The role of mandatory and voluntary joint bidding in promoting efficiency in conservation auction

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Abstract

In this paper, we conduct a lab experiment to investigate the effectiveness of voluntary and mandatory joint bidding in promoting the performance of the conservation auction. Our results suggest that joint bidding treatments (either voluntary or mandatory) are more effective in encouraging auction performance than the baseline (i.e., single bidding auction). However, voluntary joint bidding treatment with/without bonus incentives performs worse than mandatory treatments in promoting auction outcomes. Moreover, the self-selection of participants (e.g., value/cost of their environmental items or their other-regarding preferences) into joint bidding teams should be carefully considered by policymakers in designing the joint bidding auctions.

Keywords: Auction; Conservation; Mandatory; Joint bidding; Voluntary.

JEL codes: C57, C90, D70, Q50.

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1 Introduction

Ecosystems (e.g., forest ecosystems) are a critical component of the global biodiversity that provides environmental goods and services, such as carbon storage, erosion control or recreation services (Myers, 1996; Klooster and Masera, 2000; Alix-Garcia and Wolff, 2014; FAO and UNEP, 2020). Payments for ecosystem services (PES) aim to encourage agricultural or forest activities that produce positive or less negative environmental externalities. PES are allocated to producers for adopting conservation efforts and can be implemented by social and conservation planners to achieve environmental goals. However, conservation costs are often unknown to policymakers; in addition, conservation costs can be very heterogeneous among producers depending both on land characteristics and on their management practices. Conservation auctions appear as a potential solution to overcome this problem of asymmetric information since these allocation mechanisms help to reduce rent-seeking behavior (Kits et al., 2014). For example, conservation auctions are implemented by the Biodiversity Finance Initiative of the United Nations and the Conservation Reserve Program in the US.

This paper studies conservation auctions a type of procurement or reverse auctions) in a lab experiment taking biodiversity as an example of environmental good to be protected. In addition, we test if joint bidding can perform better, and compare a voluntary context to a mandatory one. When voluntary, participants are free to joint bid or not whereas, when mandatory, they are obliged to joint bid. We test as well two types of incentives. When participants are forced to collaborate, we test how communication between them can enhance the joint bidding process. When participants only voluntarily collaborate, we allow them to communicate and test the effect of a bonus payment. Our results confirm that the performance of these auctions depends on cost heterogeneity but not on risk preference (Boxall et al, 2013. . .). Our results show as well that conservation auctions are more cost-efficient when participants are obliged to bid in a joint bidding process and when they can communicate. When joint bidding remains a voluntary decision, auction efficiency is lower, all the more so in the event of a bonus. Moreover, communication in a voluntary context tends to diminish efficiency as bids are higher than the ones we obtained in a mandatory context.

Conservation auctions is one way to decrease informational rents among other solutions like screening contracts or gathering information on observable behaviors (Ferraro, 2008). In conservation auctions, there are many rules of pricing: discriminative/uniform-price auctions, sealed/open-bid auctions, private/common-value auctions, sequential/simultaneous auctions, single-shot/repeated auctions. . . Discriminative-price auctions seem to be more efficient in revealing prices closer to landowners' opportunity costs (Latacz-Lohmann and Van der Hamsvoort, 1997). However, conservation auctions are recent as well as their experimental study (Schilizzi, 2017), and many questions remain about the optimal design. In identifying key insights and contributions from the experimental literature on conservation auctions, like auction format, implementation rules, bidders' characteristics and behaviours, and auction performance, Schilizzi (2017) pinpointed some pending issues like the existence of a market for '*conservation auctions in the private sector or mixed private/public sector*'. Other questions relative to the comparability of results drawn from a student or a stakeholder sample are common to all experimental studies.

For conservation auctions to reduce informational rent, they require reaching enough competition among sellers. At the same time, some environmental benefits are spatially supra additive, which advocates for collaboration and cooperation between sellers.Indeed, existing literature has suggested that a conservation measure that would be adopted by some landowners could have external effects on their neighborhood often located in a relatively cohesive geographical area (Parkhurst et al., 2002; Banerjee et al., 2012, 2014). Specifically, individuals could gain additional conservation benefits from their neighbours' efforts to enrol their own parcels of land, known as co-benefits, agglomeration, network, or edge benefits. It would then enhance the effectiveness of the conservation projects by harnessing the complementarities across bidders. Agglomeration bonuses for contiguous plots and joint bidding in teams are two possibilities to get bidders to collaborate, and consequently obtain higher environmental results.

Usually, an agglomeration bonus (or contiguity bonus, Banerjee, 2011) is an extra payment to participants to motivate on-site synergies, using most of the time adjacency (Banerjee et al., 2012; Hanley et al., 2012; Liu et al., 2019) . Bonus payments have been suggested as a measure to cope with spatial externalities in PES programs. Thus, conservation goals could be more easily achieved when targeting policy to a group of individuals rather than single ones (Banerjee et al., 2012; Calel, 2012; Banerjee et al., 2014).

Joint-bidding auctions can be an interesting alternative tool to promote spatial coordination. Joint bidding "*is the practice of two or more similar firms submitting a single bid*", for which there exists a regulation in Europe (Albano et al., 2009). Joint bidding is a way to create interdependence between group members and has the potential to decrease transaction costs for governments. Joint bidding seems more relevant in environmental protection especially when suppliers (farmers of foresters) are close from a spatial point of view. In addition to the environmental edge benefits, a joint-bidding auction may result in a higher level of pro-environmental behavior (Dall'Asta et al., 2012; Tagkaloglou and Kasser, 2018). Some literature suggested that joint participation increases auction efficiency and seller revenue because joint bidders are more likely to have higher valuations and submit higher bids (Rondeau et al., 2016). One study suggested that joint bidding is preferable to a single bid since it reduces payments for taking conservation measures (Calel, 2012). In another study, the authors indicated that joint bidding could improve environmental outcomes by encouraging coordination among bidders and reducing competitiveness (i.e., the number of bids is lower) (Banerjee et al., 2021).

Joint bidding specifically questions the willingness of individuals to associate in a voluntary way. In addition, the joint-bidding scheme in a voluntary context raises questions of economic efficiency and effectiveness : are there enough sellers willing to joint bid, who are those who decide to joint bid in terms of cost and value of their environmental item, and what is the effect of a payment bonus? Joint bidding also requires that all neighbours concerned agree to participate as a team. However, joint bidding can also induce hold-out and collusion (Ferraro, 2008), then reducing competition between sellers, and *in fine* efficiency. Indeed, as it is impossible to outlaw communication between sellers who bid in a team, participants will share their private information. Society and regulators have to anticipate it. Furthermore, the self-selection issue generated by voluntary participation is a problem that should be carefully considered.

