary 1: Firms renounce the activation of the communication device in the *RD* treatment.

If all firms renounce the activation of the communication device, they all become eligible for leniency after cartel formation. Hence all firms would be better-off not activating the communication device, forming the cartel and reporting if they are given the possibility to do so. Hence firms face the same prisoner's dilemma as in *LEN* and obtain the same expected payoffs. We therefore formulate the following proposition:

Proposition 3: The cartel formation game in the *RD* treatment has a unique strict subgame perfect equilibrium, where an all-inclusive cartel is formed and always reported.

5.3.5 Hypotheses

Following the results obtained in the former section we may now postulate our hypothesis. Following proposition 1 we expect firms to form cartels despite the probability of being detected. The reason is that higher expected payoffs (94 Talers) occur by forming cartels compared to the non-collusive case (64 Talers). Therefore the antitrust authority should not impact on firms' willingness to form cartels. This hypothesis is in line with similar experiments conducted by Apesteguia et al. (2007) and Hinloopen and Soetevent (2008) among others who also report high rates of cartel formation in the absence of leniency.

By contrast, in our *LEN* treatment, all subjects are given an equal chance to report the cartel. As Proposition 2 suggests, cartels are always formed but they are also reported by the whistleblowers. Apesteguia et al. (2007), Hinloopen and Soetevent (2008), and

Bigoni et al. (2012), however, show that a non-discriminatory leniency policy deters cartel formation in experimental settings. In comparison to a treatment without leniency the rate of cartel formation is always lower. Although this phenomenon is not explained in any of these experiments, Leslie (2006) suggests that fear of betrayal by whistleblowers may deter cartel formation.[15] Therefore we expect less firms to be willing to form a cartel when leniency is possible:

Hypothesis 1

The leniency policy leads to a deterrence of cartel formation in LEN: less cartels should occur compared to AA.

Proposition 3 outlines that in the *RD* treatment all-inclusive cartels are always formed. The communication option may also be a powerful institution increasing cartel formation rates as suggested in Cooper and Kühn (2009) and Fonseca and Normann (2012). Note that chat activation comes at a cost, i.e., firms dismiss the chance to report the cartel in the leniency stage. Andersson and Wengström (2007) find that costly communication reduces cartel formation.[16] In our experiment, activation of the chat device comes at the cost of losing the right to blow the whistle. Thus, subjects should be reluctant to activate chat. Following Andersson and Wengström (2007) this should lead to a lower cartelization rate. As firms should again use the leniency option this will further deter cartelization rates. Hence we postulate the following hypotheses:

Hypothesis 2

In the RD treatment both, the ringleader-discrimination policy and the leniency program should deter cartel formation:

[15] This observation is in line with Bohnet and Zeckhauser (2004) who suggest that subjects are prone to betrayal aversion, i.e., they dislike situations where another agent may turn the outcome of the game to one's disadvantage.

[16] Note, however, that the baseline theoretical model by McCutcheon (1997) shows that communication cost may not necessarily mitigate the formation of cartels.

(a) less cartels should occur in RD compared to AA.

(b) less cartels should occur in RD compared to LEN.

One of the key aspects of our experiment is the analysis of the emergence of multiple ringleaders. In this regard we infer the effect of a discriminatory leniency policy on the total number of ringleaders in a market. The activation of the communication device implies a renunciation so that we expect a decrease in the number of ringleaders following Corollary 1. By contrast, in *AA* and *LEN* chat activation does not come at a cost. Thus, there should be no difference in the number of ringleaders between these treatments. We formulate the following hypothesis:

Hypothesis 3

In the RD treatment we observe the lowest number of ringleaders.

5.4 Results

In the following we report our results. When using non-parametric tests, we always report two-sided p-values.

5.4.1 Summary statistics

Figure 5.1 depicts the average fraction of cartels established in our three treatments: *AA*, *LEN*, and *RD*. It also reports the frequencies of cartels which were not revealed (survived), the frequency of reports (whistleblow), and finally how often cartels were detected (detected) by the random mechanism.

The diagram reveals that 82% cartels are established in *AA*, whereas under the nondiscriminatory leniency policy the fraction of established cartels decreases down to 64%. The discriminatory leniency policy leads to 86% of formed cartels in *RD*. More firms

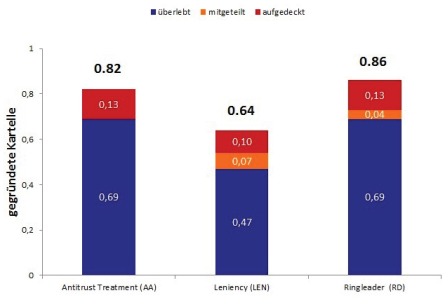


Figure 5.1: Established cartels and the frequencies of survived, reported, and detected cartels.

make use of the leniency option in *LEN* (7%) compared to the case when ringleaders are discriminated against (4%).

Figure 5.2 depicts the average fraction of established cartels over time. A conspicuous finding of the *LEN* treatment is the sharp decrease of established cartels between periods 1 and 2. This emphasizes that the nondiscriminatory leniency policy turns out to be very efficient at the beginning of the game, i.e., firms establish 78% cartels in the first period and subsequently 29% of those cartels are reported. This leads to a significant decrease of firms' willingness to form cartels in period 2 where only 44% cartels are established (Wilcoxon Matched-Pairs test p-value = 0.083). At the same time no distinct development of established cartels can be found in periods 3–16. By contrast, the fraction of established cartels increases between periods 1 and 8 in *AA* (from 44% to 89%) and *RD* (from 22% to 100%). A Spearman's rank correlation coefficient of *established cartels* and *period* is significant and positive for periods 1–8 in *AA* ($\rho = 0.280$, p-value = 0.017) and in *RD* ($\rho = 0.488$, p-value < 0.001). No significant correlation can be found in *LEN* ($\rho = 0.069$, p-value = 0.565). Finally, there is an end-game effect in all three treatments: in periods 15–16 less cartels are established.

