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Bargaining with confirmed proposals: an experimental analysis of tacit collusion in Cournot and Bertrand duopolies

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Abstract

In this paper, we investigate theoretically and experimentally the performances of a bargaining over strategies protocol with confirmed proposal, with either symmetric or asymmetric power of confirmation. We apply it both on a *Bertrand duopoly market*, in which competition is in prices, and on a *Cournot duopoly market*, in which players compete on the amount of output they will produce. We show that bargaining over strategies of price- or quantity-setting acts as a communication device in competitive environments, capable of increasing the level of collusion and of reducing the bargaining length. In particular, we report experimental evidence of an overall better performance of a Bertrand duopoly market in reaching an equitable, welfare-maximizing and Pareto-efficient agreement. However, competing in price rather than in quantity setting reduces the bargaining length only under an asymmetric proposal protocol, while under a symmetric proposal protocol price setting only has a second-order effect on reducing the bargaining length.
JEL codes: C72, C91.

Keywords: Bargaining, Tacit collusion, Experiments, Betrand duopoly, Cournot duopoly.

1 Introduction

Bargaining procedures are a major object of analysis of a very long-lived and prolific literature [we refer to Karagözoğlu and Hyndman, 2022, for a rich both theoretical and experimental overview of

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current bargaining research]. The main scope of this literature is to represent stylized situations of interaction between economic agents who want to reach an agreement on the distribution of wealth. Since Nash's definition of a mechanism [Nash, 1953][1] for the strategic implementation of his famous cooperative bargaining problem [Nash, 1950], bargaining has represented the most effective way to bridge the gap between non-cooperative and cooperative game theory, allowing the players to reach a (Pareto-efficient) cooperative solution through strategic interaction. Similarly, bargaining procedures may be implemented in the context of original strategic situations, such as the Prisoner's Dilemma or the Trust Game, in which the Nash equilibrium of the original game is not Pareto-efficient, while social optimality may be reached through some form of communication.

Bargaining over strategies represents a form of communication between strategic players, often sufficient to achieve a cooperative outcome. It is indeed a stylized model of usual practises in contract negotiation, when two parties develop a commitment rule fully describing the actions to be followed by both.

We consider bargaining over strategies in the form of two-player bargaining games with confirmed proposals. Games with confirmed proposals are interactive strategic situations in which at least one player, in order to give official acceptance of a contract, must confirm his/her proposal in combination to the proposal of his/her opponent. The most well-known two-player bargaining game with confirmed proposal is represented by the famous *bargaining over a pie* model by Rubinstein [1982]. In this model, players may reach a cooperative agreement on how to share a fixed-size pie through a sequential non-cooperative play and though an alternating proposal protocol. Similarly, Attanasi et al. [2015] propose a bargaining process super-game over the strategies to play in several common two-player games: the Prisoner's Dilemma, the Hawk-Dove Game, the Trust Game, and the Ultimatum Game. In each of these games, they show that, theoretically, the bargaining process gives rise at equilibrium to Pareto-efficient agreements that are typically different from the Nash equilibrium of the original game. In Attanasi et al. [2013], the authors apply such protocol in a laboratory experiment on a super-game built over the Prisoner's Dilemma, showing that the equitable and Pareto-efficient agreement is reached by almost all bargaining pairs and that assigning the power of confirmation of the proposal to only one of the two players, rather than alternating this role, significantly increases the probability of signing a cooperative agreement in the very first bargaining period.

In this paper, we investigate theoretically and experimentally a bargaining over strategies process, along the lines of Attanasi et al. [2013, 2015]. In this game, two players sign a contract about how they will play in two (discretized) duopoly markets, namely a *Bertrand duopoly market*, in which competition is in prices, and a *Cournot duopoly market*, in which players compete on the amount of output they will produce. Collusive (cooperative) behaviors are frequently observed in markets with two firms, under both Bertrand competition and Cournot competition, even if more

[1] This paper represents the first step of an original research program, known under the name of *Nash program*.

collusive behavior is detected in price-setting experiments when compared to quantity setting experiments [Suetens and Potters, 2007]. The level of collusion dramatically increases if experimental subjects are given the possibility to communicate among themselves. Fonseca and Normann [2012] compare pricing behavior with and without the possibility of communicating (through a non-face-to-face talking) between firms in Bertrand oligopolies with various numbers of firms. They find strong evidence that communication helps firms coordinate in collusive pricing schemes. Waichman et al. [2014], instead, investigate the impact of two different kinds of communication on quantity behavior in a Cournot market: "standardized-communication" and a "free-communication", showing how the second performs better with a student population. An alternative stream of experimental research shows that collusive behavior may occur even if the conversation can merely be imagined through a "virtual bargaining", in which players need to imagine a bargaining process without actually needing to communicate [Melkonyan et al., 2017].

Differently from verbal communication or virtual bargaining, which consists of a large set of potential messages and interchange protocols whose efficiency cannot be clearly assessed, bargaining over strategies in the form of confirmed proposals represents a simple language communication, whose only messages are the possible strategies of the duopoly game. In our model, two players bargain over their strategies in a 4x4 strategic game, either a discretized Cournot or a discretized Bertrand duopoly, where a confirmed agreement between bargaining players concerns the pair of independent strategies in the original non-cooperative game. The super-game ends when the agreement reached in two subsequent stages is confirmed by one of the two players. We implement the mechanism both with symmetric (alternating proposal protocol) and with asymmetric (unilateral proposal protocol) power of confirmation. The resulting bargaining super-games have potentially an infinite number of stages, involving an infinite number of strategies. Nonetheless, we show that, under mild assumptions, the subgame perfect equilibrium outcomes are finite (and, sometimes, are unique) in all the resulting super-games.

We focus on the analysis of duopolies as they are of particular interest in the economic literature. On the one hand, similarly to the Prisoner's Dilemma, they represent formal models of social dilemma-like situations. On the other hand, they are one of the earliest and more relevant applications of interactive strategic reasoning. In this context, we believe that previous experimental results on 2x2 games, such as the Prisoner's Dilemma [Attanasi et al., 2013], can originate from many confound factors. At first, because 2x2 social dilemmas, when repeated, become simple to understand, and players rapidly realize how to reach cooperation, simply thanks to a learning-by-doing principle.[2] On the contrary, models of fighting over a market, both on prices or on quantities, and even in a simple discretized version, confront decision makers with much more complex strategic choices, being more representatives of real practises in contract negotiation. In this experimental

[2]Literature on the repeated Prisoner's Dilemma is vast. See, between the many, the classical paper by Kreps et al. [1982].

study, it is this more complex structure that allows us to disentangle which factors play a predominant role in the negotiation toward an agreement. For both duopolies, Bertrand and Cournot, and for both proposal protocols, symmetric and asymmetric, we conduct an analysis of the possible agreements on a final outcome distribution. In particular, we highlight whether such agreements are: equitable[3], welfare-maximizing, (strongly) Pareto-efficient, and subgame perfect equilibria of the super-game. We observe that a Bertrand duopoly and a Cournot duopoly have different structures, with Cournot having a much higher number of possible equilibria and then resulting in a possibly more complicated negotiation process. We analyze the frequency of reaching an agreement that displays one or more of the aforementioned properties, under the different conditions, and how this impacts the likelihood of reaching an agreement faster.

Summing up our analysis, and confirming our intuition, we report an overall better performance of a Bertrand duopoly market in reaching an equitable, welfare-maximizing and Pareto-efficient agreement. However, its positive effect in reducing the bargaining length is only found under an asymmetric proposal protocol. In fact, when the power of ending the game is symmetrically distributed among the two players, the performance of Bertrand and Cournot duopoly markets in terms of agreement speed is much closer.

Finally, and in line with the previously listed experimental literature of different communication schemes in price- and quantity-setting experiments, we conclude that bargaining over strategies of price- or quantity-setting acts as a communication device in competitive environments.

The paper is organized as follows. Section 2 presents the definition of our duopolies and the theoretical results in term of subgame perfect equilibria. Section 3 presents the experimental design, the setting of our experiment and our experimental hypotheses. All results are presented in Section 4. Section 5 concludes.

2 Bargaining games with confirmed proposals

Let S_i be the finite strategy space for player i in the original game. Starting from the original game, we define a (super-)Game with Confirmed Proposals (henceforth, GCP). The GCP has a potentially infinite sequence of bargaining periods t, with $t = 1, 2, ..., \infty$. In each period, one player acts as a proposer, and the other player acts as a respondent. Each period t has three stages, denoted as $(t.I)$, $(t.II)$, and $(t.III)$. In each stage, only one player is active: the proposer is active at $(t.I)$ and $(t.III)$, and the respondent is active at $(t.II)$. In the first two stages, $(t.I)$ and $(t.II)$, the two players sequentially declare the strategy they intend to play (proposal stages); $(t.III)$ is the confirmation stage, in which the active player decides whether to confirm or not the strategy profile

[3] Equity, as for the *bargaining over a pie* model by Rubinstein [1982], is often reported as an important factor, playing a crucial role for the acceptance of a proposal, even in competitive settings [Kreps et al., 1982, Bolton and Ockenfels, 2000a, Georgantzís and Attanasi, 2016].

originated by the proposals of the first two stages. Hence, the game can end only if the proposer accepts the strategy profile, which becomes a confirmed agreement between the two players.

Theoretically, the proposer in each period t can be randomly chosen or picked-up according to any predetermined rule. In the paper, we only consider two confirmed proposals settings, in which the proposer in each period is randomly chosen at the beginning of the game: the symmetric GCP, where there is alternating power of confirmation, and the asymmetric GCP, in which the proposer is the same in every period of the game.

Symmetric GCP. In the symmetric version of the game, the player that is randomly selected to be the proposer (respondent) at the beginning of the game will play as proposer (respondent) in period 1 and in each odd period; the opponent will play as proposer (respondent) in each even period. Hence, players alternate in exerting the power to end the game by confirming the agreement reached in a period.

Asymmetric GCP. In the asymmetric version of the game, the player that is randomly selected to be the proposer (respondent) at the beginning of the game will play as proposer (respondent) in period 1 and in each subsequent period. Hence, only this player has the power to end the game by confirming the agreement reached in a period.

Assumptions on players' preferences. Following Attanasi et al. [2013] we make three assumptions on players' preferences: (i) *Disagreement is not better than any (confirmed) agreement:* If an agreement is never reached, the outcome is the disagreement event in which each player has a payoff lower than the minimum payoff of the game. (ii) *Patience:* It is irrelevant when the agreement is reached (i.e, there is no discounting). (iii) *Stationarity:* the preference between two agreements does not depend on the bargaining period.

