Cartel Formation and Pricing:
The Effect of Managerial Decision Making Rules

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Abstract

We experimentally investigate how the managerial decision making process affects choices in a Bertrand pricing game with an opportunity to form non-binding cartels. To do so we compare the effects of three decision-making rules for the firm (decisions by CEOs, majority rule and consensus) to each other and to decisions in a benchmark consisting of single-individual firms. It has been argued elsewhere that groups behave more competitively than individuals. In this setting this predicts that for all three decision-making rules we should observe fewer cartels and lower prices. This is not what we find. For the formation of cartels, there are no differences across treatments. For prices asked, we find that first, cartels lead to higher prices in al treatments, despite the fact that they are non-binding. Second, the decision-making rules strongly affect the prices asked. One thing that stands out is that firms run by CEOs ask higher prices than observed in the other treatments.

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1. Introduction

To what extent is the formation and the stability of cartels affected by the managerial decision making process within the participating firms? Whereas the experimental literature has focused on the effects of institutional factors and costs, the role of the firms' hierarchal structure has not been considered.[1] On the contrary, following the tradition in economic theory, in industrial organization (IO) experiments the firm is usually represented by a single individual making all decisions. In this paper, we break with this tradition and focus on how the decision to join a cartel as well as the subsequent pricing decision are affected by the way in which a firm makes its decisions.

This is important, because the management of firms outside of the laboratory typically consists of more than one person. Often, an executive board is responsible −or at least consulted− in the decision making process. In addition, the outcome of the decision usually affects not just one individual but the whole company. One can therefore not simply assume that findings for individual participants in an experiment automatically hold for group decision contexts. Moreover, when decisions are made by groups, the procedure by which they decide may have an important impact on the decision (Bornstein et al. 2004; Gillet et al. 2009). We will therefore not only distinguish between decisions made by individuals and by groups but in the latter case also consider distinct group decision making rules.

There is in fact quite some evidence pointing at differences between individual and group decision-making (see for instance, Kerr et al 1996 and Kerr & Tindale 2004 for reviews of the psychology literature). One important finding −especially in an IO context− is that groups are more competitive than individuals. This finding, dubbed the Discontinuity Effect, has mainly been advanced in research by Chester Insko, John Schopler and their various co-authors (eg. Schopler & Insko 1992; see Insko et al. 1998 for an overview of this research). The authors repeatedly show that groups choose competitive options (in a prisoners' dilemma environment) more often than individuals do. Their explanation is twofold. Firstly, they argue that groups are less trusted than individuals. When someone interacts with a group, so-called

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[1]Examples of recent experimental studies on the formation of cartels are Apesteguia et al. (2007) and Hinloopen & Soetevent (2008) who study the effects of leniency programs and Andersson & Wengström 2007, who study the effects of varying the cost of communication.

'negative outgroup schemas' are activated, causing distrust and fear about the expected competitiveness of the other group. Expecting the opponent to be competitive makes it less advantageous for the decision-maker to act cooperatively. Additionally, these authors argue that groups are more selfish than individuals in situations where they expect cooperation by the others. They contend that greedy decisions exploiting others violate norms and principles regarding equity and reciprocity and that making counter-normative decisions is easier in the context of a group than individually.

Experimental studies in economics confirm the notion that groups are more competitive (i.e., less cooperative) than individuals. Groups have been shown to behave less cooperatively in the ultimatum game (Bornstein & Yaniv 1998; Robert & Carnevale 1997) and the trust game (Song 2008; Kugler et al. 2007), for example. Using a common pool environment, Gillet et al (2009) support this finding of higher competitiveness amongst groups.

Given its importance, it is surprising how little attention has been given to the role of group decision making in the experimental IO literature. There are a few noteworthy exceptions, however. These typically use majority rule as the structure by which decisions are made. The results vary. On the one hand, groups in a Bertrand pricing game converge more slowly to the competitive equilibrium than individuals do (Bornstein and Gneezy 2002).[2] In addition, groups more easily fall prey to the winner's curse in common value auctions than individuals do (Cox and Hayne 2006; Sutter et al. 2008). On the other hand, groups behave significantly more strategically than individuals do in a signaling game (Cooper & Kagel 2005). Hence, the jury is still out on the difference between groups and individuals in an IO context.

Moreover, the extent of the competitiveness of groups also depends on the mechanism used to reach a group decision (Bornstein *et al*. 2004). First, it could matter whether a group decision is reached when a majority of group members agrees on a particular choice or that all members have effective veto power.[3] Second, we

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[2] These authors focus on how the procedure by which the firm's earnings are divided across the group affects the results. In a sense, their experiment is not really about group decision making because the aggregate price decision is simply the sum of the members' prices, implying that competition may even play a role within the group. Also, note that Bornstein and Gneezy do not study cartel formation in their Bertrand game.
[3] Two studies cast some doubt on whether this difference affects group decisions, however. Blinder & Morgan (2005) find that majority and consensus groups behave practically indistinguishable in their monetary policy experiment. In the Gillet et al. (2009) common pool environment, the higher competitiveness by groups holds both when decisions are made by consensus and when they are

need to consider another way in which groups make decisions. In the case of firm decision making, decisions are often made by a single individual, the CEO. This is still different than individual decision making because the CEO will typically discuss issues with board members before making a decision. Moreover, her decisions affect others in the group as much as they affect her. We therefore include in our experiment treatments where a single individual makes the decision for the whole group, after consultation.