Do voluntary programs generate better results than mandatory ones in environmental conservation in general ? Choosing between a voluntary or a mandatory scheme can be influenced by ideological considerations, but at least two questions are constantly worth investigating : how to achieve a higher environmental state of service, and is it cost-efficient? To achieve environmental objectives, most of the regulations tend to be mandatory ones, not allowing any flexibility and being rather costly in the implementation and in the control. In addition, such mandatory schemes tend to produce adversarial relationships (Borck and Coglianese, 2009) and free-riding behaviours. But, even if governments tend to develop voluntary environmental programs for instance to reduce costs for governments or conflicts between firms and governments, success in effectiveness in terms of environmental issues is mainly due to some regulatory threats (Coglianese and Nash, 2016). Looking at the agricultural sector in particular, it was shown that the effectiveness of voluntary programs often requires incentivising participation, ensuring additionality, improving environmental outcomes, and/or labeling, but these conditions are not always easy to achieve (Segerson et al., 2013).

Only a handful of studies looked at the sensitivity of payments to whether they took place in a mandatory or voluntary context. Carneiro and Carvalho (2014) is an example. They showed that under collective and mandatory payments, WTP are higher than under individual and voluntary ones. Concerning the payment vehicle, a debate has arisen over whether different methodological approaches assess the efficiency of either collective and mandatory or individual and voluntary payment to achieve conservation goals (Wiser, 2007), but not many studies have investigated on the sensitivity of WTP to whether payments have to be made collectively or voluntarily (Stithou and Scarpa, 2012). In our article, it is a real and not hypothetical WTA.

The effects of communication on efficiency in experiments in general, and in experimental auctions in particular, are ambiguous. Communication between bidders can positively impact environmental performance, depending on the way people communicate (e.g., face to face, or not), the size of group social dilemmas. Communication can also enhance public good provision, through some necessity of trust between landowners and government. However, as mentioned earlier, it can also induce collusion and contribute to decrease auctions' cost effectiveness (Balliet, 2013; Vogt et al, 2013, Tóth et al., 2009, Rabotyagov et al., 2013). But collusion is not automatic, and communication can overall ~~somehow help participants to~~ improve environmental outcomes and global efficiency (Krawczyk et al, 2016).

The main objective of our study is to investigate the effectiveness of voluntary and mandatory joint bidding in promoting the performance of conservation auctions. Banerjee et al. (2021) did compare the impacts of agglomeration bonuses and voluntary joint bidding on auction efficiency, but did not consider mandatory joint bidding. Our study also aims to assess the impact of communication on joint bidding auction performance. More specifically, due to the complexity of joint bid submission, communication helps bidders to transmit information and coordinate with their partner and thus could positively impact auction efficiency. Last, since in joint-bidding auctions bidding behaviours depend not only on social knowledge (i.e., information about the value and cost of their partners' environmental items) but also on their partners' decisions, we examine the role of individual risk and other-regarding preferences (i.e., whether they care about the outcomes for others) in determining the auction outcome.

We test conservation auctions in a lab experiment using discriminatory pricing. We implement a control treatment with individual bids, two treatments of joint bidding within a mandatory context, and two other treatments of joint bidding within a voluntary context. Communication between participants is allowed in one of the treatments in the mandatory context and in both voluntary contexts. A payment bonus is implemented as an incentive to collaborate in the second treatment of the voluntary context. We implement an economics with a between-subject design experiment to test the difference between the modes of collaboration between participants taking the single effect of communication and the combined one of communication and bonus in the voluntary context. We look at auction efficiency both through environmental performance and bidding price. Then, the determinants of individual bidding behavior are analysed in the two contexts. Finally the joint decisions as well as the winners' behaviors are estimated.

The remainder of this study is organized as follows. In Section 2, we discuss the theoretical framework and present theoretical predictions. Section 3 describes the experimental design. Estimation results are presented in Section 4. Section 5 is devoted to discussion and conclusion.

2 Single- and joint-bidding conservation auctions

Let us consider that there are N landowners (e.g., foresters or farmers) competing in a pay-as-bid conservation auction, in which bidders receive payments equal to their bidding price for each good they sell. Each landowner participates in several rounds, each time with a different environmental item in terms of cost (with a high random cost $\bar{c}_i$ or low random cost $\underline{c}_i$), environmental value (high $\bar{v}_i$ or low $\underline{v}_i$), and random environmental bonus value b_i. The heterogeneity in the environmental value can be justified by, e.g., the diversity in the sizes of the plots, the number of species on the plot.

Let p_i be the producer i's single-bidding price and $x_i = 1$ if i wins the auction. Thus, i's expected payoff could be written as follows:

$$E[\pi_i^S(p_i)] = (p_i - c_i)Pr[x_i = 1]. \tag{1}$$

Regarding the mandatory joint-bidding context, each producer ~~could decide to~~ submits a joint bid with their neighbours. For simplicity, we consider each producer to be assigned to a team of two. Thus, N producers result in $K = \frac{N}{2}$ joint bidding teams. Let p_d be the joint bidding price of the team d. When bidders participate in a joint bid, each team member will give an individual joint bidding price for their team. The average of these two prices will give the final joint bidding price of the team. Thus, we have $p_d = \frac{p_{i,d}+p_{j,d}}{2}$ for all $i, j \in d$. The sum of the individual costs will be the total cost of the team. Thus, bidder i's expected payoff in team d can be written as follows:

$$E[\pi_{i,d}^J(p_{i,d})] = \frac{1}{2}\left(p_d - \sum_{i\in d} c_i\right) Pr[x_d = 1]. \tag{2}$$

$$E[\pi_{i,d}^J(p_{i,d})] = p_d - \frac{1}{2}\left(\sum_{i\in d} c_i\right) Pr[x_d = 1]. \tag{3}$$

For a given landscape structure, the regulator or auctioneer uses a conservation auction to optimize the total environmental benefits within a limited budget. In the spirit of Banerjee et al. (2021), along with evaluating the auction performance that only accepts individual bidders, our design allows us to take both individual and joint bids. Let v_s and p_s be the environmental value of and payment for the selected individual items in the case of a single bid or the selected joint item in the case of the joint bid. We consider that the regulator uses the discriminatory pricing rule to optimally select individuals' and combinations of individuals' items s that maximize the following environmental benefit function.

$$\max_s V(x_s) = \sum_s \frac{v_s + b_s}{p_s} x_s, \tag{4}$$

$$s.t., \sum_s p_s x_s \leq W, \tag{5}$$

where W is the regulator's budget constraint. The auction performance is measured using the ratio between environmental value and price (i.e., how much environmental quality gained per dollar spent), also known as the Cost-Effectiveness Score (CES)(see Equation (4)). The benefits of spatial coordination between two bidders are evaluated by the regulator if both connected bidders win the auction. We assume that joint bidding provides a higher total environmental value than single counterparts, i.e., $v_i + b_i > v_i$ for any $b_i > 0$. Moreover, joint participation could help incentivize adjacent landowners to collaborate to achieve a common target, thus encouraging them to submit a more competitive joint bid that may not otherwise be submitted. Therefore, our first hypothesis is as follows:

Hypothesis 1: Joint bidding could be more efficient than single bidding in promoting auction efficiency.