2.1 Bertrand duopoly with confirmed proposals

The first GCP we consider is one where the original game is a (discretized) Bertrand duopoly. The two players are firms who produce homogeneous products and compete by setting prices, in a market characterized by the linear demand $P = 6 - \frac{Q}{2}$. We assume that both firms have marginal (and fixed) costs equal to zero. For each player i, the set of possible price strategies is $S_i = \{1, 2, 3, 4\}$. The original game is therefore described by the following matrix:

	1	2	3	4
1	5,5	10,0	10,0	10,0
2	0,10	8,8	16,0	16,0
3	0,10	0,16	9,9	18,0
4	0,10	0,16	0,18	8,8

Table 1: Bertrand duopoly

Note that if the two firms colluded, their optimal collusion would be obtained by setting $p = 3$, which is the monopoly price, thus leading each firm to a profit of 9. In the discretized version that the subjects play, the Nash equilibrium is found where $p_1 = p_2 = 1$, thus leading to a profit of 5.

Proposition 1. *The Bertrand Duopoly with confirmed proposals and symmetric power of confirmation has a unique subgame perfect equilibrium outcome, the cooperative agreement* $(3, 3)$*, that can be confirmed in any bargaining period* $t = 1, 2, ..., \infty$.

Proof. Consider the game in Table 1. First of all, notice that players cannot agree in equilibrium on any contract off the diagonal, in which one of the two player receives a zero payoff. In any period t, if the proposer receives zero payoff he will not have an incentive to confirm the contract, as he/she can always commit to play the strategy $(1, Yes)$, allowing him/her a payoff of at least 5 in period t. If it is the respondent who receives zero payoff from the contract, he/she will not have an incentive to propose the specified strategy, as he/she can always commit to play the strategy $(1, Yes)$ in $t + 1$, allowing him/her a payoff of at least 5 in period $t + 1$.

Also, $(1, 1)$ cannot be an equilibrium agreement. This can be verified by using a stationarity argument. Given that the game horizon is infinite, all subgames starting in odd nodes are identical and the same holds for all subgames starting in even nodes. Since the players are rational, strategy profiles confirmed in period t will be the same as the ones that would have been confirmed at $t + 2$, with $t = 1, 2, ..., \infty$. We therefore characterize a subgame perfect equilibrium based solely on stationary strategies. Let us assume that $(1, 1, Yes)$ is an equilibrium outcome. In a stationary equilibrium, the payoff profile at the end of period $t = 1$ has to coincide with the payoff profile at the end of period $t > 1$, for each $t = 1, 2, ..., \infty$. Moreover, the game starting in period t and the one in period $t + 1$ are isomorphic for each t, as the set of strategies in the two games are the same and the original game is symmetric. Therefore, we can assign to each non-terminal node at the end of every bargaining period t the payoff profile $(5, 5)$ of our suggested equilibrium. This implies that the payoff profile in the continuation game at the end of period 1 is $(5, 5)$ for all non-terminal histories. That would lead the first proposer, player 1, to choose Yes at the end of period 1 in every node on or above the diagonal. Moreover, the payoff he/she obtains in the terminal node $(1, 1, Yes)$ is the same as in the non-terminal node $(1, 1, No)$, due to stationarity. Hence, he/she is indifferent between confirming the contract $(1, 1)$ and not confirming it. Going backwards, in any case the respondent (player 2) would best-reply to a price p with the same price, as replying to p with a lower price would lead to the contract being rejected, which gives a strictly lower payoff for any $p > 1$. Hence, at the beginning of period 1, player 1 would propose the collusion price 3, player 2 would respond with the same price 3 and player 1 would confirm, thus leading to the payoff profile $(9, 9)$ at the end of period 1, which contradicts that the confirmed agreement $(1, 1, Yes)$ is a stationary equilibrium outcome. In the same way we can rule out $(2, 2)$ and $(4, 4)$ as equilibrium agreements.

Therefore, only $(3, 3)$ can be an equilibrium agreement. Let us verify that the game may end in some period t with the following plan of actions: $(3, 3, Yes)$. Assume that period t is a period in which player 1 is the proposer. Given that we assign to each non-terminal node at the end of bargaining period t the payoff profile $(9, 9)$, the proposer confirms the contracts where $p_1 < p_2$ and does not decline $(3, 3)$, given that he/she gets the same payoff in the terminal node $(3, 3, Yes)$ and in the non-terminal node $(3, 3, No)$. Going backwards, the respondent would best-reply to any p_1 with $p_2 = p_1$, so that the proposer is indifferent between proposing any price at the beginning of the period, as prices different from 3 will lead to a rejected contract and to the same continuation payoff as $(3, 3, Yes)$. @The case in which in period 2 the respondent is player 2 can be symmetrically addressed.@ Therefore, the agreement $(3, 3)$ can be confirmed in equilibrium in each bargaining period t. ■

Proposition 2. *The Bertrand Duopoly with confirmed proposals and aymmetric power of confirmation has two subgame perfect equilibrium outcomes, the cooperative agreement* $(3, 3)$*, and the agreement* $(3, 4)$*, that can be confirmed in any bargaining period* $t = 1, 2, ..., \infty$*.*

Proof. Consider the game in Table 1. If there is asymmetric power of confirmation players cannot agree in equilibrium on any contract with $p_1 > p_2$, as each of these contracts gives the proposer a payoff of 0. This can be proved by using the same argument of Proposition 1.

Let us now consider contracts where $p_1 < p_2$, which give player 2 (the respondent) a payoff of 0. Among these contracts, only $(3, 4)$ can be an equilibrium agreement. This is because player 2 cannot commit on any counter-proposal which can yield him/her a higher payoff with certainty. For example, consider the outcome $(1, 2)$. If we assign the payoff profile $(10, 0)$ to each non-terminal node in which player 2 receives a strictly positive payoff. Given that he/she gets the same payoff in the terminal node $(1, 2, Yes)$ and in the non-terminal node $(1, 2, No)$, he/she is indifferent between confirming or not $(1, 2)$, and, when indifferent, he/she will confirm because of the preference for an early agreement. Going backward, the respondent (player 2 in all periods) is indifferent between any price in all nodes in which he/she is active (he/she would get a payoff of 0 whatever his/her counter-proposal), but, due to the preference for early agreement will propose a price greater than 1, in order to have the agreement. The proposer, instead, will accept only contracts which lead to a payoff weakly higher than 10. Therefore, if the proposer offers 2, the respondent will optimally choose 3 or 4, and if the proposer offers 3 the respondent will optimally choose 4. In the light of this, the proposer strictly prefers to offer 3, leading to a confirmed agreement $(3, 4)$ which gives him/her a payoff of 18. The same argument can be applied to show that $(1, 3)$, $(1, 4)$, $(2, 3)$ and $(2, 4)$ cannot be equilibrium agreements.

On the contrary we can show with a stationarity argument that $(3, 4)$ can be an equilibrium agreement.

Let us now consider the outcomes on the diagonal, where $p_1 = p_2$. Note that $(1, 1)$ cannot be an equilibrium outcome. To see this, note that if $(1, 1, Yes)$ is an equilibrium, the proposer confirms any other contract on the diagonal, for example $(3, 3)$, and above the diagonal, while contracts below the diagonal are declined. Moving backwards, the respondent finds it optimal to propose $p_2 = p_1$ for any strategy p_1 of the proposer. Hence, the proposer finds it optimal to choose $p_1 = 3$, which leads to a higher payoff. In the same way we can show that $(2, 2)$ and $(4, 4)$ are not sustainable as confirmed contracts in equilibrium. The fact that the agreement $(3, 3)$ can be confirmed in equilibrium in any bargaining period t can be easily proved by assigning the payoff profile $(9, 9)$ to each non-terminal node at the end of bargaining period t, and following the stationarity argument used in the proof of Proposition 1. ■

2.2 Cournot duopoly with confirmed proposals

The second GCP we consider is one where the original game is a (discretized) Cournot duopoly. The two players are firms who produce homogeneous products and compete by setting quantities, in a market characterized by the linear demand $P = 6 - \frac{Q}{2}$. We assume that both firms have marginal (and fixed) costs equal to zero. Note that the setting (demand and firms' cost functions) is the same as the Bertrand duopoly of the first GCP. For each player i, the set of possible quantity strategies is $S_i = \{2, 3, 4, 5\}$. The original game is therefore described by the following matrix:

	5	4	3	2
5	5,5	7.5,6	10,6	12.5,5
4	6,7.5	8,8	10,7.5	12,6
3	6,10	7.5,10	9,9	10.5,7
2	5,12.5	6,12	7,10.5	8,8

Table 2: Cournot duopoly

Note that if the two firms colluded, their optimal collusion would be obtained by setting $q_1 = q_2 = 3$, thus producing overall the monopoly quantity of 6 (sold at the monopoly price $p = 3$) and leading each firm to a profit of 9. In the discretized version that the subjects play, the Nash equilibrium is found where $q_1 = q_2 = 4$, thus leading to a profit of 8. Observe that the Nash equilibrium of the original game our Cournot duopoly model does not coincide with the Nash equilibrium of our Bertrand duopoly model.

Proposition 3. *In the Cournot Duopoly with confirmed proposals and symmetric power of confirmation has the set of subgame perfect equilibrium outcome is* $\{(3, 3), (4, 3), (4, 2), (3, 2), (3, 4), (2, 3), (2, 4)\}$. *These equilibrium outcomes can be confirmed in any bargaining period* $t = 1, 2, ..., \infty$.

Proof. Consider the game in Table 2. First of all, notice that players cannot agree in equilibrium on contracts $(5, 5)$, $(2, 5)$ and $(5, 2)$, in which one of the two player receives a payoff of 5. In any period t, if the proposer receives payoff 5 he/she will not have an incentive to confirm the contract, as he/she can always commit to play the strategy $(4, Yes)$, allowing him/her a payoff of at least 6 in period t. If it is the respondent who receives payoff 5 from the contract, he/she will not have an incentive to propose the specified strategy, as he/she can always commit to play the strategy $(4, Yes)$ in $t+1$, allowing him/her a payoff of at least 6 in period $t+1$.