The remainder of this paper is organized as follows. Section 2 describes our experimental design and procedures. This is followed by a formulation of our research hypotheses in section 3. Section 4 present and analyzes our results and section 5 contains concluding remarks.

2. Experimental Design and Procedures

186 subjects participated in the experiment at the CREED Laboratory of the University of Amsterdam. Including a €5 show-up fee, subjects earned on average €15.30 in sessions that lasted between 45 and 90 minutes. Subjects were randomly assigned to one of the four treatments to be described below. Earnings in the experiment are in 'points'. Each participant starts with an endowment of 6 points and may earn more (or lose some) across 10 rounds of play. At the end of the experiment the aggregate number of points earned is exchanged for euro's at a fixed exchange rate.[4] All of the following procedures are common knowledge and explained in the computerized instructions. A translation of the instructions is included in the Appendix.

The environment in which we study cartel formation is a Bertrand Pricing Game (Hinloopen & Soetevent, 2008). Participants play the role of a producer, with three producers per market. A producer is either represented by a single participant or by a group of three participants working together. For ease of presentation we will refer to these producers –be they individuals or groups– as *firms* even though we did

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subject to majority rule. In the former case, higher competitiveness is only observed after repetition of the game, however.

[4] The exchange rate varies across treatments; points are worth three times as much when participants make decisions in groups of three (to wit, €1.50 per point) than when they do so individually (50 cents per point). Since group earnings are divided equally by group members, earnings at the participant level are comparable across all sessions.

not use this term in the instructions or in the user interface of the experiment. As usual in economics experiments, the game was purposely explained in neutral terms.

In each of the ten decision rounds of the experiment, each firm can produce one unit of a good at marginal costs equal to 90. The firms simultaneously choose a price $p^f \in \{91, 92,\ldots, 102\}$. The firm choosing the lowest price *sells* its good on the market and earns $p^f - 90$. The other firms produce and earn nothing. If two or more firms choose the same lowest price the earnings are divided equally between them.

Firms can form a non-binding cartel, which is simply a mutual promise amongst the three firms in a market to choose the highest price, 102. If and only if all three firms in the market choose to enter a price-agreement, a cartel is formed. If a cartel exists in a round, firms are shown –before deciding on a price– an announcement stating that there is an agreement to choose the highest price. If there is no cartel, a similar message says there is no agreement.

In each round there is a probability of 15% that a cartel will be discovered by the 'authorities'.[5] The probability of being discovered is independent across rounds and firms. Cartel discovery is determined randomly after the firms have chosen a price and sold their good. Whenever a cartel is discovered, any firm that sold their good in that round pays a fine of $0.12*p^f$. Hence, if a cartel is discovered the firm choosing the lowest price earns (or loses) $0.88*p^f - 90$. Firms without sales pay no fine. If two or more firms choose the lowest price the fine is also divided equally.

If a cartel exists in a particular round and is not discovered, the firms are not asked to decide again whether or not to join a cartel. The existing cartel remains active in the next round and can still be discovered and fined. The firms are reminded of the existence of their promise to choose the highest price before making their price decision in the subsequent round.

In summary, firms make two decisions in each round: first, if applicable, whether or not to form a cartel and second, after learning whether or not a cartel exists, what price to charge for their good. Aside from the announcements regarding price agreements there is no communication between firms. Further information in the experiment is limited. For the decision about cartel formation participants are only told whether or not all three firms voted for a cartel; if a cartel is not formed, firms are not told who, or how many firms opposed it. As for pricing, after choosing a price

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[5] This percentage is based on Bryant & Echkhard's (1991) empirical estimation that in any given year somewhere between 13 and 17% of the existing cartels (in the U.S.) are discovered.

firms only learn: (i) the lowest price; (ii) whether they were the firm that chose the lowest price; and, if so, (iii) whether they were the only one choosing the lowest price. After the lowest price has been revealed, firms learn (if applicable) whether their cartel has been discovered or not. Only the firms who pay a fine know the size of their fine.

There are four treatments: a benchmark where firms are represented by individuals and three where each firm is a group of three participants. Participants in a session are randomly appointed to a market and (if applicable) group. For groups, we vary the group decision-making rule. The three treatments we distinguish between have the following characteristics in common. Each firm consists of three individual participants, deciding collectively what to do and sharing firm earnings equally. Hence, any market consists of nine participants divided into three firms of three. Before each decision a firm has to make (i.e., cartel formation and pricing), the three participants are allowed to communicate within their group via a chat application. Group-members can exchange messages for three minutes at each instance (except for the first round, where they had two chat-periods of five minutes). Subjects are free to chat about anything but are told to refrain from revealing their identity.[6] After the chat-period each group-member has to enter her or his choice. The three choices determine the group decision is a way that varies across treatments.