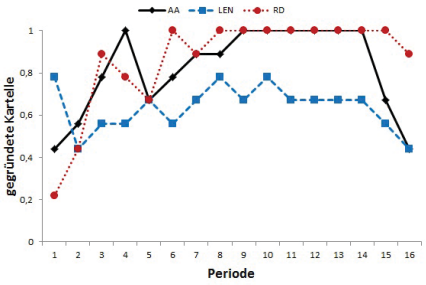


Figure 5.2: Average development of established cartels over time.

5.4.2 Main Treatment Effects

In this section we test our hypotheses. The analysis starts by reporting non-parametric tests. Subsequently, we run regressions to clarify the picture of the treatment effects and the time dynamics.

The previous subsection has shown that firms in our experiment are prone to a pronounced learning behavior and are affected by an end-game effect (periods 15–16). Hence, we neglect the end-game effect and run non-parametric tests focusing on the second half of the game (periods 9–14). Here, the fraction of established cartels is the same (100%) in *AA* and *RD*. However, in *LEN* significantly less cartels are established (69%) compared to *AA* (Mann-Whitney test, $p - value = 0.066$). Finally, significant more cartels are established in *RD* (100%) than in *AA* (69%) (Mann-Whitney test, $p - value = 0.066$).

We present the analysis of our treatment effects in two parts. First, we test Hypotheses 1–3 by estimating a probit model of cartel establishment. Second, we infer Hypothesis 4 by estimating an OLS-regression model. Both models use the same independent variables and are clustered at the group level for 27 independent groups. The variables are as follows: *LEN* and *RD* are dummy variables which are equal to one in the respective treatments (*AA* is the omitted treatment variable). We also incorporate control variables controlling for the impacts of the time dynamics: *period 1–8* is a dummy variable which is positive (zero) when data of periods 1–8 (periods 9–16) are analyzed. *Periods 15–16*

is a dummy variable indicating the data of periods 15–16 when equal to one. Finally, we add interaction terms of the treatment and time dummies. We focus on the following interaction effects: *LEN* × *period 1–8*, *RD* × *period 1–8*, *LEN* × *period 15–16* and *RD* × *period 15–16*.

We typically report three regressions: Regression (1) represents the impact of our treatment variables only. Regression (2) incorporates the time effects in periods 1–8 and 9–16 as control variables. Regression (3) analyzes the interaction terms of *periods 1–8* with our treatment dummies. It also controls for the interaction terms of *periods 15–16* with our treatment dummies.

Table 5.2 presents the results of the regressions on the probability of cartel establishment.

Regression 1 points out that there are no significant effects when ignoring time dynamics, whereas *periods 1–8* and *periods 15–16* (in regression 2) are highly significant with negative signs. This again confirms the previously reported pattern of firms' learning behavior in Figure 5.2 and that end-game effects are of importance. As time dynamics crucially influence firms' decisions, we control for time effects (regressions 2 and 3) when testing Hypotheses 1–3.[17]

Controlling for time dynamics in the first and second half of the game (regression 2) and incorporating the end-game effect (regression 3), we find that *LEN* is significant with a negative sign. Thus, the leniency policy deters cartel formation in *LEN*: less cartels are established compared to *AA*. We therefore confirm Hypothesis 1.

Result 1:

In LEN less cartels are formed than in AA.

[17] Ai and Norton (2003) point out that the interpretation of interaction effects in non-linear models might be problematic. Hence we do not not interpret the coefficients in detail. We also conducted robustness checks using General Linear Models (GLM) confirming the same signs, magnitudes, and significant levels for all of our variables of interest. There is only a minor exception for the interaction terms in regression 4, i.e., *LEN* × *period 1–8* and *RD* × *period 1–8* are not significant ($p > 0.10$).

	established cartels		
	(1)	(2)	(3)
LEN	-0.576	-0.658*	-4.940***
	(0.376)	(0.383)	(0.432)
RD	0.172	0.178	0.000
	(0.209)	(0.222)	(0.088)
periods 1-8		-0.826***	-4.748***
		(0.221)	(0.267)
periods 15-16		-0.924***	-5.283***
		(0.315)	(0.323)
LEN × *periods 1–8*			4.584***
			(0.327)
RD × *periods 1–8*			-0.043
			(0.315)
LEN × *periods 15–16*			4.800***
			(0.586)
RD × *periods 15–16*			1.454**
			(0.578)
Constant	0.913***	1.543***	5.422***
	(0.172)	(0.221)	(0.063)
R^2	0.051	0.113	0.174
Observations	432	432	432
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

Table 5.2: Clustered probit regression on cartel establishment. Omitted treatment dummy is *AA*, robust standard errors are reported in parentheses.

Regressions 2 and 3 further reveal that the coefficient of *RD* is positive and never significantly different from zero. This suggests that the leniency policy with ringleader discrimination does not reduce the probability of cartel establishment compared to *AA*. We therefore have to reject Hypothesis 2a.

Result 2a:

The RD treatment does not decrease the number of formed cartels compared to AA.

A Wald test reveals that the likelihood of cartel formation is significantly higher in *RD* than in LEN (p - value < 0.001). This rejects Hypothesis 2b.

Result 2b:

In RD significantly more cartels are formed compared to LEN.