Also, $(4,4)$ cannot be an equilibrium agreement. This can be verified by using a stationarity argument, along the lines of the proof of Proposition 1. Recall that we can assign to each non-terminal node at the end of every bargaining period t the payoff profile $(8,8)$ of our suggested equilibrium. This implies that the payoff profile in the continuation game at the end of period 1 is $(8,8)$ for all non-terminal histories. That would lead the first proposer, player 1, to choose Yes at the end of period 1 in the following nodes $\{(5,3),(5,2),(4,3),(4,2),(3,2)\}$. Moreover, the payoff he/she obtains in the terminal node $(4,4,Yes)$ is the same as in the non-terminal node $(4,4,No)$, due to stationarity. Hence, he/she is indifferent between confirming the contract $(4,4)$ and not confirming it. He/she is also indifferent between confirming contract $(2,2)$ and not confirming it, as it gives the same payoff as the continuation payoff. Going backwards, in any case the respondent (player 2) would best-reply to a quantity $q<5$ with the same quantity, as replying to q with a higher quantity would lead to the contract being rejected, which gives a lower payoff. Hence, at the beginning of period 1, player 1 would propose the collusion quantity 3, player 2 would respond with 3 and player 1 would confirm, thus leading to the payoff profile $(9,9)$ at the end of period 1, which contradicts that the confirmed agreement $(4,4,Yes)$ is a stationary equilibrium outcome. In the same way we can rule out $(2,2)$, $(4,5)$ and $(5,4)$ as equilibrium agreements.

Also $(5,3)$ cannot be an equilibrium agreement. As a matter of fact, in such an equilibrium, in periods in which player 1 is the proposer, he/she confirms any contract in which his/her payoff is at least 10, including contract $(4,3)$, which delivers a higher payoff for player 2. As a consequence, whenever it is its turn to propose, player 2 proposes 3 and confirms only offers with $q_1<5$. With the same argument it is possible to show that $(3,5)$ is not an equilibrium agreement.

$(3,3)$ is an equilibrium agreement. Let us verify that the game may end in some period t with the following plan of actions: $(3,3,Yes)$. Assume that period t is a period in which player 1 is the proposer. Given that we assign to each non-terminal node at the end of bargaining period t the payoff profile $(9,9)$, the proposer confirms the contracts where $p_1<p_2$ and does not decline $(3,3)$, given that he/she gets the same payoff in the terminal node $(3,3,Yes)$ and in the non-terminal node $(3,3,No)$. Going backwards, the respondent would best-reply to any p_1 with $p_2=p_1$, so that the proposer is indifferent between proposing any price at the beginning of the period, as prices different from 3 will lead to a rejected contract and to the same continuation payoff as $(3,3,Yes)$. The case in which in period 2 the respondent is player 2 is symmetric. Therefore, the agreement $(3,3)$ can be confirmed in equilibrium in each bargaining period t. In the same way we can show that $(4,3)$, $(4,2)$, $(3,2)$, $(3,4)$, $(2,3)$ and $(2,4)$ are equilibria. ■

Proposition 4. *In the Cournot Duopoly with confirmed proposals and asymmetric power of confirmation has the set of subgame perfect equilibrium outcome is* $\{(5,3),(5,2),(4,3),(4,2),(3,3),(3,2)\}$.

These equilibrium outcomes can be confirmed in any bargaining period $t = 1, 2, ..., \infty$.

Proof. Consider the game in Table 2. If there is asymmetric power of confirmation players cannot agree in equilibrium on any contract with $q_1 < q_2$, as each of these contracts gives the proposer a payoff lower than the cooperation one.

Let us now consider contracts where $q_1 < q_2$. Among these contracts, only $(5, 4)$ cannot be an equilibrium agreement. This is because both players have a payoff which is lower than the cooperation one. With the same argument, we can rule out $(5, 5)$, $(4, 4)$ and $(2, 2)$ as possible equilibrium agreements.

On the contrary, the fact that the agreement $(3, 3)$ can be confirmed in equilibrium in any bargaining period t can be easily proved by assigning the payoff profile $(9, 9)$ to each non-terminal node at the end of bargaining period t, and following the stationarity argument used in the proof of Proposition 1. Similarly, we can show that $(5, 3)$, $(5, 2)$, $(4, 3)$, $(4, 2)$, and $(3, 2)$ can be sustained as equilibrium agreements. ■

2.3 Structure of the payoff matrices and equilibria distribution

Throughout the paper, for both the Cournot and the Bertrand duopoly, we denote the strategies set of a player as $\{A, B, C, D\}$. For example, strategy A in a Cournot corresponds to setting a quantity equal to 5, while in a Bertrand it corresponds to setting a price equal to 1. Note that the payoff matrices of the two duopolies are built so that the cooperative outcome is obtained with the agreement on the strategy profile (C, C), and that the equitable agreements on the diagonal correspond to the same price-quantity allocation for each firm. The two duopolies differ instead in what happens out of the diagonal.

In accordance with our intention of representing a stylized model of fighting over a market, we refer to strategy A as to *Fighting a lot*, strategy B as to *Substantially fighting*, strategy C a.s to *Slightly fighting* and strategy D as to *Do not fight*. Observe that, with this terminology, the agreement *à la* Nash in Bertrand original game corresponds to a final play of the game in which both players *fighted a lot*, while an agreement *à la* Nash in Cournot original game corresponds to a final play of the game in which both players *substantially fighted*. Instead, the collusive agreement in both duopolies corresponds to a final play in which they *slightly fighted*.

The most interesting differences between these two duopoly markets can be isolated by looking at the features of the different outcomes of the two game matrices of Table 1 (Bertrand duopoly) and Table 2 (Cournot duopoly). We build the analysis that follows on four main criteria. The first three criteria rely only on the outcome structure of the game, and do not require solving the super-game with confirmed proposals. Hence, these three criteria apply regardless of the power of confirmation in the bargaining game (symmetric or asymmetric). Indeed, for each possible outcome of the 4x4 matrices of our discretized Bertrand duopoly (Table 1) and Cournot duopoly (Table 2), we highlight whether the outcome is: equitable, welfare-maximizing, (strongly) Pareto-efficient. Figure 1 visually represents the set of outcomes that satisfy each of these properties of the payoff matrix of the original game.

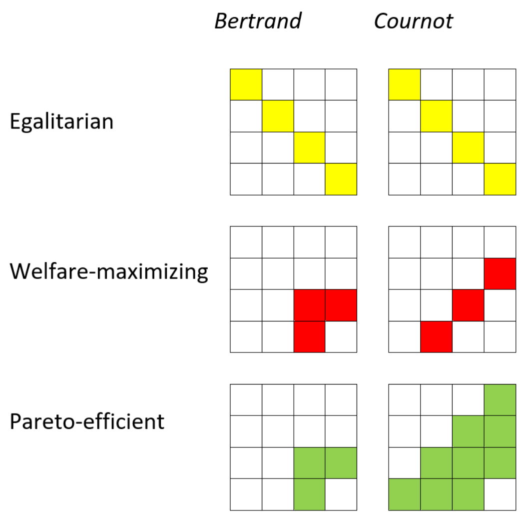

Figure 1: Equitable, welfare-maximizing and (strongly) Pareto-efficient outcomes in the Cournot and in the Bertrand matrices of payoffs

The fourth criterion follows from our Equilibrium analysis in Propositions 1-4. We disentangle the game agreements of Tables 1-2 according to whether they can be obtained in a subgame perfect equilibrium of the four super-games with confirmed proposals: Figure 2 visually represents the set of outcomes that can be agreements in subgame perfect equilibria of the super-game. Being the set of subgame perfect equilibria of the super-game dependent on the payoff matrix (Bertand vs. Cournot) and the type of confirmation power (symmetric vs. asymmetric), we have four different sets of behavioral predictions.

Note that, both in the Bertrand and in the Cournot duopoly, the collusive agreement (C, C) (line 3, column 3 of Figures 1-2) is the only one addressing all the aforementioned criteria (equitable, welfare-maximizing, Pareto-efficient, equilibrium of the super-game) while in both cases, the Nash equilibrium of the original game provides an outcome satisfying only the equitable property.

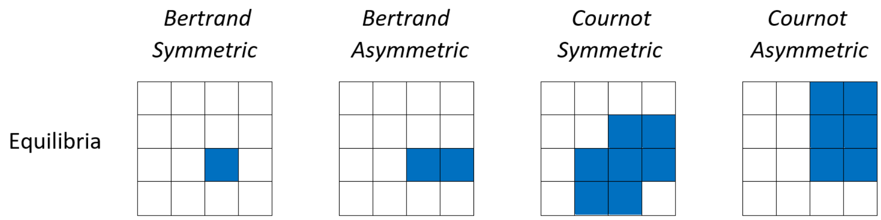

Figure 2: Subgame perfect equilibria in *Bertrand Symmetric, Bertrand Asymmetric, Cournot Symmetric* and *Cournot Asymmetric*

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3 The experiment

3.1 Procedures and design

The experiment was run at the LEEN, Laboratory of Experimental Economics of Nice, in May 2022.[4] The experiment was computerized with z-Tree [Fischbacher, 2007] and participants were recruited using ORSEE [Greiner, 2015]. We held 17 sessions with a total of 208 participants. Each person could only participate in one of these sessions. Average earnings were €13.40, including a €5 show-up fee (minimum and maximum earnings were respectively €5 and €23); the average duration of a session was 35 minutes, including instructions and payment.

Prior to the experiment, subjects were asked to fill a short questionnaire, intended to collect personal information (age, sex, studying and working life), their social attitude (level of social trust and risk preferences) and their level of intuitive thinking.

At the beginning of the experimental session, subjects were informed that the experimental game would last (as specified also in the recruitment instructions) a maximum of 90 minutes. Also, in order to avoid the formation of uncontrolled beliefs regarding the implications of this time limit for the number of periods that would be played, we limited by design the maximum time that each negotiation period could last up to 3 min (80 sec per subject's proposal and counter-proposal and 20 sec for the confirmation stage). This guaranteed the subjects that at least 30 periods could be played even in the case of the longest possible pre-agreement process. Subjects in a pair did not have to wait for the other pairs to end the game. Once a pair has reached an agreement, the two players belonging to this pair left their cubicles, and they proceeded to two separate rooms in which they were individually paid, blind of the identity of their co-player. If no agreement were reached in a pair within the 90 min limit, subjects in this pair would leave the room with the minimum payoff they could individually get in the experimental game.[5] As a matter of fact, such a disagreement payoff

[4] Experimental instructions are available in Online Appendix available at this link: CLICK HERE.

[5] This is in line with assumption (i) in the theoretical analysis: disagreement is not better than any (confirmed)

was never used. Indeed, average bargaining period time was lower than 10 min (median agreement period = 2nd, mean = 4th), and only 1 out of the 104 pairs of experimental participants arrived close to the time limit, with an agreement in the 34th period, with the experimenter announcing that only 2 minutes lasted before the end of the session.

The experiment has a 2 x 2 between-subject design, where the treatment variables are (i) whether the game is a Cournot or a Bertrand duopoly; (ii) whether the confirmation power is Symmetric or Asymmetric.