We also test the voluntary joint-bidding context, which gives bidders the choice to get into a joint-bidding scheme or not. In other words, participants can decide to join a team with their assigned partner or play as a single bidder. From Equation (1) and (3), we observe that bidders prefer joint bidding to single bidding if and only if

$$E[\pi^J_{i,d}(p_{i,d})] \geq E[\pi^S_i(p_i)]. \tag{6}$$

For given bidding prices p_d and p_i such that $\frac{1}{2}\left(p_d - \sum_{i \in d} c_i\right) = p_i - c_i$, the inequality (6) holds if and only if $Pr[x_d = 1] \geq Pr[x_i = 1] \Leftrightarrow \frac{v_i+v_j+b_i+b_j}{p_d} \geq \frac{v_i}{p_i}$. Thus, individual bidders with a higher environmental value than their partners would have a lower probability of joining a team. On the other hand, for given bidding pricse p_d and p_i such that $Pr[x_d = 1] = Pr[x_i = 1]$, individual bidders with a higher cost compared to their partners are more likely to make the team with their partner. Therefore, our second hypothesis is as follows:

Hypothesis 2: Bidders with lower environmental values and higher costs are more likely to join a team than other counterparts.

To further incentivise joint participation, bidder i can also receive a bonus payment $M_d > 0$ if he or she joins team d and the team wins the auction. We assume that team d's bonus monetary incentive for participation in joint bidding equal to $M_d = \sum_{i \in d} b_i \delta$, where $\delta > 0$ is the parameter of the bonus monetary incentive. Thus, bidder i's expected payoff in the team d is written as follows:

$$E[\pi^J_{i,d}(p^J_{i,d})] = \frac{1}{2}\left(p^J_d + \sum_{i \in d}(b_i\delta - c_i)\right) Pr[x_d = 1]. \quad (7)$$

It is straightforward that a bonus payment incentive would help promote joint participation, but it is more costly for the regulator to acquire joint projects. However, as previously mentioned, joint participation could encourage bidders to collaborate to achieve an environmental target. Moreover, bonus payments could incentivize them to submit a more competitive bid (i.e., lower bidding price) than the case without the bonus payment. Therefore, our third hypothesis is as follows:

Hypothesis 3: A bonus payment could incentivize joint bidding participation and encourage higher auction efficiency.

Finally, in our experiment, we also examine the impact of communication on auction efficiency in the context of mandatory joint bidding. On the one hand, the existing literature has highlighted the high risk of collusion if we allow communication in joint-bidding procurement auctions. On the other hand, it is hard to prevent neighbour landowners from communicating with each other. Moreover, since the submission of joint bids entails additional complexity, communication between team partners during the experiment can positively impact the auction outcome. In particular, communication allows bidders to transmit information, negotiate and coordinate with their partners. Therefore, our fourth hypothesis is as follows:

Hypothesis 4: Communication during the experiment could positively impact joint bidding auction efficiency.

3 Experimental design

3.1 Treatments

Five treatments were designed to assess the impacts of mandatory and voluntary joint bidding on auction performance (Figure 1). Particularly, Treatment T0 is the baseline treatment or control, where all subjects participated in a single-bidding auction. In the mandatory joint-bidding treatments (i.e., Treatments T1 and T2), all subjects were invited to participate in a joint-bidding auction, while in the voluntary joint-bidding treatments (i.e., Treatments T3 and T4), subjects were presented with the opportunity to submit both single bids and joint bids with their partners.

	Single bid (baseline)	**Joint bid**	
		Mandatory	**Voluntary**
Treatment	No treatment (T0)	No communication (T1)	Communication (T3)
		Communication (T2)	Communication and Bonus payment incentive (T4)

Figure 1: Four treatments and one control treatment.

The total five treatments were tested during 15 different experimental sessions, and only one treatment was tested in each session. In Treatment T2, subjects are assigned to the mandatory joint bidding treatment without communication. In the presence of communication, subjects assigned to Treatments T2, T3, and T4 have an opportunity to participate in a two-minute discussion via a chat box with their partners. In the presence of a bonus payment incentive (Treatment T4), subjects receive information about the bonus payment obtained if their joint bids are selected. The treatments are implemented in a balanced between-subject design.

3.2 Experimental procedure

The experiment was conducted from February to March 2022 with 60 subjects per treatment. Thus, a total of 300 students at the University of Strasbourg were recruited for the experiment. The experiment consists of four parts: Part 1 comprises a risk elicitation task; Part 2 involves an ultimatum game; Part 3 is the conservation auction; Part 4 presents a demographic survey. At the beginning of each part, subjects receive instruction and are invited to read it carefully. An experimentalist explained the instructions and answered subjects' questions before the beginning of each part.

In the first part of the experiment, subjects are invited to participate in a simple risk elicitation task with five different lotteries to capture subjects' sensitivity to risk (Eckel and

Grossman, 2008) (see Figure B.2 in Appendix B).

Part 2 of the experiment presents an ultimatum game in that Player A must choose among 11 proposals of dividing a given amount of money between himself and Player B (see Figure B.3 in Appendix B), while Player B can either accept or refuse the proposal chosen by Player A (see Figure B.4 in Appendix B) (Thaler, 1988; Blanco et al., 2011). In this game, each subject is invited to play the game as Player A (i.e., a sender) and then as Player B (i.e., a receiver). Ultimately, the computer randomly pairs them to determine the roles and payoffs.

At the beginning of Part 3, subjects are invited to participate in an eight-period conservation auction, where each subject represents a landowner who receives an environmental item. At the beginning of each period, subjects receive information about the environmental value and the cost of the item. Depending on the treatments, they are also informed about the bonus environmental value and the bonus payment incentive. High-value subjects receive $\bar{v}_i \sim U[350, 400]$, while low-value subjects receive $\underline{v}_i \sim U[200, 250]$. High-cost subjects receive $\bar{c}_i \sim U[900, 1000]$, whereas low-cost subjects receive $\underline{c}_i \sim U[600, 700]$. In all the joint-bidding treatments, a perfect stranger design is applied (i.e., no subject encounters another more than one) to ensure the balanced matching and rule out strategic joint-bidding decisions (Fehr and Gächter, 2000).