To test Hypothesis 4 we analyze the number of ringleaders over time in our treatments. Figure 5.3 depicts the development of the average number of ringleaders in *AA*, *LEN*, and *RD*. The diagram shows a distinct time development of the average numbers of ringleaders in *AA* and *RD*. In *AA* the average number of ringleaders decreases from 2.44 (period 1) down to 1.22 (period 16). By contrast, it increases in *RD* from 1.22 (period 1) to 3.44 (period 16).

To infer treatment effects in the number of ringleaders we use OLS-regression analyses. Table 5.3 presents the results of OLS regressions on the number of ringleaders. Again, we use the same independent variables and report the same regressions as in Table 5.2.

Regressions 1 and 2 show that the number of ringleaders is not different in *LEN* and *RD* when compared to *AA*. Controlling for interaction effects between our treatment and time dummies, it turns out that *RD* is significant and positive, i.e., in *RD* more firms

	number of ringleaders		
	(1)	(2)	(3)
LEN	0.736	0.736	0.870
	(0.544)	(0.545)	(0.747)
RD	0.924	0.924	1.463**
	(0.557)	(0.558)	(0.711)
periods 1-8		0.157	0.713*
		(0.241)	(0.383)
periods 15–16		-0.000	-0.426
		(0.155)	(0.310)
LEN × *periods 1–8*			-0.412
			(0.594)
RD × *periods 1–8*			-1.255**
			(0.477)
LEN × *periods 15–16*			0.574
			(0.371)
RD × *periods 15–16*			0.704*
			(0.380)
Constant	1.729***	1.650***	1.426**
	(0.403)	(0.447)	(0.520)
R^2	0.061	0.064	0.101
Observations	432	432	432
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

Table 5.3: Clustered OLS regression on the numbers of ringleaders. Omitted treatment dummy is *AA*, robust standard errors are reported in parentheses.

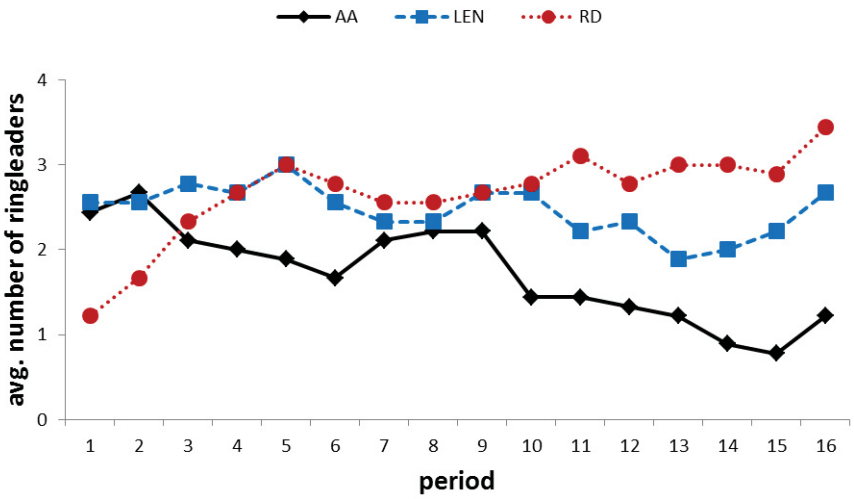


Figure 5.3: Development of ringleader activity over time.

become ringleaders compared to *AA*. The interaction of *RD* and *periods 1–8* is significant with a negative sign. This emphasizes that at the beginning of the game less firms become ringleaders than in *AA*. Furthermore, it confirms the pattern observed in Figure 5.3. Hence, during the course of the game firms in *RD* learn to signal trust by becoming ringleaders.

A Wald test reveals that the number of ringleaders is not significantly different in *RD* compared to *LEN* (p - value = 0.421). We summarize that we do not observe the smallest number of ringleaders in *RD*, we thus have to discard Hypothesis 3.

Result 3:

In RD the number of ringleaders is significantly higher than in AA and insignificantly higher than in LEN.

5.4.3 Analysis of the Chat Protocols

To get a better understanding of firms' cooperation strategies the chat protocols are analyzed in this subsection. As in Clemens and Rau (2013) we first follow an approach

similar to Andersson and Wengström (2007). Here, the number of messages sent and the fraction of "collusive agreements" are accounted. In Andersson and Wengström (2007) a "collusive agreement" is a case where subjects proposed a price which was not rejected by other participants. In our framework we stick to the term "cheap-talk" agreement. We name all cases "cheap-talk" agreements where a firm's proposal to form a market agreement was not rejected by other firms.

Table 5.4 gives an overview of the average chat messages sent and the fraction of cheap talk messages in periods 1–8 and in periods 9–16.

	AA		LEN		RD	
periods	1-8	9-16	1-8	9-16	1-8	9-16
chat messages sent	7	4	7	7	7	6
cheap-talk agreements (in%)	82	28	67	19	78	21

Table 5.4: Average number of "cheap-talk" agreements over time

The average number of chat messages is constant between the first half of *LEN* (7) and the second half (7). The same is true for the *RD* treatment, where an average of seven messages are sent between periods 1–8 and six messages are sent between periods 9–16. However, the *AA* treatment is an exception, i.e., the average amount of chat messages declines from seven (periods 1–8) to four (periods 9–16). This once more emphasizes that in the absence of a leniency policy less firms tend to communicate because collusion is easier to establish.

Focusing on the average fraction of cheap-talk agreements between periods 1–8, the lowest fraction (67%) is observed in *LEN*, while 82% of the firms decide to have a cheap-talk agreement in *AA* and 78% in *RD*. This suggests that the leniency policy may disrupt collusive behavior in *LEN* compared to RD.