In all treatments, at the beginning of the experimental session, pairs were randomly formed and remained fixed during the whole session. Within each pair, each player was randomly chosen to play either the role of proposer or respondent in the first period. Each player was informed of his/her initial role in the experiment by the computer screen. The identity of the proposer in subsequent periods depended on whether the treatment was Symmetric or Asymmetric. More specifically:

Bertrand vs. Cournot treatment. In Bertrand treatments, players play the GCP with the payoff matrix of Table 1, while in Cournot treatments they play it with the payoff matrix of Table 2.

Symmetric vs. Asymmetric treatment. In Symmetric treatments the player who has been selected as proposer in the first period acts as proposer in every odd period, and the other player (first-period respondent) is the proposer in every even period. In the Asymmetric treatments, instead, the first-period proposer is the proposer in each subsequent period.

In what follows, we will refer to the different treatments respectively as to *Bertrand-Sym, Bertrand-Asym, Cournot-Sym* and *Cournot-Asym*, respectively. We have a total of 50, 52, 56 and 50 observations for each treatment.[6].

3.2 Experimental hypotheses

Our experimental hypothesis can be divided into two sets: agreement features and speed. Both sets of hypotheses dwell with behavioral differences across the four treatments of our bargaining game.

The first set of hypotheses (H1) focuses on the features of the agreement reached through bargaining with confirmed proposals.

The first three hypotheses of this set (H1) are inspired by the structure of the payoff matrix in the Bertrand and Cournot experimental duopoly – equitable, welfare-maximizing, and Pareto-

agreement. In the Bertrand (resp., Cournot) game of Table 1 (resp., Table 2), the minimum payoff each player could get in the game is 0 (resp., 5).

[6] The difference in the number of participants between the two mechanisms is a result of variations in the show-up rate among experimental sessions.

efficient outcomes – described in Figure 1, and are not directly theory-driven. Being these outcome features independent from the type of confirmation power of the GCP, we should find no significant difference between the symmetric and the asymmetric version of the GCP. According to Figure 1, we should find no significant difference also between Bertrand and Cournot as for the likelihood of reaching an equitable or welfare-maximizing outcome, since both duopoly games present the same number of both (respectively, 4 equitable and 3 welfare-maximizing outcomes). Given the lower number of Pareto-efficient outcomes in the Bertrand than in the Cournot duopoly (3 vs. 9), we expect that in the latter game the bargaining agreement will more likely be Pareto-efficient. With this, we formulate H1.1 - H1.3.

H1.1 *The frequency of equitable agreements is not significantly different between types of confirmation power and between duopoly games.*

H1.2 *The frequency of welfare-maximizing agreements is not significantly different between types of confirmation power and between duopoly games.*

H1.3 *The frequency of Pareto-efficient agreements is not significantly different between types of confirmation power and is significantly higher in the Cournot than in the Bertrand duopoly game.*

The last hypothesis of the first set is instead directly theory-driven by Propositions 1-4, which derive the equilibria of the GCP in the four implementations of the duopoly game: *Bertrand-Sym, Bertrand-Asym, Cournot-Sym*, and *Cournot-Asym.* Figure 2 shows the existence of a higher number of equilibria in the Cournot than in the Bertrand duopoly, regardless of the type of confirmation power. This should make an equilibrium more likely to be reached. However, the fact that both the unique equilibrium in Bertrand-symmetric and one of the two equilibria in Bertrand-asymmetric are at the same time equitable, welfare-maximizing and Pareto-efficient makes such an outcome more likely to be reached than in the Cournot duopoly where, regardless of the type of confirmation power, only one out of the 7 (resp., 6) equilibria holds all the three properties in the symmetric (resp., asymmetric) implementation.

H1.4 *An equilibrium agreement is more frequently reached in the Cournot duopoly. Reaching an equitable, welfare-maximizing and Pareto-efficient equilibrium agreement is more likely in the Bertrand duopoly. Both predictions hold regardless of the power of confirmation.*

The second set of hypotheses (H2) considers the speed at which an agreement is reached and how this speed depends on the above-mentioned agreement features.

The first hypothesis of this second set is a corollary of H1.4. Given the smaller number of subgame perfect equilibria in the Bertrand duopoly (Figure 2), these should act as focal points, thereby allowing the two players to coordinate more quickly on the equitable, welfare-maximizing and Pareto-efficient subgame perfect equilibrium outcome. This outcome is the unique subgame perfect equilibrium in *Bertrand-Sym*, and one of the two equilibria in *Bertrand-Asym*.

H2.1: *An agreement is reached faster in the Bertrand duopolies. This is especially true if the agreement is an equitable, welfare-maximizing and Pareto-efficient equilibrium outcome of the game.*

The second hypothesis relies on the structure of the communication that the GCP involves. When players alternate in exerting the power to end the game, a communication in the form of bargaining over strategies and confirmed proposals is more effective, as both players have the chance to reveal their preferences on the strategy they want to play, and on the payoffs they are not ready to accept. With this, we formulate our last experimental hypothesis.

H2.2: *An agreement is reached faster in the symmetric treatments. This is especially true if the agreement is an equitable, welfare-maximizing and Pareto-efficient equilibrium outcome of the game.*

4 Results

In this section, we discuss the facts obtained from the statistical analysis of our data, by testing the hypotheses introduced in Section 3.2. The complete list of all patterns and dialogues emerging from our experimental data is illustrated in Appendices A-D.

We begin by testing the first set of hypotheses, which concerns the features of the reached agreement.

Figure 3 reports the relative frequency of equitable, welfare-maximizing, Pareto-efficient and equilibrium agreements which resulted from bargaining with confirmed proposals in the four treatments *Bertrand-Sym*, *Bertrand-Asym*, *Cournot-Sym*, and *Cournot-Asym*.

As for H1.1, a Kruskal-Wallis equality-of-populations rank test indicates significant differences in the distribution of equitable agreements across the four treatments ($p\text{-}value = 0.0011$). Pairwise comparisons through Chi-square tests shows no difference between symmetric and asymmetric treatments, keeping constant the duopoly type ($p\text{-}value = 0.6703$ for Bertrand and 0.2022 for Cournot). Keeping constant the type of confirmation power, significant differences are instead found in favor of the Bertrand duopoly ($p\text{-}value = 0.0222$ for Symmetric and 0.0022 for Asymmetric). With this, we conclude that **H1.1 is verified for the type of confirmation power, but not for the duopoly type.**

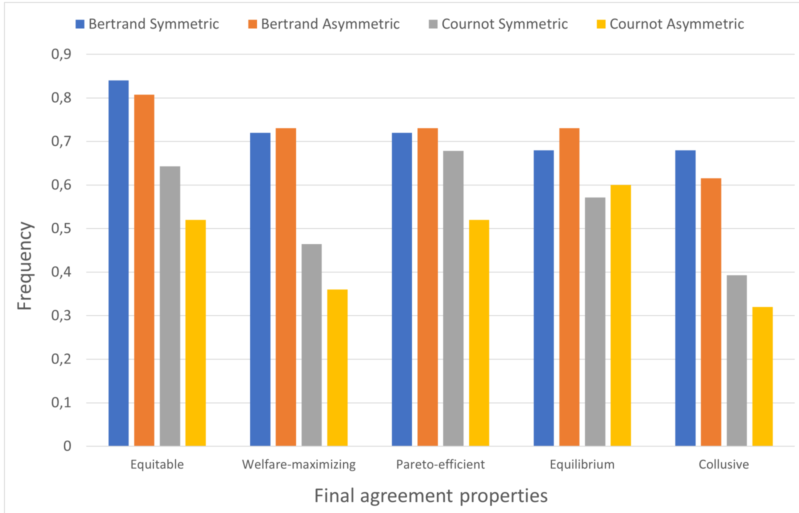

Figure 3: Final outcome properties distribution for *Bertrand-Sym, Bertrand-Asym, Cournot-Sym, and Cournot-Sym.*

A similar picture emerges when testing H1.2. Significant differences in the distribution of welfare-maximizing agreements are found across the four treatments (*p-value* = 0.0001, Kruskal-Wallis test), with no difference between symmetric and asymmetric treatments, keeping constant the duopoly type (*p-value* = 0.9035 for Bertrand and 0.2790 for Cournot), and significant differences in favor of the Bertrand duopoly, keeping constant the type of confirmation power (*p-value* = 0.0079 for Symmetric and 0.0002 for Asymmetric). With this, we conclude that **H1.2 is verified for the type of confirmation power, but not for the duopoly type.**

Also H1.3, is confirmed for the type of confirmation power but not for the type of duopoly. In fact, we do not find a significantly higher frequency of Pareto-efficient outcomes in the Symmetric treatment (Chi-square test, *p-value* = 0.0972 in the Cournot duopoly; textitp-value = 0.9035 in the Bertrand duopoly). As for the duopoly type, contrarily to H1.3, we find a significantly higher frequency of Pareto-efficient outcomes in the Bertrand duopoly when the confirmation power is symmetric (Chi-square test, *p-value* = 0.0285; textitp-value = 0.6444 when it is asymmetric). With this, we conclude that **H1.3 is only verified for the type of confirmation power, but not for the duopoly type.**

As for H1.4, we see from Figure 3 that it is not true that an equilibrium agreement is more frequently reached in the Cournot duopoly: no significant difference is found under asymmetric power of confirmation (*p-value* . = 0.1634) and a difference in favor of the Bertrand duopoly is detected when the power of confirmation is symmetric (*p-value* = 0.0028). Focusing on the equilibrium agreement that is equitable, welfare-maximizing and Pareto-efficient, we find that the Bertrand duopoly acts even more as a boosting of the coordination device of the GCP, and that this holds regardless of the type of confirmation power (*p-value* = 0.0029 in the Asymmetric and 0.0033 in the Symmetric treatment). With this, we conclude that **H1.4 is verified when focusing on the equitable, welfare-maximizing and Pareto-efficient equilibrium agreement.**

Table 3: Logit regression models to predict the likelihood that the final agreement of the GCP is equitable (1), welfare-maximizing (2), Pareto-efficient (3), one of the subgame perfect equilibria of the GCP (4), and holds all these four features at the same time (Model 5)