In each period of the auction, ten subjects are competing in selling their environmental item for profit or selling it as a source of ecosystem goods or services (i.e., non-timber goods/environmental goods) to a public buyer (e.g., state, representative or public agency) via an auction. The public buyer's maximization problem is to offer contracts to landowners who provide an item with high environmental value (see Equation (4)). Thus, depending on their bidding price, the winning probability and treatment (see Figure 1), subjects' payoffs can be calculated using Equations (1), (6) and (7). Before making the decision, subjects could simulate their expected payoff using a simulator (see Figure B.5 in Appendix B). In the presence of communication, subjects in a team will have two minutes to discuss with their partner via a chat box before making the decision (see Figure 2). Each subject in a joint-bidding team will be invited to give their team a joint-bidding price after the chat, and the average bidding price given by each member will be calculated as the joint bidding of the team.

In Part 4 of the experiment, we collected information from participants on various socio-demographic characteristics. In particular, we collected data on age, gender, level of education and field of education. We also elicited information on several questions related to environmental concerns via 15 modified General Environmental Behavior (GEB) scales to help us identify individual perceptions toward the environment (Kaiser and Wilson, 2000) (see Table

A.2 in Appendix A). There were also several other questions to capture participants' opinions and concerns about the environment. All questionnaires are available in the Supplementary Materials.

4 Results

This section is separated into two parts: (i) the first part focuses on the impacts of the different treatments on auction environmental performance and auction efficiency, and (ii) the second part discusses the impacts of treatments and other factors on individual bidding behaviour, i.e., bidding price and decision to participate in joint bids. Note that the the environmental performance is the total environmental benefits from the selected items, and auction efficiency is calculated based on the CES in Equation (4).

4.1 Auction efficiency

From the results of the mean-differences between treatments in Table 1 and Figure 2, we observe that subjects in all treatments submitted a more efficient bid (i.e., higher CES) than those in the baseline (i.e., single-bidding auctions). Results of the Wilcoxon Rank Sum (WRS) test in Table 1 also indicates that joint bidding auction mechanisms (either voluntary or mandatory) provide more cost-effective auction performance than the baseline.

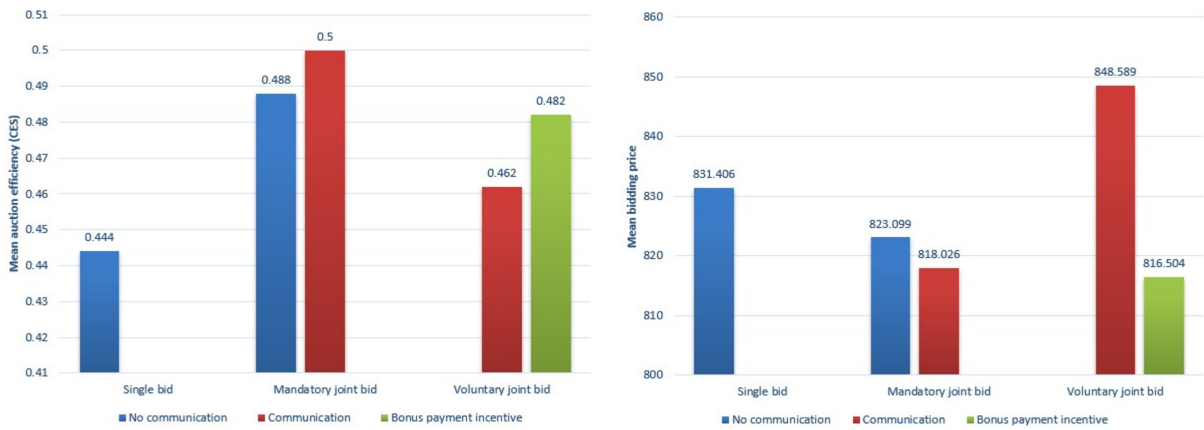

Figure 2: Histogram of mean auction efficiency (CES) and bidding price.

We also observe in Figure 2 that "Communication" helps increase the auction efficiency. In other words, subjects assigned to mandatory joint bidding with communication (i.e., Treatment T2) submitted lower bids than those in mandatory joint bidding without communication (i.e., Treatment T1). However, the results of the WRS test indicate that the difference between T2 and T1 is not statistically significant (see Table 1).

Table 1: Difference-in-mean in environmental value and auction efficiency of winning bids between treatments (Wilcoxon Rank Sum test).

	Treatment T0 vs.				Treatment T1 vs.			Treatment T2 vs.		Treatment T3 vs.
	T1	T2	T3	T4	T2	T3	T4	T3	T4	T4
Environmental value	-38.580***	-43.874***	-27.953***	-29.160***	-5.294	10.627**	9.42	15.921***	14.714**	-1.207
	(0.000)	(0.000)	(0.000)	(0.000)	(0.731)	(0.022)	(0.098)	(0.003)	(0.034)	(0.577)
Efficiency (CES)	-0.044***	-0.056***	-0.018**	-0.038***	-0.012	0.026***	0.006	0.038***	0.018**	-0.020***
	(0.000)	(0.000)	(0.011)	(0.000)	(0.266)	(0.000)	(0.397)	(0.000)	(0.041)	(0.006)

Notes: p-value of the Wilcoxon Rank Sum test in parentheses.
** $p < 0.05$; *** $p < 0.01$.

Comparing the differences between voluntary and mandatory treatments, we observe that mandatory treatment "T2" performs better than the voluntary one "T3" in promoting auction outcome (i.e., improved efficiency and lower bidding price). Moreover, in the case of a bonus payment incentive to encourage joint participation, our result suggests that individuals who received bonus payment incentives submitted lower bidding prices only compared to Treatment T3 (see Figure 2 and Table 1). Thus, implementing the voluntary joint bidding auction could harm the auction performance, especially with no bonus payment incentives.

4.2 Individual bidding behavior

This section analyzes the impact of different treatments on individual bidding decisions and joint participation. In particular, we evaluate the factors that influence subjects' bidding patterns related to the submission of single/joint bids, their decision to join a team with their partner, and their probability of winning across all treatments. The estimation results with bootstrapped standard errors are reported in Tables 3 and 4. The descriptive statistics of all the variables are reported in Table 2.

Table 2: Descriptive statistics and variable definitions.