The group treatments vary by their group decision-making procedures. All groups in a particular market decide in the same way.

I.   In the *CEO* condition only the choice of one of the team-members matters. One group member is randomly appointed to be CEO for all rounds. All group members know who the CEO is (though they cannot identify her or him personally, of course). There is within-group communication before the decisions, however, and all players have to enter a choice, though in the end only the decision of the CEO matters.

II.   In the *Majority* treatment any decision needs to be supported by a majority (i.e. two or three members need to make the same choice). Note that there is always a majority either in favor or against a cartel. If no (majority) decision is reached with respect to the price, (i.e., each member chooses a different price) the members earn nothing in that round. Because a price is needed for the

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[6] As far as we can tell from the chat transcripts no identities were revealed.

market, one of the prices is selected randomly and entered. The other players in the market do not learn that this decision was not made by a majority.

III.   In *Consensus* each of the three members has veto power. The group decides to join the cartel only if all three members choose to do so and all three members need to choose the same price. If any member decides not to join the cartel, the firm's decision is not to join. If the group does not reach a consensus on the price, the members earn nothing in that round. One of the prices is selected randomly, without other participants being informed that this occurred.[7]

We have data from 24 participants in *Individual* (24 firms in 8 markets), 72 participants in *CEO* (24 firms, 8 markets), 54 participants in *Majority* (18 firms, 6 markets) and 36 participants in *Consensus* (12 firms, 4 markets).

3. Hypotheses

A first thing to notice is that the efficient outcome is for all firms to collude implicitly by choosing p^f=102, without forming a cartel. This maximizes surplus without the possibility of fines. In contrast, the risk neutral subgame perfect Nash equilibrium is to not enter a cartel and to choose the lowest possible price (p^f=91).[8] Though this does not predict any treatment effects, we can use the literature discussed in the introduction to derive hypotheses with respect to our individual benchmark and the three cases with group decision-making.

Based on the hypothesis that groups are trusted less than individuals we expect (1) groups to propose (and form) fewer cartels, since they are expected to be broken anyway and are costly to install (chance of a fine). In addition, the hypothesis that groups are more competitive than individuals is expected to lead to (2) groups choosing lower prices. We further expect (3) group effects to be larger for treatments with more difficult decision requirements as they will demand higher involvement with the group decision process. The idea is that since consensus demands the most of the group in terms of agreement it will cause a higher level of *group identity* and,

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[7] In the end, this mechanism of appointing group decisions was used only rarely; only in 2 (out of 180) cases in *Majority* and 3 (out of 120 decisions) in *Consensus* did groups not reach an agreement.

[8] A cartel will lead to a slightly higher equilibrium price, of p^f=92, but the expected revenue is lower because of possible fine. Without cartel, the expected revenue of choosing 91 (and expecting the same from others) is: (91 − 90)/3 = 0.333. With cartel the expected revenue of all choosing 92 is 0.85*(92 − 90)/3 + 0.15*(0.88*92 − 90)/3 = 0.115. Unilaterally choosing a lower price will yield an expected loss: 0.85*(91 − 90) + 0.15*(0,88*91 − 90) = −0.638. Finally, if all choose 91 with a cartel, expected earnings are 0.85*(91 − 90)/3+ 0.15*(0,88*91 − 90)/3 =−0.213 and a best response is to abstain from trading by asking a higher price.

consequently, larger group effects – fewer cartels, lower prices than individuals – and that because a group with a CEO requires the least input from its members the group effects for this condition will be the smallest, with the size of the effects for the groups deciding by majority somewhere in between.

In summary, denoting the number of cartels by *c*, we will test the following joint hypotheses on cartel formation. The null hypothesis is that there are no differences across treatments.

H_{10}: $c_{\text{individual}} = c_{\text{CEO}} = c_{\text{majority}} = c_{\text{consensus}}$

H_{11}: $c_{\text{individual}} > c_{\text{CEO}} > c_{\text{majority}} > c_{\text{consensus}}$

For pricing, the reasoning above predicts that we will observe lower prices in group treatments than in the benchmark. Moreover, prices should be lowest for the case where groups require consensus for making a decision. This reasoning should certainly hold for the markets in which no cartel has been formed.

H_{20}: $p_{\text{individual}}^{f,\ nocartel} = p_{\text{CEO}}^{f,\ nocartel} = p_{\text{majority}}^{f,\ nocartel} = p_{\text{consensus}}^{f,\ nocartel}$

H_{21}: $p_{\text{individual}}^{f,\ nocartel} > p_{\text{CEO}}^{f,\ nocartel} > p_{\text{majority}}^{f,\ nocartel} > p_{\text{consensus}}^{f,\ nocartel}$

For markets with cartels the prediction is less straightforward. The fact that a cartel has been formed is an indication of relatively low competitiveness, irrespective of whether the decision was made by an individual or a group. This yields the prediction that prices are higher when there are cartels, even if these are non-binding. This is formalized in H_3.