To shed more light on firms' strategies to collude we follow Kimbrough et al. (2008), Fonseca and Normann (2012), and Clemens and Rau (2013) and present the content of

representative chat protocols. These papers have shown that quoting chat protocols may reveal important details about subjects' behavior in chat communications.

In the following we present examples of typical first-period chat communications in *AA*, *LEN*, and *RD* to reach collusive agreements:

Market 4, period 1: AA

```
firm 3:  EVERYBODY SHOULD ALWAYS TAKE PART
firm 2:  highest possible payoff for everybody:  ALWAYS market agreement
firm 3:  Then, everybody would maximally get 100 and at least 60
firm 3:  Absolutely
firm 3:  15% is not much for a detection rate
firm 2:  It won't work with a 15% chance in every of the 16 periods but
         this does not matter
firm 3:  so true
firm 2:  perfect!
firm 4:  I would also agree
firm 2:  firm1?
firm 3:  Hopefully nobody will defect from the agreement :D
firm 1:  Ok, alright!
firm 3:  Works out!
```

This emphasizes firms' most frequent discussions in *AA*, i.e., in period 1 firms most often discussed that the expected payoff of taking part in the agreement is higher than refusing to form cartels. In *AA*, firms refuse to talk about cartel formation in the subsequent periods, this is also documented by the declining fraction of cartel agreements.

Market 8, period 1: LEN

```
firm 2:  Shall we work together so that everybody takes part?  Then
         everybody should not reveal the cartel and we should hope that
         this is also not done by the authority..
firm 1:  If everybody always takes part and nobody whistle-blows we
         could end up with 20 euros
firm 2:  Sounds good
firm 3:  Correct ;)
firm 4:  yes!
```

Thus, the first-period chat protocols of LEN are quite similar compared to AA. Whereas, a crucial difference is that firms discuss the leniency option and state that it should not be used.

Market 3, period 1: RD

```
firm 2:  I would propose that everybody always activates the chat, then
         we could skip the leniency phase
firm 1:  And always form a market agreement.  Then everybody would get
         100
firm 3:  Except if the agreement would be revealed
firm 1:  Otherwise we would only get 64
```

In most of *RD*'s first-period discussions firms rather talk about revealing cartels and activating the chat. The protocol presented above is an example of a group which at an early stage of the experiment realized that chat activation could be used as an instrument to trigger collusion in *RD*.

To get more insights on the potential disruptive effect of the leniency policy in *LEN*, we present a *LEN* chat protocol right after a cartel was reported.

Market 6, period 4: LEN

```
firm 3:  Oh my god, looks like we have the most honest participants in
         this experiment
firm 2:  yes, this is how you could do it
firm 1:  This is only a suspicion, but I believe that firm 4 works
         against us!
firm 3:  very nice
firm 4:  sorry, but I love capitalism!
firm 4:  your pain is my gain
firm 3:  Congratulations
firm 1:  There goes our cooperation
firm 1:  40 cent more for you!
```

This example shows that firms immediately discuss when a cartel was reported. Furthermore it illustrates that "blowing the whistle" by firm 4 leads to an end of cooperation. After that this group barely managed to form cartels in subsequent periods. In period 5 a cartel was established for the second time (after period 3) and it was also reported by firm 4. We now present the chat protocol of period 5.

Market 6, period 5: LEN

```
..
firm 1:  Now you earned for the second time 40 Talers more than all of
         us.  But from now on you will receive 40 Talers less...firm 4,
         is that what youwould call "capitalism"?
firm 3:  Unbelievable how bold people can be..
firm 3:  sad enough
firm 4:  We are not a team!
```

This once more highlights how the leniency policy operates in order to disrupt trust between firms. By contrast, in the *RD* treatment there is evidence that firms use chat activation to signal that they want to "lay down their arms." Which positively stimulates trust, leading to more collusion.

Market 19, period 3: LEN

```
firm 3:  I decided to always activate the chat in order to signal that I
         am not interested in whistle-blowing the agreement
firm 3:  :-)
firm 1:  Yes true, this is in deed a good idea
firm 3:  :-)
```

This finding supports the intuition that firms were able to develop strategies in *RD* to stabilize/increase collusion by using the chat-activation option. We find evidence that firms interpret chat activation as trust and they actively become ringleaders to strengthen trust:

Market 25, period 3: RD

```
firm 2:  firm 1, you never activate chat, I hope you will not report us.
         However, this will not give you an advantage.
firm 3:  If firm 1 would additionally activate the chat, then the trust
         would be strengthened
firm 1:  Has worked out very well in former periods.  Hopefully the
         success will maturate very soon.  However, from now on I will
         also take part.
```

This illustrates that firms in the beginning of *RD* are undecided regarding the chat activation. However, successful cartel establishment and chat communications in subsequent periods also encourage them to become ringleaders.

5.5 Discussion

Do discriminatory leniency policies disrupt cartel formation? Our results suggest an answer in the negative. A non-discriminatory leniency policy more successfully prevents the formation of a cartel than a discriminatory leniency program that denies ringleaders the right to file for leniency. While the possibility to report the cartel within a leniency program may deter the formation of a cartel, the exclusion of ringleaders from leniency programs has a converse effect. A leniency policy that discriminates against ringleaders not only facilitates the formation of cartels but also induces firms not to report the cartel to an antitrust authority. The majority of the subjects renounce their right to blow the whistle by becoming ringleaders. This induces other subjects not to report the cartel and in some cases to become ringleaders as well. We thus provide an explanation to the formulated research question indicating how the coordination challenge induced by the discriminatory leniency policy may be overcome.