	Definitions	Mean	Std.Dev	Min	Max
Dependent variables					
Bidding decision	Log of subjects' bidding price.	6.770	0.155	6.404	7.090
Joint decisions	=1 if a subject assigned to a Voluntary joint bidding auction decides to join a team with her partner.	0.815	0.387	0	1
Winnings	=1 if a subject wins the auction.	0.415	0.492	0	1
Explanatory variables					
Mandatory	=1 if a subject is assigned to a Mandatory bidding auction (Treatment T1).	0.20	0.40	0	1
Mandatory & Com	=1 if a subject is assigned to a Mandatory joint bidding auction with communication (Treatment T2).	0.20	0.40	0	1
Voluntary & Com	=1 if a subject is assigned to a Voluntary joint bidding auction with communication (Treatment T3).	0.20	0.40	0	1
Voluntary & Com & Bonus	=1 if a subject is assigned to a Voluntary joint bidding auction with communication and bonus payment incentives (Treatment T4).	0.20	0.40	0	1
Bonus payment	Log of bonus payment.	0.623	1.552	0	4.758
Value	Log of environmental value.	5.668	0.249	5.303	5.986
Cost	Log of cost.	6.662	0.196	5.881	6.907
Bonus value	Log of bonus value.	2.680	1.937	0	4.353
Control variables					
Period	Experimental period.	4.50	2.29	1	8
Socio-demographic variables					
Female	=1 if an individual is female.	0.570	0.495	0	1
Age (in log)	Log of individual age.	3.084	0.139	2.890	3.689
Age (in years)	Individual age.	22.070	3.427	18	40
Psychological variables					
Environmental attitude	Aggregate score of 15 Environmental Attitude questions.	44.390	4.786	31	57
Risk	Respondents' switching point in the risk elicitation task.	3.097	1.433	1	5
Altruism	=1 if respondents decided to give at least or more than one half of their initiate endowment to their partner.	0.453	0.497	0	1
Descriptive norm	=1 if respondents believed that most of their friends is taking actions to protect the environment.	0.780	0.414	0	1
Injunctive norm	=1 if respondents believed that the actions to protect the environment will be approval by most of their friends.	0.833	0.372	0	1

The variables "Value", "Cost" and "Bonus value" are continuous variables used to control for subjects' heterogeneity in the value of items' cost and quality. The variable "Period" is used to control for the time trend. Treatments T1, T2, T3 and T4 are dummy variables that take a value of 1 if an individual is assigned to Treatments T1, T2, T3 and T4, respectively. "Risk" is a category variable that takes a value from 1 to 5, presenting the subjects' switching points in the risk elicitation task. This variable is used to capture the subjects' level of risk aversion. Other variables, including "Female", "Age", "Environmental attitude", etc., are to capture subjects' demographic and psychological characteristics.

Results of Models (1) and (2) in Table 3 show that all treatments perform better than the baseline (i.e., single bidding auction) in encouraging subjects to submit a more competitive bid (i.e., lower joint bidding prices), except for the voluntary joint bid with communication (Treatment T3). These results confirm our previous findings that joint bidding auction mechanisms are better than single bids in encouraging auction efficiency. Therefore, Hypothesis 1 is satisfied.

Moreover, we observe that Treatment T2 negatively impacts individuals' bidding prices (see Model (3) of Table 3), meaning that communication could help encourage bidders to submit lower bids. However, the results of WRS in Table 1 suggest that it could not significantly influence the auction efficiency. Thus, communication could help reduce the bidding price, but it could not significantly influence the auction efficiency. Therefore, Hypothesis 4 is not satisfied.

From Model (4) in Table 3, we observe that Treatment T3 positively impacts individuals' bidding decisions, suggesting that voluntary joint bidding is worse than mandatory joint bidding in lowering subjects' joint bidding prices. In addition to voluntary joint bid, Results of Model (5) in Table 3 suggest that the bonus payment incentives help motivate subjects to submit a more competitive bid (i.e., lower joint bidding prices) compared to the case without payment incentives. However, according to the WRS test in Table 1, voluntary treatment with bonus payment (Treatment T4) does not perform better than the mandatory joint bid (Treatments T1 and T2). Therefore, Hypothesis 3 is partially satisfied.

Looking at the result of the joint decisions (see Models (6) and (7) in Table 4), we observe that voluntary joint bidding with communication and bonus incentives (Treatment T4) could not significantly impact subjects' decisions to join a team with their partners. Moreover, subjects with a lower cost and higher value seem less likely to join a team with their partners. Thus, Hypothesis 2 is satisfied. This is a strategic situation because the high-cost and low-value participants always have a lower probability of winning when they play as a single bidder than joining a team with their partner. Thus, joining a team, in this case, seems to be a good decision from the subjects' point of view.

Moreover, we observe that the variable "Altruism" is negative and statistically significant, meaning that other-regarding participants would be less likely to join a team. This could be

Table 3: Estimation results of individual bidding behavior.

		Mandatory		Voluntary	
	Full sample	No communication (T0 vs. T1)	Communication (T1 vs. T2)	Communication (T2 vs. T3)	Communication & Bonus (T3 vs. T4)
Variables	(1)	(2)	(3)	(4)	(5)
Value	0.087***	0.101***	0.029***	0.101***	0.101***
	(0.016)	(0.016)	(0.008)	(0.016)	(0.016)
Cost	-13.388***	-11.803***	-11.104***	-12.609***	-11.611***
	(3.014)	(3.069)	(1.536)	(3.045)	(3.066)
$Cost^2$	1.039***	0.921***	0.876***	0.982***	0.907***
	(0.226)	(0.230)	(0.115)	(0.228)	(0.230)
Bonus value	0.001***	0.0004***	0.0005***	0.0004***	0.0004***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Treatments					
Mandatory	-0.066***	-0.011**	-	-	-
	(0.015)	(0.005)			
Mandatory & Com	-0.080***	-	-0.015***	-	-
	(0.015)		(0.005)		
Voluntary & Com	-0.015	-	-	0.035***	-
	(0.012)			(0.007)	
Voluntary & Com & Bonus	-0.062***	-	-	-	-0.015**
	(0.013)				(0.007)
Control variables					
Period	-0.006***	-0.006***	-0.006***	-0.006***	-0.006***
	(0.001)	(0.001)	(0.0009)	(0.001)	(0.001)
Risk	-0.002	-0.003	0.0006	-0.002	-0.002
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Altruism	-0.003	-0.003	0.001	-0.002	-0.002
	(0.006)	(0.006)	(0.004)	(0.006)	(0.006)
Age (in log)	-0.025	-0.025	-0.037**	-0.022	-0.014*
	(0.024)	(0.024)	(0.016)	(0.024)	(0.024)
Female	-0.003	-0.003	-0.005	-0.004	-0.003
	(0.006)	(0.007)	(0.004)	(0.006)	(0.007)
Environmental attitude	0.001*	0.001*	0.0008*	0.001*	0.001*
	(0.0006)	(0.0007)	(0.0004)	(0.0006)	(0.0007)
Descriptive norm	-0.003	-0.001	0.004	-0.003	-0.002
	(0.008)	(0.008)	(0.005)	(0.008)	(0.008)
Injunctive norm	0.001	0.002	-0.0001	0.003	0.003
	(0.006)	(0.009)	(0.006)	(0.009)	(0.009)
Intercept	49.289***	43.890***	41.770***	46.551***	43.223***
	(10.031)	(10.212)	(5.118)	(10.134)	(10.204)
Observations	2400	960	960	960	960
Number of subjects	300	120	120	120	120
Adjusted R^2	0.539	0.515	0.463	0.502	0.544