VARIABLES	(1)	(2)	(3)	(4)	(5)
Cournot-Sym	0.533	0.527	0.819*	0.178	0.456
	(0.428)	(0.424)	(0.431)	(0.425)	(0.435)
Bertrand-Asym	1.390***	1.578***	0.897*	0.695	1.259***
	(0.463)	(0.440)	(0.431)	(0.439)	(0.429)
Bertrand-Sym	1.638***	1.596***	0.952**	1.507***	1.667***
	(0.500)	(0.452)	(0.443)	(0.509)	(0.455)
Gender	0.228	0.258	0.351	0.756**	0.533
	(0.376)	(0.351)	(0.353)	(0.364)	(0.350)
Age	0.217	0.007	0.007	0.027	0.027
	(0.288)	(0.027)	(0.026)	(0.027)	(0.027)
Occupation	0.626	1.094	0.931*	0.251	1.117**
	(0.537)	(0.539)	(0.513)	(0.540)	(0.559)
Subject of study	-0.333	-0.053	0.121	0.141	-0.037
	(0.359)	(0.334)	(0.336)	(0.351)	(0.330)
Experience	-0.076	0.013	0.043	0.051	0.060
	(0.626)	(0.060)	(0.060)	(0.063)	(0.060)
Trust	0.756	0.512	0.013	0.082	0.016
	(0.078)	(0.073)	(0.073)	(0.076)	(0.073)
Risk	-0.070	-0.083	-0.032	0.045	-0.052
	(0.076)	(0.071)	(0.072)	(0.074)	(0.069)
CRT	-0.010	0.588	0.046	-0.088	-0.034
	(0.165)	(0.155)	(0.157)	(0.159)	(0.154)
const	-0.773	-1.757	-1.239	-1.348	-2.204
	(1.276)	(1.243)	(1.202)	(1.253)	(1.257)

Robust standard errors in parentheses

*** p<0.01, ** p<0.05 * p<0.1

Table 3 reports the results of logit regression models meant to support the non-parametric testing of H1.1-4. The five models predict the likelihood that the final agreement of the GCP is equitable (Model 1), welfare-maximizing (Model 2), Pareto-efficient (Model 3), and one of the subgame perfect equilibria of the GCP (Model 4), and holds all these four features at the same time (Model 5). Besides the two treatment variables and their interactions (baseline category: treatment *Cournot-Asym*), the set of explanatory variables include *Gender* (1=female, 0=male), *Age*[7], *Occupation* (1=student, 0=other), *Subject of study* (1=economics, 0=other), *Experience* (number of economic experiments previously attended), self-assessment measures of trust (*Trust*)[8] and risk seeking (*Risk*)[9], and the results of three cognitive reflection tests [Frederick, 2005], *CRT*[10], all elicited through a pre-experimental questionnaire. Regression coefficients in Table 3 refer to the marginal effects of the explanatory variables on each of the four features of the final agreement. Looking at the significant regression coefficients of treatment manipulations, it is easy to notice that the five models confirm our non-parametric testing of H1.1-4, with models 1-3 respectively referring to the test of H1.1-3, and models 4-5 referring to the test of H1.4. As for the other regression coefficients, we find a positive effect of gender on reaching an equilibrium agreement (column 4), and a positive effect of being a student on the likelihood of reaching the collusive agreement.

Let us now move to the second set of hypotheses (H2.1-2), which concern the speed with which an agreement is reached. Recall that a sequence proposal-counterproposal-(no)confirmation represents a single bargaining period in our GCP. We first look at the length of the bargaining process in the four treatments. In Figure 4, we represent the distribution of the agreement period for the four treatments. Figure 5 reports the average agreement period conditional on the four features of the final agreement discussed in the test of H1.1-4 above (equity, welfare-maximization, Pareto-efficiency, equilibrium, all the four features together).

We combine the statistics reported in Figures 4-5 with six OLS regression models with the agreement period as dependent variable, and the same explanatory variables of Table 3, i.e., the two treatment variables, their interaction, and players' idiosyncratic features elicited through a pre-experimental questionnaire. We report the results of the OLS regressions in Table 4. Model 1 considers all the final agreements, i.e., all experimental participants. Model 2 focuses on participants' pairs reaching an equitable final agreement. In a similar fashion, Model 3 focuses on welfare-maximizing final agreements, Model 4 on Pareto-efficient ones, Model 5 on equilibrium ones,

[7]Education level not included as explanatory variable because too highly correlated with age (Spearman's rho = 0.6221, *p-value* < 0.0001).

[8]Are you a person who generally trust people? On a scale from 0 to 10, how much do you trust people in general (0 meaning "I do not trust people at all" and 10 meaning "I fully trust people")? [Guiso et al., 2009].

[9]Are you a person who generally likes to take risks? On a scale from 0 to 10, how much are you ready to take risks (0 meaning "I do not want to take any risk" and 10 meaning "I am fully ready to take risks")? (adapted by Bernasconi et al. [2014] from Dohmen et al. [2011]).

[10]The variable *CRT* is the sum of correct answers to the three following questions (from Frederick 2005): Q1) A bat and a ball cost 1.10 euros in total. The bat costs 1.00 euro more than the ball. How much does the ball cost? Q2) If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? Q3) In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?

and Model 6 on those pairs reaching the collusive agreement (i.e., equitable, welfare-maximizing, Pareto-efficient, and a subgame perfect equilibrium at the same time).

Table 4: OLS regression models to predict the agreement period considering all final agreements (1), equitable final agreements (2), welfare-maximizing final agreements (3), Pareto-efficient final agreements (4), equilibrium final agreements (Model 5) and collusive final agreement (Model 6)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Bertrand	-2.623***	-0.588	-2.522**	-3.239**	-4.190	-2.477***
	(.999)	(1.053)	(1.258)	(1.334)	(1.382)	(1.436)
Symmetric	-3.297***	-1.840*	-3.346**	-3.813***	-4.985***	-3.427**
	(1.015)	(1.109)	(1.379)	(1.376)	(1.476)	(1.561)
Bertrand#Symmetric	3.457**	1.601	3.372**	3.827**	4.749**	3.118
	(1.404)	(1.430)	(1.703)	(1.819)	(1.914)	(1.951)
Gender	0.217	-0.223	-0.081	0.099	-0.403	-0.582
	(0.816)	(0.823)	(0.943)	(1.055)	(1.141)	(1.096)
Age	-0.1014	-0.081	-0.143	-0.168*	-.148*	-0.152*
	(.062)	(.059)	(.073)	(.080)	(.083)	(0.078)
Occupation	-1.230	-.282	-2.099	-3.306*	-.663	-2.160
	(1.230)	(1.328)	(1.740)	(1.748)	(1.736)	(1.996)
Subject of study	0.366	0.072	0.397	0.357	0.531	0.601
	(0.768)	(0.765)	(0.901)	(0.984)	(1.036)	(1.006)
Experience	0.099	0.144	0.140	0.167	0.134	0.213
	(0.136)	(0.145)	(0.152)	(0.168)	(0.181)	(0.185)
Trust	0.079	0.013	0.033	0.196	0.034	0.057
	(0.169)	(0.168)	(0.198)	(0.210)	(0.231)	(0.214)
Risk	0.481***	0.436**	0.616***	0.714***	0.638***	0.640***
	(0.163)	(0.174)	(0.200)	(0.217)	(0.222)	(0.231)
CRT	-0.254	-0.181	-0.587	-0.699	-0.506	-0.604
	(0.360)	(0.356)	(0.425)	(0.466)	(0.503)	(0.495)
const	6.160**	4.254	8.165**	9.082**	8.625**	8.625*
	(2.841)	(3.074)	(3.844)	(3.967)	(4.120)	(4.365)

Robust standard errors in parentheses

*** p<0.01, ** p<0.05 * p<0.1

Figure 4 shows that the average agreement period is significantly smaller in the Bertrand than in the Cournot treatment under Asymmetric (3.5 vs. 6.2; t-test: *p-value* = 0.0357) but not under Symmetric power of confirmation (3.8 vs. 2.8; t-test: *p-value* = 0.1141). Model 1 confirms that the latter is due to a positive interaction with Symmetric power of confirmation in increasing the bargaining length. The negative effect of Bertrand and the positive effect of Bertrand-Sym interaction on the bargaining length also hold when restricting the reached agreement to a welfare-maximizing

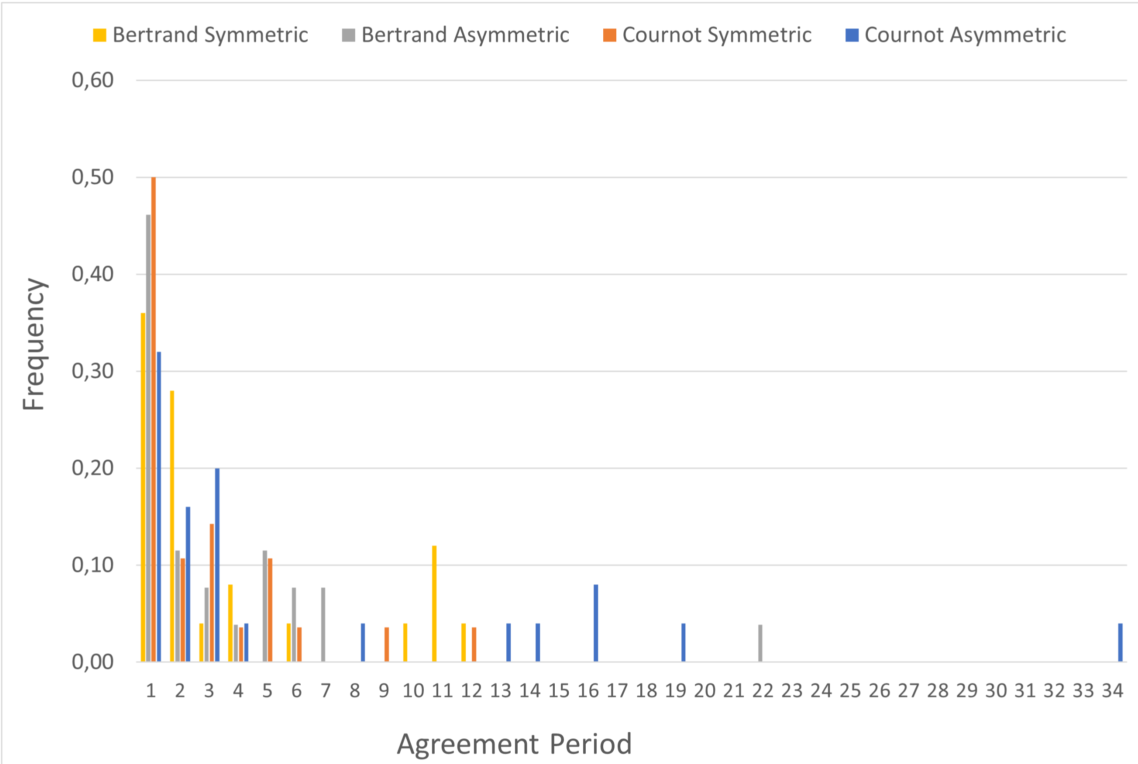

Figure 4: Distribution of the agreement period for *Cournot-Asym, Cournot-Sym, Bertrand-Asym and Bertrand-Sym*

(Model 3), Pareto-efficient (Model 4), equilibrium (Model 5) or collusive one (Model 6). None of these effects is significant when restricting the final agreement to an equitable. With this, we state that **H2.1 is verified for all final agreements but the equitable ones**.