Our experiment is conducted in a simplified setting with four symmetric firms which may not encompass the full complexity of a cartel formation process. Furthermore the entire scope of the ringleaders' responsibilities reported in Davies and De (2013) cannot be covered in one experiment so that more evidence on the effect of ringleader discrimination is unmistakably needed. Yet, we provide important evidence on the emergence of multiple ringleaders in cartels, a phenomenon that has been widely neglected by the economic literature. Paradoxically, the emergence of multiple ringleaders is most recurrently observed when there is a discriminatory leniency policy that denies amnesty to ringleaders. Our experiment therefore provides a direct connection between the emergence of multiple ringleaders and a discriminatory leniency policy.

So far, the economic literature has revealed a possible mixed picture of the effect

of ringleader discrimination on leniency. On the one hand it deters firms from becoming ringleaders as it implies a renunciation of the leniency option. On the other hand it signals commitment to the cartel by the ringleader and may therefore serve as a positive signaling device. Our results contribute to the literature as we find support for a stabilizing effect of ringleader discrimination on cartel formation. We not only observe more cartels in the ringleader treatment but also find that cartels are rarely reported. This stabilizing effect may be attributed to the decision to become a ringleader which implies the renunciation of blowing the whistle. The increasing number of ringleaders in our discriminatory treatment hints at a possible trust-facilitating effect of the ringleader discrimination policy as the risk of being reported decreases with an increase in ringleaders. While the reforms of the E.U. leniency policies in 2002 and 2006 limited ringleader exclusion to those firms that took steps to coerce other firms to join the cartel, the emergence of multiple ringleaders is still possible under E.U. law. Our results would thus speak in favor of the Canadian and U.S. American approach which identifies a single firm as the only possible ringleader. Yet, renouncing ringleader discrimination per se most effectively prevents firms from turning the policy against the antitrust authority and make leniency policies more effective in deteriorating cartel formation.

Appendix

Experimental Instructions

General Information

Welcome to this decision experiment. Please read the instructions carefully. You will find a questionnaire at the end of these instructions in order to double check if you understand the instructions. Please answer those questions. When you answered them correctly, the experiment will start. During the experiment you can earn chips depending on your and the decisions of the other participants. At the end of the experiment, the gained chips are exchanged at a rate of

100 Taler = 1 €

and paid out to you. In order to do so, please wait in your booth until you are called forward to collect your earnings. Please bring all documents, which were given to you, to the payout after the experiment.

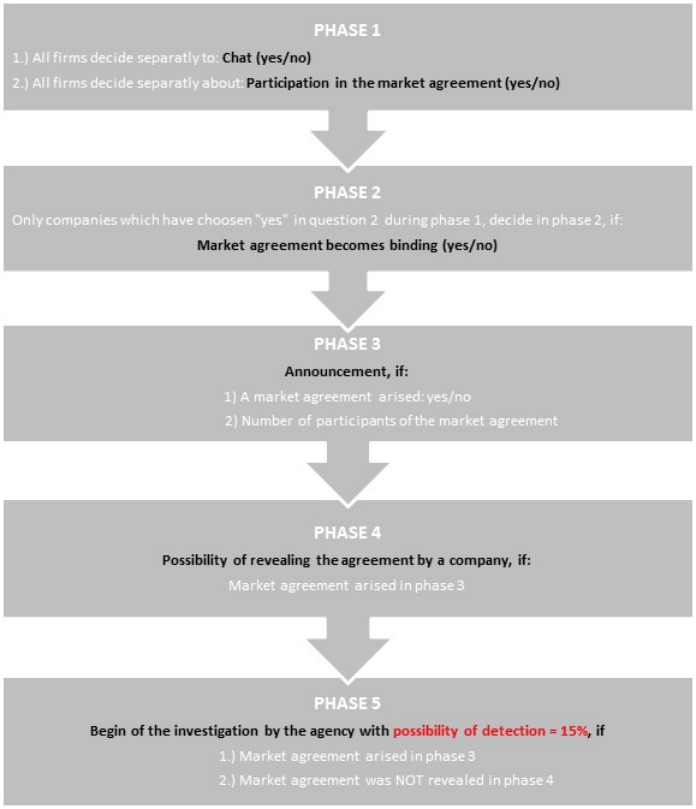
Please note that from now on and during the entire experiment, you must not talk to any other participant. We are forced to call of the experiment, should it happen. If there are any questions, please raise your hand and we will come to you to answer your question.

The experiment consists out of **16 rounds**. In these rounds you take up the role of a company on a market together with three other companies played by the other participants. This market totally consists of these four companies. The constitution of these markets is set at the beginning of the experiment. During the experiment the constitution of the market will not change. Hence you are acting in a four-company market every round, which consists of exactly the same companies. Moreover in every market there exists an agency which is represented by the computer. During the experiment you will not be able to gain information about the identity of the other companies. This is also the case after the experiment. The other participants are unable to gain any personal information about

you, too. Thus all interactions during the experiment are anonymous. We do not record any data linked to your name.

Detailed Information on the Experiment

The experiment consists of 16 rounds. All rounds are identical and are divided into five phases (look chart):
In each round you can achieve earnings ("round earnings"), which depend on the implemented actions. Your round earnings depend on the total number of participants (non-participants) of the market agreement. Moreover, your earnings depend on the detection or non-detection of the agreement by the agency. In order to get a more detailed explanation how the round earnings are composed in the single cases, please take a look at the below-mentioned tables.



The table shows the earnings which arise from the formation of a market agreement. It illustrates all possible combinations of the several participants and non-participants.