Note: Dependent variable is the log of individual bidding price.
Bootstrapped standard errors in parentheses with 500 bootstrap replications.
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

because they are afraid that when they are on the team, their decisions could influence their partners' outcomes. Therefore, the self-selection of participants could make the voluntary joint bidding treatment become worse than the mandatory one.

Table 4: Estimation results of joint decisions and probability of winning.

	Joint decisions		Winnings	
Variables	(6)	(7)	(8)	(9)
High value	-1.523***	-1.094***	2.663***	2.037***
	(0.257)	(0.350)	(0.117)	(0.163)
Low cost	-1.543***	-1.122***	1.784***	1.118***
	(0.259)	(0.348)	(0.113)	(0.169)
High value*Low cost	-	-0.921**	-	1.096***
		(0.429)		(0.226)
Bonus value	5.164	5.163	0.091***	0.099***
	(164.942)	(163.067)	(0.030)	(0.031)
Team	-	-	0.730***	0.749***
			(0.130)	(0.130)
Voluntary & Com & Bonus (Treatment T4)	0.184	0.219	-	-
	(0.272)	(0.274)		
Control variables				
Period	0.024	0.027	0.004	-0.001
	(0.058)	(0.058)	(0.022)	(0.022)
Risk	-0.023	-0.012	0.021	0.023
	(0.086)	(0.087)	(0.037)	(0.038)
Altruism	-0.582**	-0.570**	0.086	0.092
	(0.266)	(0.267)	(0.104)	(0.105)
Age (in log)	-0.132	-0.264	-0.360	-0.410
	(0.906)	(0.910)	(0.393)	(0.398)
Female	-0.366	-0.318	0.023	0.013
	(0.275)	(0.276)	(0.112)	(0.113)
Environmental attitude	0.003	-0.001	-0.003	-0.002
	(0.025)	(0.026)	(0.011)	(0.011)
Descriptive norm	-0.156	-0.161	0.087	0.075
	(0.392)	(0.396)	(0.140)	(0.142)
Injunctive norm	-0.298	-0.246	-0.085	-0.100
	(0.408)	(0.410)	(0.157)	(0.158)
Intercept	2.426	2.720	-2.080	-1.469
	(3.167)	(3.186)	(1.326)	(1.344)
Observations	960	960	2400	2400
Number of subjects	120	120	300	300
Log likelihood	-186.808	-185.275	-1148.849	-1137.400

Note: Bootstrapped standard errors in parentheses with 500 bootstrap replications.
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

5 Discussion and conclusion

The findings in our paper suggest that policymakers should be careful about the design of conservation auctions if they want to include joint bidding. Our main result suggests that the voluntary joint bidding auction does not seem more effective than the mandatory joint bidding auction in promoting auction efficiency. We observe that other-regarding participants (i.e., altruists) are less likely to participate in a joint bidding auction than other individuals. Thus, other-regarding preferences could be a reason for subjects to self-select into single bids (i.e., they are less likely to join a team with their partner) in our joint bidding auction experiment. This result is in line with the existing literature that the self-selection of participation (e.g., due to highly prosocial, self-regarding, pro-environmental, etc.) generated by a voluntary joint bidding auction mechanism may harm auction efficiency (Anderson et al., 2013; Cooper and Kagel, 2016; Jack and Jayachandran, 2019). For instance, altruistic individuals tend not to participate in a prosocial or pro-environmental program since they signal prosocial and pro-environmental behavior at the cost compared to other selfish individuals (Eckel and Grossman, 2000; Gautier and Klaauw, 2012). Therefore, further research should carefully take self-selection into consideration when implementing treatments allowing voluntary participation.

Moreover, a well-designed joint bidding auction with communication allows bidders to negotiate, coordinate and express their preferences to others in their groups. In other words, communication could result in more socially responsible bidding by allowing individuals to discuss and transmit information to their partners (Jerdee and Rosen, 1974). However, our study suggests that communication between subjects in a group helps facilitate coordination by reducing the bidding price and thus improving overall auction efficiency. Existing literature has suggested that a chat could facilitate spatial coordination but also encourage collusion since it aims at increasing information rents and minimizing changes in efficiency (Krawczyk et al., 2016). Therefore, enabling mutual communications between group members to promote more realistic and efficient bids should be carefully considered to ensure the success of the conservation auction outcomes (Leimona et al., 2020).

Our result shows that a bonus payment incentive helps incentivize subjects to participate in a joint bidding auction and submit a more competitive bid than in the case without bonus treatment. However, allowing for voluntary joint bidding, even with a bonus payment incentive, does not seem to enhance auction efficiency compared to the mandatory treatment since individuals submit higher markups in the case of voluntary participation than in the automatic case.

Policy implications

Our results suggest that mandatory joint bidding is more cost-effective than voluntary joint bidding. However, this raises a number of questions for policy implementation. It has been suggested that one of the advantages of voluntary approaches to nature conservation, e.g. PES or conservation auctions, is a higher acceptability among land owners than with more command and control type of regulations. To which degree, implementing a mandatory joint bidding desing will have adverse impacts on acceptability should be considered in field experiments.

Limitations and future research directions

This analysis has several shortcomings which could be addressed by future research. Firstly, this study only considers a single-round auction design which is more common in practice, while a multi-round auction (i.e., sequential auction) could generate a lowballing effect that reduces the first-round price (Mezzetti et al., 2008). However, it depends on the extent to which the regulator can absorb the public transaction costs of implementing a multi-round auction (Banerjee et al., 2021). Secondly, to simplify the experimental design, our study only considers the joint participation of two bidders in a joint bidding team. Thus, larger group size is interesting to assess the impacts of group sizes and the effects of communication on the effectiveness of joint bidding auctions. However, it should be noted that full cooperation, where landowners cooperate all together, is less likely to emerge in practice, but they prefer to cooperate within smaller groups (Bareille et al., 2022). Finally, a different spatial setup or network structure where people at different locations can communicate with a different number of neighbors could be a more interesting and realistic setting if the future study aims to investigate the coordination between subjects in an auction.