H_{30}: $p_{\text{individual}}^{f,\ cartel} = p_{\text{individual}}^{f,\ nocartel} ; p_{\text{CEO}}^{f,\ cartel} = p_{\text{CEO}}^{f,\ nocartel} ; p_{\text{majority}}^{f,\ cartel} = p_{\text{majority}}^{f,\ nocartel} ; p_{\text{consensus}}^{f,\ cartel} = p_{\text{consensus}}^{f,\ nocartel}$

H_{31}: $p_{\text{individual}}^{f,\ cartel} > p_{\text{individual}}^{f,\ nocartel} ; p_{\text{CEO}}^{f,\ cartel} > p_{\text{CEO}}^{f,\ nocartel} ; p_{\text{majority}}^{f,\ cartel} > p_{\text{majority}}^{f,\ nocartel} ; p_{\text{consensus}}^{f,\ cartel} > p_{\text{consensus}}^{f,\ nocartel}$

As for a comparison across treatments, in H_4 we maintain the hypothesis that groups will be more competitive than individuals even after forming cartels.

H_{40}: $p_{\text{individual}}^{f,\ cartel} = p_{\text{CEO}}^{f,\ cartel} = p_{\text{majority}}^{f,\ cartel} = p_{\text{consensus}}^{f,\ cartel}$

H_{41}: $p_{\text{individual}}^{f,\ cartel} > p_{\text{CEO}}^{f,\ cartel} > p_{\text{majority}}^{f,\ cartel} > p_{\text{consensus}}^{f,\ cartel}$

In the following section, we will formally test H1-H4 against their respective nulls.

4. Results

We first present a general overview of our experimental results in section 4.1. Rigorous statistical tests are provided when we more closely investigate the formation of cartels (4.2), their duration (4.3) and the firms' pricing decisions (4.4).

4.1 General Overview

Table 1 displays some key statistics per treatment. A first thing to note is that firms want to form cartels. This can only be measured in rounds when there was no pre-existing cartel. In these rounds most firms decided in favor if forming a cartel. Groups (especially those deciding by consensus or majority rule) are slightly less inclined to do so than individuals, however. In combination with the decision-making procedure this yields far fewer new cartels for the consensus case (17.7%) than for the other treatments. This is not particularly surprising because this decision requires much more coordination here than in the other group treatments; all nine participants need to be in favor in a particular round for the cartel to be formed. Once a cartel has been formed, it exists until it is discovered. In most treatments, this leads to cartels existing in approximately 80% of all markets. Only in the case where consensus is needed are there (far) fewer cartels (30%).

Of course, cartels may exist without the participating firms sticking to their promise to ask p^f=102. We define *defection* from a cartel as any choice p^f<102. The fifth row in table 1 shows that defection is observed in roughly two-thirds of all cartels, except when decisions are made by CEOs, who defect 46% of the time. Defection may be a response to earlier defection by other firms, however. We therefore also consider defection in newly formed cartels. Then, defection is much lower in three cases (20-36%). When firms decide by consensus, almost 78% of them defect in the first round of a cartel, however. Apparently, decision making by consensus makes it very difficult for cartels to be successful. Not only do such firms form far fewer cartels, when they do there is a very high rate of defection. In aggregate in this treatment, we observed only one market (out of 40) where the price was at its maximum level of 102.

Table 1: **Average results per treatment**

	Individuals (24 firms in 8 markets)	**Groups**			
		CEO (24 firms in 8 markets)	**Majority** (18 firms in 6 markets)	**Consensus** (12 firms in 4 markets)	**Pooled** (54 firms in 18 markets)
Firms in favor of cartel (%)[1]	73.8 (44.2)	71.4 (45.4)	65.2 (48.0)	64.7 (48.0)	67.1 (47.1)
Cartels agreed upon (%)[2]	46.4 (50.2)	42.9 (49.8)	43.5 (50.0)	17.7 (38.3)	32.9 (47.1)
Markets with cartel (%)[3]	81.3 (39.1)	80.0 (40.1)	78.3 (41.3)	30.0 (46.0)	68.3 (46.6)
Defecting firms (%)[4]	63.1 (48.4)	46.4 (50.0)	66.0 (47.6)	72.2 (45.4)	56.4 (50.0)
Defecting firms − new cartel (%)[5]	35.9 (48.6)	30.3 (46.7)	20.0 (40.7)	77.8 (42.8)	37.0 (48.6)
Asking price (cartel)[6]	6.95 (3.91)	8.41 (1.92)	6.90 (3.75)	7.28 (3.44)	7.72 (3.65)
Market price (cartel)[7]	5.14 (3.99)	6.91 (4.31)	4.91 (3.92)	5.00 (3.26)	5.96 (4.18)
Asking price (no cartel)[8]	1.44 (2.22)	2.21 (3.56)	1.49 (2.30)	1.26 (2.90)	1.59 (2.99)
Market price (no cartel)[9]	0.60 (0.96)	0.81 (1.44)	0.54 (0.76)	0.29 (0.84)	0.49 (1.05)
Earnings per participant[10]	15.84	17.94	14.32	11.04	15.20