We conclude this section with the test of H2.2. Figure 4 shows that the average agreement period is significantly smaller in the Symmetric than in the Asymmetric treatment in the Cournot duopoly (2.8 vs. 6.2; t-test: *p-value* = 0.0034) but not in the Bertrand duopoly (3.8 vs. 2.8; t-test: *p-value* = 0.7106). Model 1 confirms that the latter is due to a positive interaction with the Bertrand duopoly matrix in increasing the bargaining length. The negative effect of Symmetric power of confirmation and the positive effect of the Bertrand-Sym interaction on the bargaining length also hold when restricting the reached agreement to a welfare-maximizing (Model 3), Pareto-efficient (Model 4), equilibrium (Model 5) or collusive one (Model 6). None of these effects is significant when restricting the final agreement to an equitable. Therefore, similarly to H2.1, we state that

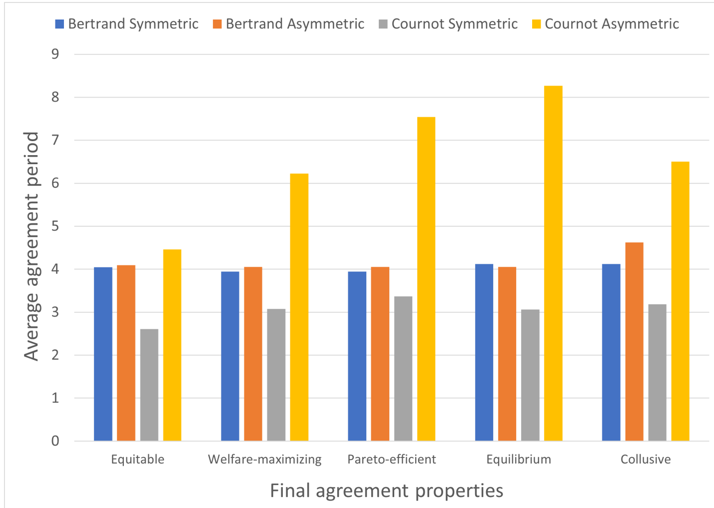

Figure 5: Average agreement period per final outcome type for *Cournot-Asym, Cournot-Sym, Bertrand-Asym and Bertrand-Sym*

H2.2 is verified for all final agreements but the equitable ones.

As for players' idiosyncratic features, it is worth noticing that – regardless of the reached agreement – risk seeking has a significant positive effect on reaching an agreement faster. This is in line with the experimental literature reporting a negative correlation between risk and time preferences, implying that risk-seeking individuals are less patient and less willing to defer consumption [see, e.g., Ferecatu and Önçüler, 2016].

5 Conclusions

In this paper we analyze theoretically and experimentally a bargaining over strategies protocol with confirmed proposals, with symmetric and with asymmetric power of confirmation, in the case in which the original game is a Bertrand or a Cournot duopoly. We consider a discretized Bertrand and a discretized Cournot duopoly, defined so as to have the same collusive outcome, and the same set of equitable agreements on the diagonal. The two duopolies differ instead in what happens out of the diagonal, in the set of Pareto-efficient outcomes, and, obviously, in their Nash equilibrium outcomes.

Theoretically, we find that in the super-game with confirmed proposals the collusive agreement can always be sustained as an outcome of a subgame perfect equilibrium. Moreover, we find a higher number of possible equilibrium outcomes when the original game is a Cournot duopoly.

We then analyze experimentally whether and how the features of the agreement reached through bargaining with confirmed proposals and the speed at which the agreement is reached depend on the type of duopoly and of confirmation power.

For what concerns the features of the agreement, we find that bargaining in the Bertrand duopoly leads more frequently to equitable agreements and to welfare-maximizing agreements regardless of the type of confirmation power. Moreover, we find that bargaining in the Bertrand duopoly leads more frequently to Pareto-efficient agreements when the confirmation power is symmetric. Finally, we show that reaching an equitable, welfare-maximizing and Pareto-efficient equilibrium agreement is more likely in the Bertrand duopoly.

For what concerns the speed of the agreement itself, we find that the Bertrand duopoly has a positive effect in reducing the bargaining length only in asymmetric treatments. In symmetric ones, the bargaining length is already small because of symmetric power of confirmation, with both duopoly types. Consistently, the symmetric power of confirmation has a positive effect in reducing the bargaining length only in Cournot duopolies. In Bertrand duopolies, the bargaining length is already small because of this type of duopoly.

These effects on the speed of the agreement hold also if we focus only on reached agreements that are welfare-maximizing, or Pareto-efficient, or sustainable in a subgame perfect equilibrium, or collusive.

Finally, either Bertrand duopoly or symmetric power of confirmation has no effect on the reduction of the bargaining length if the reached agreement is equitable. We see this as further evidence that – regardless of the bargaining mechanism – in the competitive behavior of both the Bertrand and the Cournot duopoly equity is a crucial factor and reciprocity plays a relevant role [Bolton and Ockenfels, 2000b].

The sequence of proposals and counter-proposals the subjects have announced in the laboratory during their bargaining is presented in Appendices A-D. The analysis we presented in this paper is mainly based on the characteristics of the final outcomes and on the agreement periods. However, a closer look at these dialogues may also say more about the behavioral factors that lead players to make certain choices, and to the paths that favoured the rise of some specific kind of final agreements. In conclusion, these dialogues clearly support bargaining over strategies as a form of communication between strategic players.

References

Giuseppe Attanasi, Aurora García-Gallego, Nikolaos Georgantzís, and Aldo Montesano. An experiment on prisoner's dilemma with confirmed proposals. *Organizational Behavior and Human Decision Processes*, 120(2):216–227, 2013.

Giuseppe Attanasi, Aurora García-Gallego, Nikolaos Georgantzís, and Aldo Montesano. Bargaining over strategies of non-cooperative games. *Games*, 6:275–298, 2015.

Michele Bernasconi, Luca Corazzini, and Raffaello Seri. Reference dependent preferences, hedonic adaptation and tax evasion: Does the tax burden matter? *Journal of Economic Psychology*, 40: 103–118, 2014.

Gary Bolton and Axel Ockenfels. Erc: A theory of equity, reciprocity, and competition. *American Economic Review*, 90(1):166–193, 2000a.

Gary E Bolton and Axel Ockenfels. Erc: A theory of equity, reciprocity, and competition. *The American Economic Review*, 90(1):166–193, 2000b.

Thomas Dohmen, Armin Falk, David Huffman, Uwe Sunde, Jürgen Schupp, and Gert G. Wagner. Individual risk attitudes: measurement, determinants, and behavioral consequences. *Journal of the European Economic Association*, 9:522–550, 2011.

Alina Ferecatu and Ayse Önçüler. Heterogeneous risk and time preferences. *Journal of Risk and Uncertainty*, 53(1):1–28, 2016.

Urs Fischbacher. z-tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics*, 10(2):171–178, 2007.

Miguel A. Fonseca and Hans-Theo Normann. Explicit vs. tacit collusion - the impact of communication in oligopoly experiments. *European Economic Review*, 56:1759–1722, 2012.

Shane Frederick. Cognitive reflection and decision making. *Journal of Economic Perspectives*, 19 (4):25–42, 2005.

Nikolaos Georgantzís and Giuseppe Attanasi. Non-competitive markets. In *Experimental economics*, pages 21–36. Springer, 2016.

Ben Greiner. An online recruitment system for economic experiments. *Journal of the Economic Science Association*, 1(1):114–125, 2015.

Luigi Guiso, Paola Sapienza, and Luigi Zingales. Cultural biases in economic exchange? *The Quarterly Journal of Economics*, 124(3):1095–1131, 2009.

Emin Karagözoğlu and Kyle B. Hyndman, editors. *Bargaining: Current Research and Future Directions*. Palgrave Macmillan, 2022.

David M. Kreps, Paul Milgrom, John Roberts, and Robert Wilson. Rational cooperation in the finitely repeated prisoners' dilemma. *Organizational Behavior and Human Decision Processes*, 27(2):245–252, 1982.

Tigran Melkonyan, Hossam Zeitoun, and Nick Chater. Collusion in bertrand vs. cournot competition: A virtual bargaining approach. *MManagement Science*, 64(12):5461–5959, 2017.

John Nash. The bargaining problem. *Econometrica*, 18(2):155–162, April 1950.

John F. Nash. Two person coooperative games. *Econometrica*, 21:128–140, 1953.

Ariel Rubinstein. Perfect equilibrium in a bargaining model. *Econometrica*, 50:97–110, 1982.

Sigrid Suetens and Jan Potters. Bertrand colludes more than cournot. *Experimental Economics*, 10:71–77, 2007.

Israel Waichman, Till Requate, and Ch'ng Kean Siang. Communication in cournot competition: An experimental study. *Journal of Economic Psychology*, 42:1–6, 2014.

A Pre-play strategies as tacit messages - Treatment *Bertrand-Sym*

A.1 Outcome on the diagonal, strongly Pareto-efficient

Dialogue 1
P (both) ***slightly fights*** *, R (both)* ***cooperates***

No. of pairs: 6

Period	Proposer	Responder	Confirmation
1	**C**	**C**	**YES**

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	C	C	NO
2	**C**	**C**	**YES**

Dialogue 2
P (odd periods) ***slightly fights*** *, R (odd periods)* ***maximizes his/her payoff***
P (even periods) ***slightly fights*** *, R (even periods)* ***cooperates***

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	C	B	NO
2	**C**	**C**	**YES**

Dialogue 3
P (odd periods) ***fights a lot*** *, R (odd periods)* ***maximizes his/her payoff***
P (even periods) ***slightly fights*** *, R (even periods)* ***cooperates***

No. of pairs: 2

Period	Proposer	Responder	Confirmation
1	A	A	NO
2	**C**	**C**	**YES**

Dialogue 4
Firstly P (both) ***fights a lot or substantially*** *, R (both) and P (both)* ***are not smart***
Finally P (even periods) ***slightly fights*** *, R* ***cooperates***

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	A	C	NO
2	B	C	NO
3	**C**	**C**	**YES**

Dialogue 5
P (odd periods) ***slightly or substantially fights*** *, R (odd periods)* ***maximizes his/her payoff***
P (even periods) ***slightly fights*** *, R (even periods)* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	C	B	NO
	2	C	C	NO
	3	B	A	NO
	4	**C**	**C**	**YES**

Dialogue 6
P (odd periods) ***slightly or substantially fights*** *, R (odd periods)* ***maximizes his/her payoff***
P (even periods) firstly ***fights a lot*** *, R (even periods)* ***maximizes his/her payoff***
Finally P ***slightly fights*** *, R* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	C	A	NO
	2	A	A	NO
	3	B	A	NO
	4	**C**	**C**	**YES**