Thereby it shows which payoff opportunities arise for the participants and the nonparticipants of the market agreement depending on these combinations. Furthermore, the table inidactes (in brackets) which amount of the payoff is subtracted, if the market agreement is revealed or detected. The probability of detection amounts to 15%. Example: Suppose, **only** you and one other company participates in the market agreement. Thus, there are two participants and two non-participants. This situation is described in row 3. If furthermore - after the end of the second phase - the market agreement is achieved and it is neither detected nor revealed, you gain 50 Taler, the same amount as the other participants. The non-participants will both earn 100 Taler. If the agreement is detected by the agency in phase 5, you will get a discount of 35 Taler and hence a payoff of 15 Taler. The payoff of the non-participants remains constant with 100 Taler.

Possible combinations and resulting payoffs

Composition		**Firms' Payoffs**	
# Insiders	# Outsiders	Insider	Outsider
0	4	na (na)	64
1	3	64 (na)	64
2	2	50 (-35)	100
3	1	59 (-34)	178
4	0	100 (-40)	na

Phase 1

1.) In the first round you and all other companies in phase 1 can decide to activate a chat-window. The chat-window is activated for all companies in the market if at least one company decides to activate the chat-window. Thus, it might be the case that several companies decide simultaneously to open the chat-window. Before the chat-window starts all firms are informed about the decisions of the other firms, to activate the chat or not.

If the companies want to communicate in the chat, the text can be tipped into the bottom bar. After 60 seconds the chat window closes automatically. If none of the participants decides to activate the chat window, no chat will take place and thus the chat-phase ends.
2.) Now you can decide whether you intend to participate in a market agreement. Once each participant has made his decision the next phase starts.

Phase 2

In this phase you will get information about the total number of companies in your market, which intend to participate in a market agreement.
In phase 2 two possibilities exist:
Either:
1.) In the first phase you affirmed your potential willingness to participate the market agreement. Hence, you now must decide if you really want to commit to the market agreement in phase 3. First of all, you get information about the total number of potential participants and definite non-participants and about possible earnings. Now you have to decide if you still want to participate in the market agreement; thereby the following holds: ONLY if all the companies of your market, which announced in phase 1 their willingness to participate in a market agreement, confirm this again (click "yes"), the commitment becomes binding. If even one of these companies does not confirm (click "no"), this commitment is not binding anymore: If the commitment becomes binding, then all companies which committed to implement the market agreement in phase 3 automatically stick to the agreement. If the commitment becomes non-binding all 4 firms of the market automatically behave as non-participants of the market agreement and get 64 Taler. Phase 2 ends, once you have announced whether to commit or not.
OR:
2.) You announced in the first phase that you do not want to participate in a market agreement. In this case you don‘t make a decision in phase 2. You will only be given information about how many companies intend to commit and how many companies definitively won‘t participate.

Phase 3

In this phase you will find out if the market agreement became binding, as well as the total number of companies which decided to finally commit to the market agreement.

Phase 4

This phase only starts if the market agreement becomes binding. A sequence of all participating firms is determined, which indicates in which order firms can announce the market agreement. The first company of this sequence can decide whether it wants to inform the agency about the market agreement or not. **A company which has activated the chat in phase 1 has not the opportunity to reveal the market agreement**. If the first firm in the sequence reveals the market agreement no amount is subtracted from its payoff.

In this case phase 5 is skipped and all other firms are subjected to a substraction of the terms in brackets from their payoffs.

If the market agreement is not revealed by the first company, the second company in the sequence can decide whether it reveals the market agreement. This will be continued as long as one firm reveals the market agreement or the sequence ends and no information was revealed. If none of the firms reveals the market agreement it stays undetected in this phase.

Phase 5

This phase only starts if a market agreement becomes binding and is not revealed. In this phase the agency starts its investigation. The market agreement is detected with a probability of 15%. If the **market agreement is not detected** all firms get the payoffs which are stated in the table. If the **market agreement is detected** the amount in the brackets is subtracted. Afterwards the game ends.

Check-up questionnaire

We kindly ask you to answer the following questions. The questions are only designed to check if you understand the instructions correctly. All questions are based on random examples. For simplicity, we sign the four group member with the letters “A”, “B”, “C” and “D”. If there are any questions, please raise your hand. Check-up questions 1/2

a) Assume you are company A.

- Company D, B and C decide to activate the chat window for everyone. Assume you decide to activate the chat window for everyone, will the chat window be activated for all companies? (yes/no)?
- Assume no firm decides to activate the chat window for everyone. Will the chat window be activated for all companies? (yes/no)?
- Assume only you decide to activate the chat windows for everyone. Will the chat window be activated for all companies? (yes/ no)?

b) Assume that in phase 1 you announce, that you do not participate in the market agreement. Furthermore the companies B, C and D announce, that they intend to participate in a market agreement.

- Which firms are allowed to decide in phase 2 whether to finally commit to adhere to the market agreement?
- Assume the market agreement is conducted, which earnings would be made if the market agreement would neither be reported in phase 4 nor be detected in phase 5:
  You
  Company B
  Company C
  Company D
- Assume the market agreement will not be implemented, which earnings would result for:

You

Company B

Company C

Company D

c) In phase 2 only one of the potential members (who decided in phase 1 to participate in the market agreement) wants to definitely commit to adhere to the market agreement.
-Will the market agreement be implemented (yes/no)?
d) Assume now that phase 3 begins and the computer assesses the final participants and non-participant of a potential market agreement.

- Who is finally assessed as non-participant?
- Who is finally assessed as participant?
- Which earnings result from this in phase 3 for:

  You

  Company B

  Company C

  Company D

Check-up questions 2/2
a) Assume you are company A. Company D and C decide to activate the chat window for all. You and company B decide not to do so.
-Will the chat window be activated for all firms? (yes/no)?
b) Assume that in phase 1 you announce that you decide to participate in the market agreement. Furthermore, company B, C and D announce that they intend to participate in the market agreement as well.
-Which firms are allowed to decide in phase 2 whether to finally commit to adhere to the market agreement?