Competing Interests

The authors declare no competing financial interests.

Data and Code Availability

The data and statistical codes (in R software) used in this study are available from the authors upon request.

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Appendix A: Tables

Table A.1: Mean environmental value, auction efficiency and bidding price of winning bids per treatment.

	Mean (SD)				
	T0	T1	T2	T3	T4
Environmental value	360.182	398.762	404.056	388.135	389.342
	(40.336)	(71.697)	(68.061)	(63.884)	(71.296)
Efficiency (CES)	0.444	0.488	0.500	0.462	0.482
	(0.084)	(0.072)	(0.079)	(0.073)	(0.074)
Bidding price	831.406	823.099	818.026	848.589	816.504
	(142.984)	(97.274)	(116.317)	(118.005)	(115.608)

Table A.2: The 15 GEB scale items and their response distributions (in percentage).

Pro-environmental scale items	Never	Rarely	Sometime	Often	Always	Corr
1: "I take shorter showers to save water".	7.00	22.67	33.00	29.33	8.00	0.514
2: "I turn off the water tap when brushing my teeth".	82.33	11.33	4.00	1.33	1.00	0.481
3: "I wait until I have a full load before doing my laundry".	65.00	27.67	5.33	1.33	0.67	0.491
4: "I only run the dishwasher when it is full".	3.33	2.00	4.00	16.67	74.00	0.514
5: "I use the small toilet flush button when there is a dual flush button".	5.00	6.00	17.67	30.00	41.33	0.557
6: "I sort glass, plastic, paper and metal packaging".	3.00	5.67	11.33	29.67	50.33	0.502
7: "I ride a bicycle, take public transportation, or walk to work or other".	67.67	23.67	5.67	2.67	0.33	0.392
8: "I buy the organic alternative of a product when it is available".	9.33	32.00	33.67	20.33	4.67	0.571
9: "I buy a product over a similar product because it contains less packaging".	11.67	22.00	30.00	28.67	7.67	0.654
10: "I buy a product over a similar product because it is locally produced".	5.00	24.00	35.33	28.67	7.00	0.586
11: "I turn off the lights when I leave a room".	0.33	1.00	2.33	27.00	69.33	0.438
12: "I reuse my shopping bags".	68.00	22.00	7.00	2.67	0.33	0.559
13: "I buy second-hand items".	5.33	32.67	34.33	19.67	8.00	0.509
14: "I unplug standby devices".	5.33	14.33	22.33	38.67	19.33	0.399
15: "I put on extra clothing rather than heat when it is cold".	3.58	6.31	7.00	64.16	18.94	0.557

Appendix B: Figures

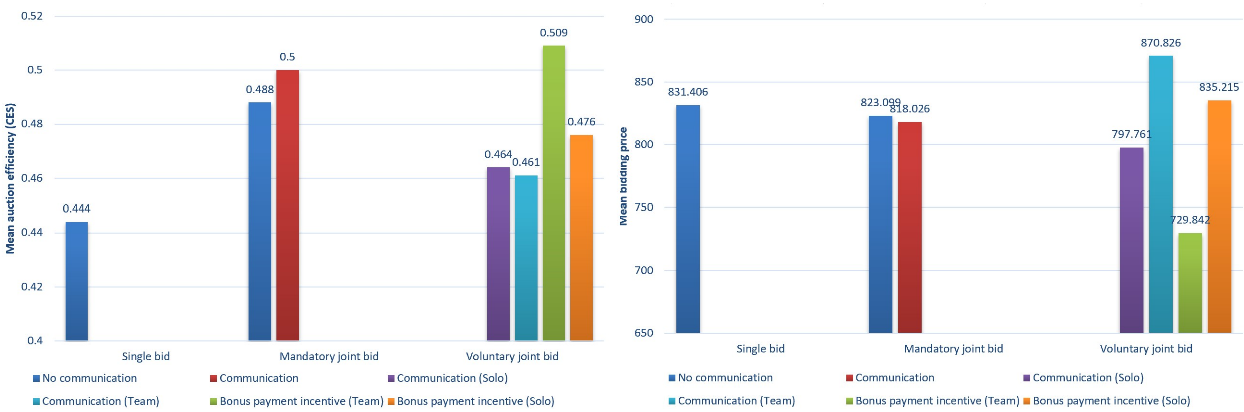
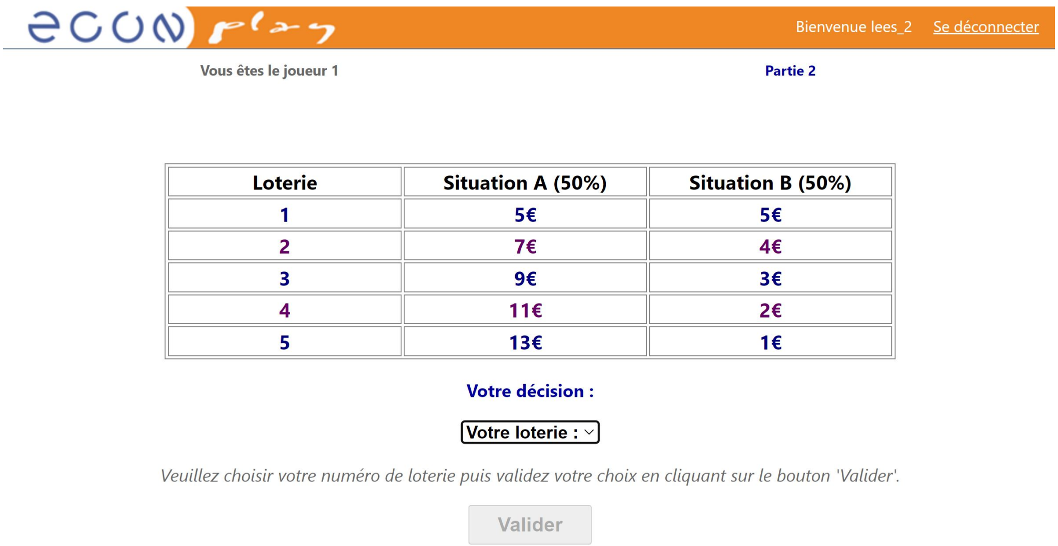
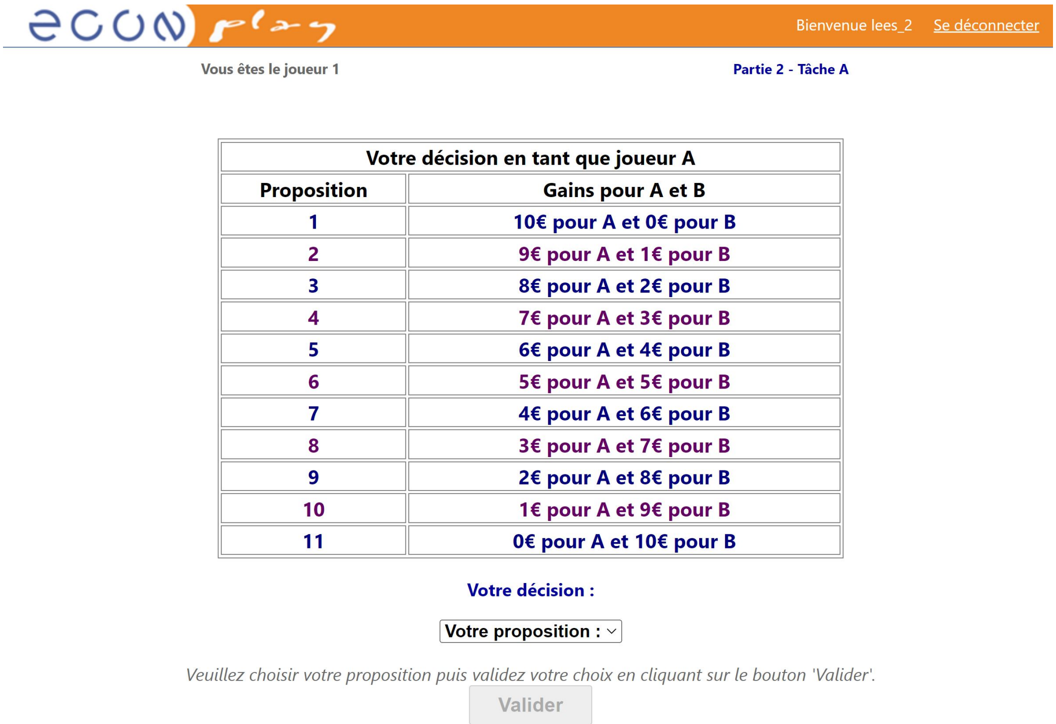