Dialogue 7
P (both) ***slightly fights*** *, R (odd periods) firstly* ***maximizes his/her payoff*** *then he/she* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	C	B	NO
	2	D	C	NO
	3	C	B	NO
	4	C	C	NO
	5	C	B	NO
	6	C	B	NO
	7	C	B	NO
	8	C	C	NO
	9	C	B	NO
	10	C	C	NO
	11	**C**	**C**	**YES**

Dialogue 8

P (odd periods) ***slightly fights*** *, P (even periods)* ***substantially fights***

Finally, P (odd periods) ***slightly fights,*** *R (odd periods)* ***cooperates***

No. of pairs
1

Period	Proposer	Responder	Confirmation
1	A	B	NO
2	D	C	NO
3	C	B	NO
4	B	B	NO
5	C	B	NO
6	B	A	NO
7	A	A	NO
8	B	B	NO
9	C	B	NO
10	B	A	NO
11	**C**	**C**	**YES**

No. of pairs
1

Period	Proposer	Responder	Confirmation
1	C	B	NO
2	C	C	NO
3	C	B	NO
4	B	A	NO
5	C	B	NO
6	B	A	NO
7	C	B	NO
8	B	A	NO
9	C	B	NO
10	B	A	NO
11	**C**	**C**	**YES**

No. of pairs
1

Period	Proposer	Responder	Confirmation
1	C	B	NO
2	B	B	NO
3	C	A	NO
4	B	B	NO
5	C	B	NO
6	B	B	NO
7	C	B	NO
8	B	A	NO
9	C	B	NO
10	C	C	NO
11	C	B	NO
12	**C**	**C**	**YES**

A.2 Other outcomes on the diagonal

Dialogue 9
P (odd periods) ***substantially fights*** *, R (odd periods)* ***cooperates***

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	**B**	**B**	**YES**

Dialogue 10
P (odd periods) ***slightly fights*** *, R (odd periods)* ***maximizes his/her payoff***
P (even periods) ***substantially fights,*** *R (even periods)* ***cooperates***

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	C	A	NO
2	**B**	**B**	**YES**

Dialogue 11
P (odd periods) ***substantially fights*** *, R (odd periods)* ***cooperates***
P (even periods) ***fights a lot*** *, R (even periods)* ***maximizes his/her payoff***

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	B	B	NO
2	**A**	**A**	**YES**

Dialogue 12
P (both) ***slighlty fight*** *, R (odd periods)* ***cooperates*** *but R (even periods)* ***maximizes his/her payoff***
Finally, P (even periods) ***fights a lot*** *, R (even periods)* ***maximizes his/her payoff***

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	A	A	NO
2	C	A	NO
3	C	C	NO
4	C	A	NO
5	C	C	NO
6	C	B	NO
7	C	C	NO
8	C	B	NO
9	B	B	NO
10	**A**	**A**	**YES**

A.3 Outcomes favouring the proposer

Dialogue 13
P (odd periods) ***slightly or substantially fights*** *, R (odd periods)* ***is not smart***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	**C**	**D**	**YES**

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	**B**	**C**	**YES**

Dialogue 14
P (odd periods) ***slightly fights*** *, R (odd periods)* ***maximizes his/her payoff***
P (even periods) ***fights a lot or substantially*** *, R (even periods)* ***is not smart***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	C	B	NO
	2	D	C	NO
	3	C	B	NO
	4	A	C	NO
	5	C	B	NO
	6	**B**	**C**	**YES**

Dialogue 15
P (odd periods) ***slightly fights*** *, R (odd periods)* ***maximizes his/her payoff***
P (even periods) ***substantially fights*** *, R (odd periods)* ***is not smart***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	C	B	NO
	2	**B**	**D**	**YES**

B Pre-play strategies as tacit messages - Treatment *Bertrand-Asym*

B.1 Outcome on the diagonal, strongly Pareto-efficient

Dialogue 1

P ***slightly fights*** *, R* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
6	1	**C**	**C**	**YES**

Dialogue 2

P ***slightly fights*** *, R firstly* ***maximizes his/her payoff*** *, then he/she* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	C	B	NO
	2	**C**	**C**	**YES**

No. of pairs	Period	Proposer	Responder	Confirmation
1	1-3	C	C	NO
	4	C	B	NO
	5	**C**	**C**	**YES**

Dialogue 3

Firstly P ***substantially fights*** *, R* ***maximizes his/her payoff***

Finally P ***slighly fights,*** *R* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	B	A	NO
	2	B	A	NO
	3	**C**	**C**	**YES**

Dialogue 4

Firstly P ***fights a lot or substantially*** *, R and P* ***are not smart***

Finally P ***slightly fights*** *, R* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	B	C	NO
	2	A	A	NO
	3-4	B	B	NO
	5	**C**	**C**	**YES**

Dialogue 5

Firstlty P ***fights a lot or substantially,*** *R* ***cooperates***

Then P ***slightly fights*** *, R firstly* ***maximizes his/her payoff*** *and finally he/she* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	A	A	NO
	2	B	B	NO
	3	C	B	NO
	4	C	A	NO
	5	**C**	**C**	**YES**

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	A	A	NO
	2	C	C	NO
	3	C	C	NO
	4	C	C	NO
	5-6	C	B	NO
	7	**C**	**C**	**YES**

Dialogue 6

P fights a lot, substantially or slightly , R maximizes his/her payoff

Finally P slightly fights , R cooperates

No. of pairs 1

Period	Proposer	Responder	Confirmation
1	C	B	NO
2	B	A	NO
3	C	B	NO
4	B	B	NO
5	C	B	NO
6	**C**	**C**	**YES**

No. of pairs 1

Period	Proposer	Responder	Confirmation
1	C	B	NO
2	B	A	NO
3	A	A	NO
4	B	A	NO
5	A	A	NO
6	**C**	**C**	**YES**

No. of pairs 1

Period	Proposer	Responder	Confirmation
1	C	C	NO
2	C	B	NO
3	B	B	NO
4	B	A	NO
5-6	B	B	NO
7	**C**	**C**	**YES**

No. of pairs 1

Period	Proposer	Responder	Confirmation
1	A	A	NO
2-3	C	C	NO
4	D	B	NO
5	C	C	NO
6	B	A	NO
7-8	C	C	NO
9	D	B	NO
10	C	C	NO
11	D	C	NO
12	C	C	NO
13	D	C	NO
14	C	A	NO
15-16	C	C	NO
17	D	D	NO
18	B	B	NO
19	C	B	NO
20-21	C	C	NO
22	**C**	**C**	**YES**

B.2 Other outcomes on the diagonal

Dialogue 7
P ***fights a lot, substantially or slightly*** *, R* ***maximizes his/her payoff***
Finally P ***substantially fights*** *, R* ***maximizes his/her payoff***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	C	B	NO
	2	A	A	NO
	3	**B**	**B**	**YES**

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	B	A	NO
	2	C	B	NO
	3	C	A	NO
	4	**B**	**B**	**YES**

Dialogue 8
P ***fights a lot*** *, R* ***maximizes his/her payoff***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	**A**	**A**	**YES**

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	A	A	NO
	2	**A**	**A**	**YES**

Dialogue 9
Firstly P ***substantially fights*** *, R* ***maximizes his/her payoff***
Finally P ***fights a lot*** *, R* ***maximizes his/her payoff***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	B	A	NO
	2	**A**	**A**	**YES**

B.3 Outcomes favouring the proposer

Dialogue 10
P ***fights a lot***, *R* ***is not smart***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	**A**	**C**	**YES**

Dialogue 11
P ***slightly fights***, *R* ***is not smart***

No. of pairs	Period	Proposer	Responder	Confirmation
3	1	**C**	**D**	**YES**

B.4 Outcomes favouring the respondent

Dialogue 12
P ***substantially fights***, *R* ***maximizes his/her payoff*** *and P* ***is not smart***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	**B**	**A**	**YES**

C Pre-play strategies as tacit messages - Treatment *Cournot-Sym*

C.1 Outcome on the diagonal, strongly Pareto-efficient

Dialogue 1

P (odd periods) ***slightly fights*** *, R (odd periods)* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
5	1	**C**	**C**	**YES**

Dialogue 2

P (odd periods) ***fights a lot*** *, R (odd periods)* ***maximizes (minimizes) his/her (the other's) payoff***

Then P (even periods) ***slighly fights*** *, R (even periods)* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	A	B	NO
	2	**C**	**C**	**YES**

Dialogue 3

P (odd periods) ***substantially fights*** *, R (odd periods)* ***maximizes his/her payoff***

Then P (even periods) ***slighly fights*** *, R (even periods)* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	B	A	NO
	2	**C**	**C**	**YES**

Dialogue 4

Firstly P (odd periods) ***substantially fights*** *, R (odd periods)* ***maximizes his/her payoff***

Then P (even periods) ***slightly fights*** *, R (even periods)* ***maximizes his/her payoff***

Finally B (odd periods) ***slightly fights*** *, R (odd periods)* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	B	B	NO
	2	C	B	NO
	3	**C**	**C**	**YES**

Dialogue 5

Firstly P (odd periods)) ***does not or slightly fights*** *, R (odd periods)* ***maximizes his/her payoff***
Then P (even periods) ***substantially fights*** *, R (even periods)* ***maximizes his/her payoff***
Finally P (odd periods) ***slightly fights*** *and R (odd periods)* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	D	A	NO
	2	B	B	NO
	3	C	B	NO
	4	B	B	NO
	5	**C**	**C**	**YES**

Dialogue 6

Firstly P (odd periods) ***fights a lot or substantially*** *, R and P (odd periods)* ***are not smart***
Then P (even periods) ***fights a lot or substantially*** *, R (even periods)* ***maximizes his/her payoff***
Finally P (even periods) ***slightly fights*** *, R (even periods)* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	A	B	NO
	2-3	B	B	NO
	4	A	A	NO
	5	A	B	NO
	6	**C**	**C**	**YES**

Dialogue 7

Firstly P (odd periods) ***substantially or slightly fights*** *, R (odd periods)* ***maximizes his/her own payoff***
Then P (even periods) ***fights a lot or substantially*** *, R (even periods)* ***maximizes his/her own payoff***
Finally P (even periods) ***slightly fights*** *, R (even periods)* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	B	A	NO
	2	A	A	NO
	3	C	B	NO
	4	A	A	NO
	5	C	A	NO
	6	B	A	NO
	7	C	A	NO
	8	B	A	NO
	9	C	B	NO
	10	B	A	NO
	11	C	B	NO
	12	**C**	**C**	**YES**