Notes. Standard deviation is in parentheses.
[1]Percentage of firms proposing a cartel in markets without pre-existing cartel.
[2]Percentage of markets where cartel is formed when there is no pre-existing cartel.
[3]Percentage of markets with a cartel, including pre-existing cartels.
[4]Percentage of firms in cartel that chooses a price lower than 102.
[5]Percentage of firms in newly-formed cartel that chooses a price lower than 102.
[6]Average price (in excess of minimum price 91) asked by firms in cartels.
[7]Average price (in excess of minimum price 91) asked by firms not in cartels.
[8]Average market price (in excess of minimum price 91) in cartels.
[9]Average market price (in excess of minimum price 91) when there is no cartel.
[10]Average earnings in euros including €5 show-up fee.

The next four rows in table 1 display average prices, distinguishing between rounds with and without cartels and between the price asked by firms (p^f) and the market price ($\min\{p^f, f=1,2,3\}$). For ease of presentation we present prices in excess of the minimum of 91, i.e., numbers represent $p^f - 91 \in \{0,1, …, 11\}$. In the remainder of this paper, we will only refer to these 'net' prices. The following patterns can be observed. First, prices are 4-6 points higher with cartels than without. This is a strong indication that implicit collusion at high prices without cartels is not observed in our data. In fact, without cartels, average prices are close to the minimum of 0 (average market prices are all lower than 1 point). Second, average market prices are quite

close to the average prices asked by firms (the largest difference is just over 2 points), indicating that in most cases the lowest price in a market is close to the other prices. Third, in all cases, the highest prices are observed for the CEO treatment. CEOs in cartels ask on average 8.41 points, which is 76% of the maximum price. We will discuss these differences in more detail in section 4.4.

Finally, the last row of the table gives average earnings. These show that participants in CEO earn most. In line with the lower number and higher instability of cartels, participants in Consensus earn least. The differences in earnings are statistically significant (Mann-Whitney tests) between Consensus and CEO (p = .001) and Consensus and Majority (p = .043) and marginally so between CEO and Majority (p = .06).

4.2 Cartel Formation

For a more rigorous statistical analysis, we first investigate the firms' decisions to start a cartel. We use a random effects Probit regression to analyze this decision. Using the treatment with individuals representing firms as a benchmark, we define dummy variables representing the three group treatments and allow for a trend by including the round number as an independent variable. We also include a variable describing the number of cartels previously discovered (and fined) in the market concerned. Table 2 gives the results. These show no statistically significant differences between the group treatments and the individual benchmark. Differences between the group conditions are not statistically significant either. The joint hypothesis that the coefficients for the three group dummies are equal to zero cannot be rejected (χ^2-test, $p=0.93$).[9] We conclude that a firm's decision to join a cartel is not influenced by the decision-making procedures within the firm. Moreover this decision is not different for groups than for individuals. We cannot reject the null hypothesis H_{10} of no differences in favor of the alternative H_{11} presented in section 3. This can be considered to be good news for theorists and experimentalists who have been studying cartel formation under the assumption that firms are single agents.

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[9] Pair wise testing of the coefficients shows that equality cannot be rejected in any case, with all *p*-values > 0.47. Finally, pooling all group treatments into one dummy-variable in the probit regression gives a coefficient equal to −0.12 with *p*=0.66.

Table 2: Cartel Formation

		Coefficient	p-value
	Constant	1.438	0.00**
	Round	−0.060	0.23
	# Cartels Discovered	−0.598	0.07
	CEO	−0.048	0.90
Treatment	Majority	−0.013	0.97
	Consensus	−0.328	0.41

Notes. The table represents the estimated coefficients of a random effects probit model where the dependent variable is the firm's decision to join a cartel. Random effects are introduced at the level of markets. Independent variables are defined as follows. *Round*=round number {1,2,..,10}. *#Cartels Discovered*=number of cartels in the market concerned that were previously discovered. *CEO*=dummy variable equal to 1 if a CEO determines the firm's decision and 0, otherwise. *Majority*=dummy variable equal to 1 if firm's decisions are made by majority vote and 0, otherwise. *Consensus*=dummy variable equal to 1 if firm's decisions are made by consensus and 0, otherwise. Firms consisting of a single individual are used as a benchmark represented by the constant term.

4.3 Cartel Stability

To investigate the stability of cartels we first consider the defection rates as shown in the fifth and sixth rows of table 1. Across all rounds in which cartels exist, the differences across treatments are not statistically significant (Kruskal-Wallis, p=0.55).[10] The six pair wise comparisons also reveal no significant differences (Mann-Whitney tests, all p>0.15).