-Assume the market agreement is implemented, which firms participate in the market agreement?

Company A

Company B

Company C

Company D

-Assume the market agreement is not implemented, which earnings would result from this in phase 3 for: You

Company B

Company C

Company D

c) In phase 2 all members (who decided in phase 1 to participate in the market agreement) want to finally commit to adhere to the market agreement. -Will the market agreement be implemented? (yes/no)? d) Assume now that phase 3 begins and the computer assesses the final participants and non-participant of a potential market agreement. -Who is finally assessed as non-participant?

-Who is finally assessed as participant?

e) Assume now that in phase 4 a sequence is determined, which states in which order the companies can reveal the market agreement. Which firms will be excluded from this sequence? Company A

Company B

Company C

Company D

f) Assume company B is the first company in the sequence. Company B decides to reveal the market agreement to the agency -How much does company B get?

-Does phase 5 take place? (yes/no)?

-What do you, company C and D get?

You:

Company C:

Company D:

g) Assume now that company B decides not to reveal the market agreement to the agency

-Which company has now the choice to reveal the market agreement?

-What do you, company B, C and D get if this company reveals the market agreement?

You:

Company C:

Company D:

h) Assume now that you and company B decided not to reveal the market agreement in phase 4. Now, phase 5 starts in which the market agreement can be detected by the agency.

-What do all firms get if the agency detects the market agreement? You

Company B

Company C

Company D

-What do all firms get if the agency does not detect the market agreement? You

Company B

Company C

Company D

How high is the detection probability?

References

[1] Ai, C., Norton, E.C., 2003. Interaction terms in logit and probit models. Economics Letters, 80, 123-129.

[2] Andersson, O., Wengström, E., 2007. Do antitrust laws facilitate collusion: experimental evidence on costly communication in duopolies. The Scandinavian Journal of Economics, 109, 321-339.

[3] Armstrong, M., and Huck, S. 2010. Behavioral economics as applied to firms: a primer. CESifo Working Paper 2937.

[4] Aubert, C., Rey, P., and Kovacic, W., 2006. The impact of leniency and whistleblowing programs on cartels. International Journal of Industrial Organization, 24, 1241-1266.

[5] Apesteguia, J., Dufwenberg, M., Selten, R., 2007. Blowing the whistle. Economic Theory, 31, 143-166.

[6] Bigoni, M., Fridolffson, S.-O., le Coq, C. Spagnolo G., 2012. Fines, leniency and rewards in antitrust: An Experiment. Forthcoming in RAND Journal of Economics.

[7] Bohnet, I., Zeckhauser, R., 2004. Trust, risk and betrayal. Journal of Economic Behavior & Organization, 55, 467-484.

[8] Bos, I., Wandschneider, F., 2011. Cartel ringleaders and the corporate leniency program. Working Paper, Center for Competition Policy, 11-13.

[9] Bos, I., Wandschneider, F., 2013. A note on cartel ringleaders and the corporate

leniency programme. Applied Economics Letters, 20, 1100-1103.

[10] Brenner, S., 2009. An empirical study of the European corporate leniency program. International Journal of Industrial Organization, 27, 639-645.

[11] Clemens, G., Rau., H.A., 2013. Rebels without a clue? Experimental evidence on partial cartels. Working Paper.

[12] Cooper, D., and Kühn, K. U., 2009. Communication, renegotiation, and the scope for collusion. Working Paper.

[13] Davies, S., De, O., 2013. Ringleaders in larger number asymmetric cartels. Forthcoming in Economic Journal.

[14] Dufwenberg, M., and Gneezy, U., 2000. Price competition and market concentration: an experimental study. International Journal of Industrial Organization, 18, 7-22.

[15] Fischbacher, U. (2007). z-Tree: Zurich Toolbox for Readymade Economic Experiments - Experimenter's Manual. Experimental Economics, 10, 171-178.

[16] Fonseca, M., Normann, H.-T., 2012. Explicit vs. Tacit Collusion - The Impact of Communication in Oligopoly Experiments. European Economic Review, 58, 1759-1772.

[17] Greiner, B., 2004. An online recruitment system for economic experiments. In: Kremer, K., Macho, V. (Eds.), Forschung und wissenschaftliches Rechnen. 2003, GWDG Bericht 63. Ges. für Wiss. Datenverarbeitung, Göttingen, 79-93.

[18] Herre, J., Mimra, W., and Rasch, A., 2012. Excluding Ringleaders from Leniency Programs. Working Paper.

[19] Hesch, M. 2012. The Effects of Ringleader Discrimination on Cartel Deterrence and Stability - Experimental Insights. Journal of Advanced Research in Law and Economics, 3, 5-58.

[20] Hinloopen, J., Soetevent, A.R. 2008. Laboratory evidence on the effectiveness of corporate leniency programs. RAND Journal of Economics 39, 607-616.

[21] Kimbrough, E.O., Smith, V.L., Wilson, B.J., 2008. Historical Property Rights, Sociality, and the Emergence of Impersonal Exchange in Long-Distance Trade. American Economic Review, 98, 1009-39.

[22] Kosfeld, M., Okada, A., Riedl, A., 2009. Institution formation in public goods games. American Economic Review, 99, 1335-1355.

[23] Leslie, C.R. 2006. Antitrust amnesty, game theory, and cartel stability, Journal of Corporation Law, 31, 453-488.