C.2 Other outcomes on the diagonal

Dialogue 8
P (odd periods) ***substantially fights*** *, R (odd periods)* ***cooperates***

No. of pairs: 5

Period	Proposer	Responder	Confirmation
1	**B**	**B**	**YES**

Dialogue 9
Firstly P (odd periods) ***fights a lot*** *, R and P (odd periods)* ***are not smart***
Then P (even periods) ***slightly fights*** *, and R (even periods)* ***maximizes his/her payoff***
Finally P (odd periods) ***substantially fights*** *and R (odd periods)* ***cooperates***

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	A	D	NO
2	C	A	NO
3	**B**	**B**	**YES**

Dialogue 10
Firstly P (odd periods) ***slightly fights*** *, R (odd periods)* ***maximizes his/her payoff***
Then P (even periods) ***fights a lot*** *, P and R (even periods)* ***are not smart***
Finally P (even periods) ***fights a lot*** *, R (even periods)* ***minimizes the other's payoff***

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	C	B	NO
2	A	C	NO
3	C	B	NO
4	**A**	**A**	**YES**

C.3 Outcomes favouring the proposer

Dialogue 11
P (odd periods) ***fights a lot*** *, R (odd periods)* ***is not smart***

No. of pairs	Period	Proposer	Responder	Confirmation
2	1	**A**	**C**	**YES**

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	**A**	**D**	**YES**

Dialogue 12
P (odd periods) ***fights a lot*** *, R (odd periods)* ***is not smart***
P (even periods) ***slightly fights*** *, R (even periods)* ***maximizes his/her payoff***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	A	D	NO
	2	C	B	NO
	3	A	A	NO
	4	C	B	NO
	5	A	A	NO
	6	C	B	NO
	7	A	A	NO
	8	C	B	NO
	9	**A**	**D**	**YES**

Dialogue 13
P (odd periods) ***substantially fights*** *, R (odd periods)* ***is not smart***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	**B**	**C**	**YES**

Dialogue 14
Firstly P (odd periods) ***fights a lot*** *, R (odd periods)* ***minimizes the other's payoff***
Then P (even periods) ***substantially fights*** *, R and P (even periods)* ***are not smart***
Finally P (odd periods) ***substantially fights*** *, R (odd periods)* ***is not smart***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	A	A	NO
	2	B	D	NO
	3	**B**	**C**	**YES**

Dialogue 15

P (odd periods) ***slightly fights*** *, R (odd periods)* ***is not smart***
P (even periods) ***fights a lot or substantially*** *, R (even periods)* ***cooperates***

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	C	D	NO
2	B	B	NO
3	C	D	NO
4	A	A	NO
5	**C**	**D**	**YES**

C.4 Outcomes favouring the respondent

Dialogue 16

Firstly P (odd periods) ***slightly fights*** *, R (odd periods)* ***cooperates*** *or* ***is not smart***
Then P (even periods) ***does not or substantially fights*** *, R (even periods) always* ***cooperates***
Finally P (odd periods) ***does not fight,*** *R (odd periods)* ***maximizes (minimizes) his/her (the other's) payoff***

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	C	C	NO
2	D	D	NO
3	C	D	NO
4	B	B	NO
5	**D**	**A**	**YES**

Dialogue 17

Firstly P (both periods) ***fights a lot*** *, R (both periods)* ***maximizes (minimizes) his/her (the other's) payoff***
Finally P ***does not fight*** *, R* ***maximizes his/her payoff***

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	A	A	NO
2	A	B	NO
3	**D**	**B**	**YES**

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	A	B	NO
2	**D**	**B**	**YES**

D Pre-play strategies as tacit messages - Treatment *Cournot-Asym*

D.1 Outcome on the diagonal, strongly Pareto-efficient

Dialogue 1
P ***slightly fights*** *, R* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	**C**	**C**	**YES**

Dialogue 2
P ***slightly fights*** *, firstly R* ***maximizes his/her payoff*** *then he/she* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	C	B	NO
	2	**C**	**C**	**YES**

Dialogue 3
P ***fights a lot*** *, R* ***maximizes (minimizes) his/her (the other's) payoff*** *, then R and P* ***are not smart***
Finally P ***slightly fights*** *, R* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	A	B	NO
	2	A	D	NO
	3	**C**	**C**	**YES**

Dialogue 4
Firstly P ***fights slightly or a lot*** *, R* ***maximizes his/her payoff***
Finally P ***slightly fights*** *, R* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	C	B	NO
	2	A	A	NO
	3	**C**	**C**	**YES**

Dialogue 5

Firstly P ***does not fight****, R* ***is not smart***

Then P ***fights a lot****, R* ***maximizes (minimizes) his/her (the other's) payoff***

Finally P ***slightly fights****, R* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	D	C	NO
	2	A	B	NO
	3	**C**	**C**	**YES**

Dialogue 6

P ***fights substantially, a lot or slightly****, R* ***cooperates*** *or* ***maximizes his/her payoff***

Finally P ***slightly fights****, R* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	B	B	NO
	2	B	A	NO
	3	B	B	NO
	4	B	A	NO
	5	A	A	NO
	6-8	B	B	NO
	9	C	A	NO
	10-11	B	B	NO
	12	A	A	NO
	13	B	B	NO
	14	C	B	NO
	15	B	B	NO
	16	**C**	**C**	**YES**

Dialogue 7

Firstly P ***fights substantially or a lot****, R* ***cooperates***

Finally P ***slightly fights****, R* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	B	B	NO
	2-7	A	A	NO
	8	**C**	**C**	**YES**

Dialogue 8

P ***fights a lot, substantially or slightly*** *, R* ***cooperates*** *most of the times*

Finally P ***slightly fights*** *, R* ***cooperates***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	C	C	NO
	2-3	A	A	NO
	4	D	A	NO
	5	B	B	NO
	6	A	A	NO
	7	C	C	NO
	8	A	A	NO
	9	B	A	NO
	10	A	A	NO
	11	D	A	NO
	12	A	A	NO
	13	B	B	NO
	14-15	C	B	NO
	16	**C**	**C**	**YES**

D.2 Other outcomes on the diagonal

Dialogue 9
P ***substatially fights***, *R* ***maximizes his/her payoff***

No. of pairs: 2

Period	Proposer	Responder	Confirmation
1	**B**	**B**	**YES**

Dialogue 10
P ***slightly fights***, *R* ***cooperates***
Then P ***does not fight***, *R* ***cooperates***

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	C	C	NO
2	**D**	**D**	**YES**

Dialogue 11
P ***fights a lot***, *R* ***minimizes the other's payoff***

No. of pairs: 2

Period	Proposer	Responder	Confirmation
1	**A**	**A**	**YES**

D.3 Outcomes favouring the proposer

Dialogue 12
P ***fights a lot*** *, R* ***maximizes (minimizes) his/her (the other's) payoff***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	**A**	**B**	**YES**

Dialogue 13
P ***fights a lot*** *, R* ***maximizes his/her payoff***

No. of pairs	Period	Proposer	Responder	Confirmation
2	1	**A**	**C**	**YES**

Dialogue 14
P ***slightly fights*** *, R* ***cooperates***
Then P ***fights a lot*** *, R* ***maximizes his/her payoff***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	C	C	NO
	2	**A**	**C**	**YES**

Dialogue 15

P ***fights a lot, substantially or slightly*** *, R* ***cooperates*** *or* ***maximizes his/her payoff***

Finally P ***fights a lot*** *and* ***R maximizes his/her payoff***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	A	C	NO
	2-4	A	B	NO
	5	A	C	NO
	6	A	A	NO
	7	B	B	NO
	8	A	C	NO
	9	A	A	NO
	10	B	B	NO
	11	A	A	NO
	12	A	B	NO
	13	**A**	**C**	**YES**

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	D	D	NO
	2-3	C	C	NO
	4	A	A	NO
	5	B	B	NO
	6	A	B	NO
	7	B	B	NO
	8	C	C	NO
	9	B	C	NO
	10-11	B	B	NO
	12-13	C	C	NO
	14-17	B	B	NO
	18	C	C	NO
	19	**A**	**C**	**YES**

Dialogue 16

P fights a lot, substantially or slightly , *R cooperates* *or* *maximizes his/her payoff*

Finally, P ***substantially fights*** *, R* ***is not smart***

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	A	C	NO
2	B	B	NO
3	C	C	NO
4	B	C	NO
5	A	A	NO
6	B	A	NO
7	A	A	NO
8	C	C	NO
9	B	C	NO
10	D	D	NO
11	B	A	NO
12	B	B	NO
13	C	C	NO
14	A	C	NO
15	D	C	NO
16	D	D	NO
17	A	B	NO
18	D	A	NO
19	C	D	NO
20	A	A	NO
21	B	B	NO
22	C	C	NO
23	A	A	NO
24	A	B	NO
25	C	B	NO
26	B	B	NO
27	C	C	NO
28	D	A	NO
29	A	B	NO
30	B	B	NO
31	C	B	NO
32	B	C	NO
33	B	B	NO
34	**B**	**C**	**YES**

Dialogue 17

P ***substantially fights*** *, R* ***is not smart***

No. of pairs: 1

Period	Proposer	Responder	Confirmation
1	B	C	NO
2	**B**	**C**	**YES**

D.4 Outcomes favouring the respondent

Dialogue 18
P ***fights a lot, substantially or slightly*** *, R* ***cooperates*** *most of the times*
Finally P ***slightly fights*** *, R* ***maximizes (minimizes) his/her (the other's) payoff*** *, P* ***is not smart***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	B	D	NO
	2	C	C	NO
	3	B	A	NO
	4	A	B	NO
	5	A	A	NO
	6	B	B	NO
	7	A	A	NO
	8	D	C	NO
	9	C	D	NO
	10	A	A	NO
	11	C	C	NO
	12	B	B	NO
	13	A	A	NO
	14	**C**	**A**	**YES**

Dialogue 19
Firstly P ***slightly fights*** *, R* ***maximizes his/her payoff***
Then P ***does not fight*** *, R* ***cooperates***
Finally P ***slightly fights*** *, R* ***maximizes his/her payoff***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	C	B	NO
	2	D	D	NO
	3	**C**	**B**	**YES**

Dialogue 20
P ***substantially or slightly fights*** *, R* ***is not smart***
Finally P ***does not fight*** *, R* ***maximizes his/her payoff***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	C	B	NO
	2	B	C	NO
	3	**D**	**A**	**YES**

Dialogue 21

P ***does not, slighly or substantially fights** , R* ***maximizes his/her payoff***

Finally P ***does not fight** , R* ***maximizes his/her payoff***

No. of pairs	Period	Proposer	Responder	Confirmation
1	1	C	B	NO
	2	B	A	NO
	3	D	A	NO
	4	**D**	**B**	**YES**