Things are different when considering defection in the first round of a cartel. In table 1, we saw that a high fraction (78%) of firms deciding by consensus renege on a promise immediately after making it. The difference across all treatments is statistically significant (Kruskal-Wallis, p=0.03). In pair wise comparisons, first round defection in Consensus is significantly higher than in the Individual benchmark (Mann-Whitney, p=0.02), CEO (Mann-Whitney, p=0.02), and Majority (Mann-Whitney, p<0.01). None of the other differences between treatment pairs is statistically significant (Mann-Whitney tests, all p>0.72). We conclude that there is strong statistical evidence in our data that decision-making by consensus causes severe cartel instability from the moment they are formed.

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[10] When testing means, we use the average of a market as the unit of observation because of statistical dependencies of observations within a market. This Kruskal-Wallis test we therefore based on 26 observations.

Figure 1: Ask Price Stability in Cartels
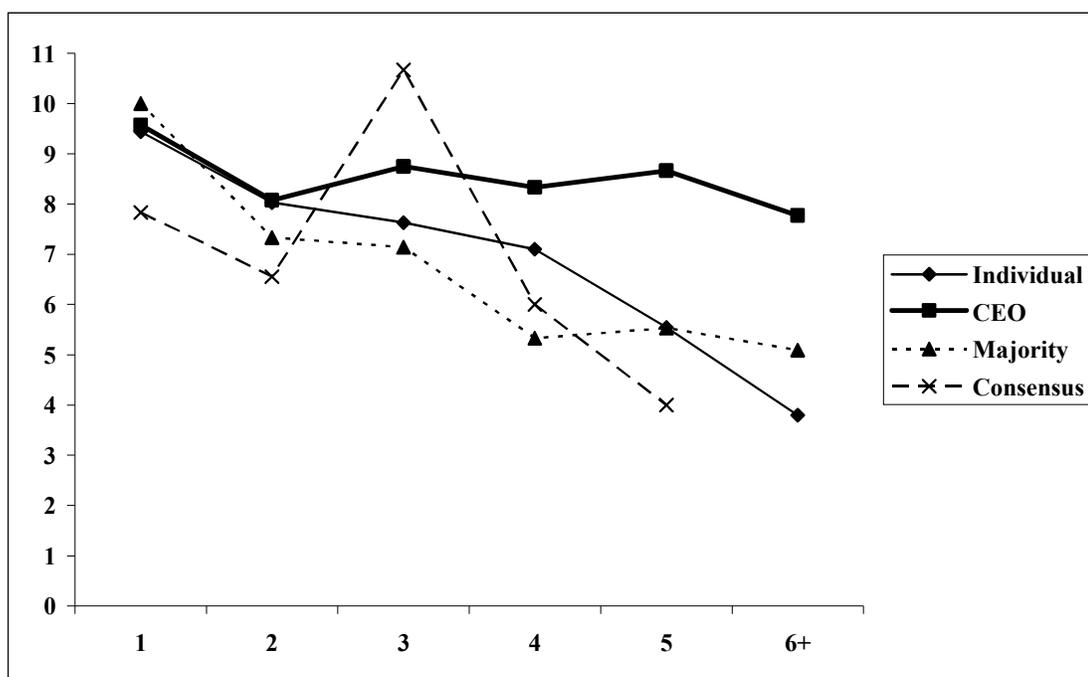
Notes. Lines represent average prices asked by firms as a function of the cartel age.

Of course, defection from the agreed upon maximum price (11) does not necessarily imply that prices in a cartel decline to zero. Table 1 shows that even in Consensus the average prices with cartels are much higher than without. We will discuss price differences across treatments in detail in the following subsection. Here we want to compare across treatments the prices firms ask in cartels as a function of the cartel age. Note that high prices that only slowly decline with the number of rounds a cartel has existed are an indication of cartel stability even if the maximum price is not maintained. Figure 1 displays the average asking price in cartels.

Three things stand out in the figure. First, in all treatments the average price starts off close to the maximum (11), and decreases steadily (in line with Cason 1995). Second, the only treatment that stands out in a new cartel (age equal to 1) is Consensus. This confirms our earlier observations. Third, CEOs manage to maintain higher prices in a cartel than other firms.[11] In some sense, this indicates higher cartel stability, even if the participating firms did not manage to maintain the promised maximum price. These results only provide partial information about ask price

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[11] The peak for Consensus for cartels of age 3 is due to the fact that it is based on only one observation, i.e., only one cartel managed to stay around for 3 rounds. In fact, this particular cartel was formed in round 6 and survived for the 5 rounds that remained.

differences across treatments; in the next section we will further investigate these differences.

4.4 Prices

To analyze the development of prices we use a random effects tobit regression explaining the firms' price decisions. Table 3 shows the results. First, note that prices tend to decrease across rounds and that cartels become unstable with age. The latter observation is in line with decreasing prices observed in figure 1. Moreover, when firms consist of individuals, cartels lead to strong increases in prices, as is apparent from the coefficient for *Individual* when there is a cartel. For various group treatments we test the effect of cartels on prices by comparing the coefficients with and without cartel. This shows that cartels always yield higher prices. Testing the differences in coefficients with χ^2 tests shows that the difference is statistically significant for firms run by CEOs ($p<0.01$), majority rule ($p<0.01$) and consensus ($p<0.01$). These results reject the null H_{30} of no differences in favor of the alternative H_{31} presented in section 3. Hence, in all treatments prices are higher when there is a cartel.