[24] Levenstein, M.C., Suslow, V., 2006. What determines cartel success? Journal of Economic Literature, 44, 43-95.

[25] McCutcheon, B., 1997. Do meetings in smoke-filled rooms facilitate collusion? Journal of Political Economy, 105, 330-350.

[26] Miller, N.H., 2009. Strategic leniency and cartel enforcement. American Economic Review, 99, 750-768.

[27] Motta, M., Polo, M., 2003. Leniency policy and cartel prosecution. International Journal of Industrial Organization, 21, 347-379.

[28] Okada, A., 1993. The possibility of cooperation in an n-person prisoners' dilemma with institutional arrangements. Public Choice, 77, 629-656.

[29] Selten, R., 1973. A simple Model of imperfect competition, where 4 are few and 6 are many. International Journal of Game Theory, 2, 141-201.

[30] Spagnolo, G., 2004. Divide et Impera: Optimal leniency programmes. Center for economic policy research discussion paper 4840.

[31] Wandschneider, F., 2012: Ringleader Exclusion from Leniency Programmes-An Experimental Analysis. Working Paper.

Chapter 6

Conclusion

In the following chapter the main findings and further research directions will be discussed.

The first part of this thesis is composed of two chapters which analyze the strategic motivation of firms' competitive and anticompetitive behavior. Chapter 2, entitled **"General purpose products in a spatial price discrimination model"** infers investment strategies of competing firms in a general purpose product. As opposed to the mill-pricing case introduced by von Ungern-Sternberg (1988) it is shown that firms choose the socially optimal degree of "general purposeness" if endogenized through a fix-cost investment in a spatial price discrimination model.

The results suggest that perfect price discrimination may have a welfare enhancing effect. Firms do not wastefully invest in an excessive general purpose degree of the respective product as in the mill-pricing case. This stems from the fact that in the spatial price discrimination case, firms maximize welfare in order to reap it off through discriminatory prices.

Chapter 3, entitled **"The Limits of Antitrust in the Assessment of Competitor Collaborations"**, introduces a horizontal competitor collaboration as in Ghosh and Morita (2012) between two firms in a three-firm oligopoly with spatial price discrimination. It is shown that all firms may increase their profit with collaboration at the expense of the consumer. This result stems from the effect of the competitor collaboration which induces an

increase(decrease) in substitutability of the colaborators's(non-collaborators's) products. Yet, this strategy does not constitute anti-competitive conduct in the classical sense as it neither consists in a curtailment of quantities nor in a collusive price agreement. Furthermore it can be shown that collaboration does not have a stabilizing effect on a possible collusive agreement exempting it from any antitrust prosecution. We thus outline the limits of antitrust in the assessment of competitor collaborations as it does not tackle possible welfare detrimental effects of product characteristics which may harm consumers.

In the second part, the thesis focuses on the behavioral aspect of anti-competitive conduct of firms.

Chapter 4, entitled **"Rebels without a Clue?-Experimental Evidence on Partial Cartels"**, analyzes the coordination challenge in the formation of partial cartels where every firm would be better if it was outside and not inside the cartel. If a firm free-rides on a partial cartel by becoming an outside firm, potential cartel members may ultimately revoke the cartel implementation in order to prevent excessive profits for the former. Our results suggest that all-inclusive cartels without profit asymmetries are always implemented, while partial cartels with asymmetries are frequently rejected. The outside firm's initial refusal to join the cartel therefore may prevent its emergence in spite of its predicted stability. Relative profits may thus matter in the formation of partial cartels.

Chapter 5, entitled **"The Disruptive Effect of Ringleader Discrimination on Cartel Formation-Experimental Evidence"** analyzes how a leniency policy that discriminates cartel ringleaders, i.e. firms that either instigated the cartel or coerced other firms to participate in it, may disrupt cartel formation. The results show that a discriminatory policy can be used by the cartel members to inject trust in the cartel formation process. Since ringleaders cannot apply for amnesty within a leniency program, colluding firms signal their commitment to the cartel by deliberately becoming a ringleader. Ultimately the presence of a ringleader not only facilitates cartel formation but also increases the number of ringleaders in a cartel and reduces the number of leniency applications. Hence non-discriminatory leniency policy may be more adequate in the fight against hard-core cartels.

References

[1] Armstrong, M., Huck, S., 2010. Behavioral economics as applied to firms: A primer. CESifo Working Paper.

[2] d'Aspremont, C., Jacquemin A., 1988. Cooperative and noncooperative R & D in duopoly with spillovers. American Economic Review 78, 1133-1137.

[3] Kamien, M.I., Muller, E., Zang. I., 1992. Research joint venture and R&D cartels. American Economic Review 82, 1293-1306.

[4] Katz, M.L., 1986. An analysis of cooperative research and development. RAND Journal of Economics 17, 527-543.

[5] Huck, S., Konrad, K.A., Müller, W. Normann, H.-T., 2007. The merger paradox and why aspiration levels let it fail in the laboratory, Economic Journal 117, 1073-1095.

[6] Huck, S., Müller, W., Normann, H.-T., 2001. Stackelberg beats Cournot - On collusion and efficiency in experimental markets. Economic Journal 111, 749-765.

Ich erkläre hiermit an Eides Statt, dass ich die vorliegende Arbeit ohne Hilfe Dritter und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe; die aus fremden Quellen direkt oder indirekt übernommenen Gedanken sind als solche kenntlich gemacht.

Die Arbeit wurde bisher in gleicher oder ähnlicher Form keiner anderen Prüfungsbehörde vorgelegt und auch noch nicht veröffentlicht.

Düsseldorf, 25.10.2013

Georg Clemens