Simultaneously testing for differences in the treatment-coefficients (χ^2-tests) rejects the null hypothesis that they are equal, both for the case where there are cartels ($p=0.03$) and where there are not ($p<0.01$) Pair wise testing of the coefficients shows that when there is no cartel prices in the CEO treatment and majority are significantly higher than in the individual ($p<0.01$ and $p=0.01$, respectively) and consensus treatment ($p<0.01$ and $p=0.03$, respectively). The difference between CEO and majority treatment is not statistically significant ($p=0.30$). These results reject the null hypothesis H_{20} of no differences but not in favor of the alternative H_{21}. Though the ranking of the three decision making rules is precisely as predicted, H_{21} predicted that prices would be higher in the individual benchmark than in any of the group treatments. The opposite is observed.

Table 3: Ask Prices

		Coefficient	p-value
	Constant	0.46	0.72
	Round	−0.668	0.00**
	# Cartels discovered	0.835	0.21
Cartel	Cartel age	-0.525	0.00**
	Individual	13.68	0.00**
	CEO	15.62	0.00**
	Majority	12.48	0.00**
	Consensus	12.75	0.00**
No cartel	CEO	6.436	0.00**
	Majority	4.854	0.01**
	Consensus	1.386	0.43

Note. The table represents the estimated coefficients of a random effects tobit model where the dependent variable is the firm's ask price (truncated to lie between 0 and 11). Random effects are introduced at the level of markets. Independent variables are defined as follows. *Round*=round number {1,2,..,10}. *#Cartels Discovered*=number of cartels in the market concerned that were previously discovered. *Cartel age*=number of rounds a cartel has existed. *CEO*=dummy variable equal to 1 if a CEO determines the firm's decision and 0, otherwise. *Majority*=dummy variable equal to 1 if firm's decisions are made by majority vote and 0, otherwise. *Consensus*=dummy variable equal to 1 if firm's decisions are made by consensus and 0. Firms consisting of a single individual and making a decision without cartel are used as a benchmark represented by the constant term.

When there is a cartel, prices are highest in CEO; the difference with Majority is statistically significant ($p=0.01$) but the differences with Individual and Consensus are only marginally significant ($p=0.09$ and $p=0.06$ resp.). The differences between Individual, Majority and Consensus are not statistically significant. Though the relatively high prices in CEO were predicted in H_{41}, this alternative hypothesis as a whole is not supported. Once again, the relatively low prices in the individual benchmark are unexpected.

5. Conclusion

In this study we compare individual and group decisions in a Bertrand game with non-binding cartels. In groups, decisions were made either by a *CEO*, a *Majority* or by *Consensus*. Previous studies have suggested that groups may behave more competitively than individuals, which in this setting would lead to fewer cartels and lower prices. Our data do not support this reasoning. First, we find no differences across treatments in the tendency to form cartels. Second, if anything, prices are higher when decisions are made by groups. We do observe systematic price

differences in our data, however. First, in all of our treatments we find that prices are higher when there is a cartel than when there is not. Even though cartels are non-binding, irrespective of how decisions are made they appear to be used as a coordinating device to keep prices up (albeit not at their maximum). Moreover, we find some interesting differences in price setting behavior across treatments. When there is no cartel, prices are higher in the *CEO* and *Majority* treatment compared to the *Consensus* and *Individual* treatment. When there is a cartel *CEO* prices tend to be higher than when decisions are made by *Majority* with prices in the *Consensus* and *Individual* treatments somewhere in between. Hence, CEOs tend to set the highest prices irrespective of whether or not a cartel has been formed.

Apparently, it matters how a firm decides. For the discussion on the effects of group decision-making, this means that the focus needs to shift from the comparison between groups and individuals to the differences between distinct managerial decision-making processes. It may make a difference if the usual single-individual firm is replaced by a multiple-agent firm, but how it makes a difference depends on how the individuals in the firm make their decisions.

Cartels of firms lead by *CEO*s appear to be more stable than other cartels. This raises interesting research questions, both for field empirical studies and for further laboratory experiments. For example, one could observe in the field the decision making culture of firms and our results suggests that firms lead by strong independent leaders would be more likely to collude (and hence be more profitable) than firms with a consensus culture. Such field studies could be complex because of contaminating factors (e.g. a consensus culture is more likely to be found in specific countries like Scandinavia or the Netherlands) and because a consensus culture may have other advantages (better support in the organization) and disadvantages (e.g. slow decision processes) than those related to pricing behavior. We therefore also see an important role for more laboratory experiments where decision processes can be easily implemented and controlled and all behavior is observable.

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1/6 [7]

You are about to participate in an experiment on decision-making in a market. You will be able to earn money in this experiment. How much you earn depends on your decisions and on the decisions of the other participants in the experiment.

It is important that you thoroughly understand these instructions. We ask you to read them carefully. These instructions use numerical examples. These are for illustrative purposes only; they have no particular relevance regarding the experiment.

Today's instructions consist of 6 [7] pages followed by a few questions.

2/6 [7]
Introduction

> *(Individual)*
> In this experiment you and the two other players are each suppliers of a single identical good.

> (*all group treatments*)
> In this experiment you are part of a team of three players. Your team and the two other teams consisting of three players are each suppliers of a single identical good.

In each round you will have to choose a price to ask for your product. This asking price must be one of the following prices:

91 – 92 – 93 – 94 – 95 – 96 – 97 – 98 – 99 – 100 – 101 – 102

You will only earn points in a round if your asking price is the lowest of the three asking prices chosen in that round. If you do choose the lowest price, your earnings are equal to the difference between the asking price and the costs, which are 90:

asking price – 90

If you do not choose the lowest price in a round, you will do not earn anything (but you do not incur any costs either). If two or more suppliers choose the same lowest price the earnings will be shared equally. The next page gives a few numerical examples.

3/6 [7]
Numerical Examples
Let us call the suppliers in the market A, B and C.

• Imagine supplier A chooses a price of 92, supplier B chooses a price of 96 and supplier C a price of 97. Only the product with the lowest price will be sold, in this case the product supplied by A. The earnings of supplier A are equal to the price minus the cost: 92 – 90 = 2. The other two suppliers do not sell anything but do not incur any costs either and both earn 0.

• Now imagine that supplier A and supplier B choose a price of 93 and supplier C chooses a price of 101. Because two suppliers have chosen the lowest price, the profit will be shared. Suppliers A and B each earn half of the difference between the price and the cost (=½ x (93 – 90) = 1 ½). Supplier C does not earn nor lose anything.

4/6

Before they choose their price suppliers can agree to choose the highest price (=102). This agreement only becomes valid if all three suppliers favor it. The price agreement may be discovered by the authorities. In this case a fine of 12% of the asking price has to be paid. Only the players selling a product pay this fine. The probability that the price agreement will be discovered in any particular round is 15%. Every price agreement remains valid – and can be discovered and fined – as long as it has not been discovered in a previous round.

Suppliers are not required to adhere to the price agreement.

The following page again gives more numerical.

5/6 [7]
• Imagine that the three suppliers form a price agreement and that all three suppliers adhere to the agreement and the agreement is not discovered. Each supplier now earns the market price minus the costs, divided by the three suppliers, which is equal to $(102 – 90)/3 = 4$.

• Imagine that the three suppliers form a price agreement and that all three suppliers adhere to the agreement and the agreement is discovered. Each supplier now earns: (market price minus cost minus the fine) divided by three suppliers is equal to $(102 – 90 – 0.12*102)/3 = – 0.08$ (which means a loss)

• Imagine the three suppliers form a price agreement but supplier A does not adhere to the agreement and chooses a price of 98. The price agreement is discovered. Supplier A earns $(98 – 90) = 8$ but also pays a fine of $(0.12 \times 98) = 11.76$. The net loss of supplier A is: $8 – 11.76 = 3.76$. Suppliers B and C do not earn nor lose anything.

6/7 [*Not applied in Individual*]
Before each decision you can confer with the other members of your team. This takes place via a chat application. In the first round you can confer for 5 minutes per choice, for the rest of the experiment there will be 3 minutes available before each choice. After the group deliberation you will be asked to enter your choice.

(CEO)
In each team, the decisions whether or not to join the cartel and what price to choose are made by a team leader. This team leader is selected randomly and will be the same person throughout the experiment.

Only the team leaders' choice matters. If you are not a team leader you can still participate in the group deliberation but your choice is irrelevant for the outcome. For practical reasons you are asked to enter a choice anyway.

(Majority)
In each team, the decisions whether or not to join the cartel and what price to choose are made by majority vote. If two or more members of the team choose an option, this becomes the team's decision.

If when deciding on the price no option is chosen by at least 2 team members, the team will earn nothing in that round. Because the other teams need a price to continue, the computer will randomly choose one of the proposed prices.

(Consensus)
The decisions in this market are made by unanimity in all teams. Only if all members of a team choose a particular option, will this be the team decision.

If the choice to make a price agreement is not unanimously supported the computer will automatically choose not to participate in a price agreement.
If there is no unanimous choice of a price, the team will earn nothing in that round. Because the other teams need a price to continue, the computer will randomly choose one of the proposed prices.

No other communication than via the computer is allowed.
We kindly request that you keep your identity (name and/or computer number) secret while chatting.

6/6 [7/7]
The experiment will last for 10 rounds. The market consists of the same three suppliers throughout the experiment.

In summary, in principle each round consists of **two** decisions: first whether or not to join the price agreement and secondly what price to choose. If there was a price agreement in the previous round and this was not discovered the first decision will be skipped in the following round.

Your earnings in points will be exchanged for euros at the end of the experiment at a rate of 2 to 1. For each point you will therefore receive €0.50.