Figure B.1: Histogram of mean auction efficiency (CES) and bidding price in case of joint bidding in team and solo.



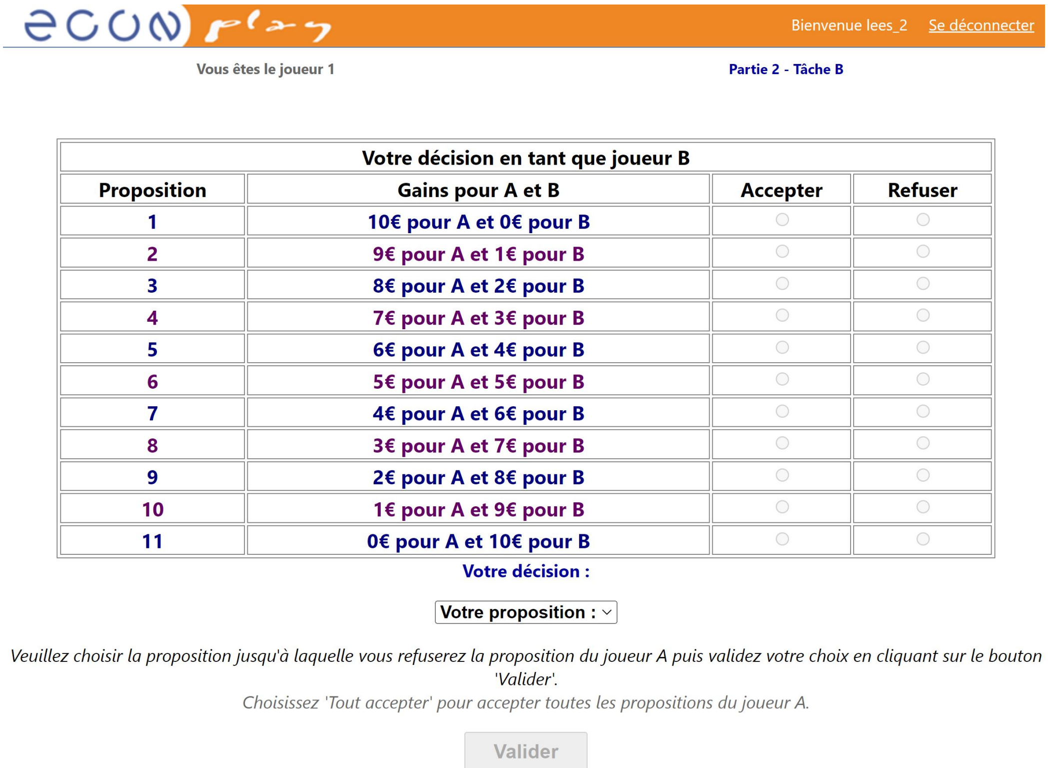
Loterie	Situation A (50%)	Situation B (50%)
1	5€	5€
2	7€	4€
3	9€	3€
4	11€	2€
5	13€	1€

Figure B.2: Part 1 of the experiment.



Votre décision en tant que joueur A	
Proposition	Gains pour A et B
1	10€ pour A et 0€ pour B
2	9€ pour A et 1€ pour B
3	8€ pour A et 2€ pour B
4	7€ pour A et 3€ pour B
5	6€ pour A et 4€ pour B
6	5€ pour A et 5€ pour B
7	4€ pour A et 6€ pour B
8	3€ pour A et 7€ pour B
9	2€ pour A et 8€ pour B
10	1€ pour A et 9€ pour B
11	0€ pour A et 10€ pour B

Figure B.3: Task A in Part 2 of the experiment.



Votre décision en tant que joueur B			
Proposition	Gains pour A et B	Accepter	Refuser
1	10€ pour A et 0€ pour B	○	○
2	9€ pour A et 1€ pour B	○	○
3	8€ pour A et 2€ pour B	○	○
4	7€ pour A et 3€ pour B	○	○
5	6€ pour A et 4€ pour B	○	○
6	5€ pour A et 5€ pour B	○	○
7	4€ pour A et 6€ pour B	○	○
8	3€ pour A et 7€ pour B	○	○
9	2€ pour A et 8€ pour B	○	○
10	1€ pour A et 9€ pour B	○	○
11	0€ pour A et 10€ pour B	○	○

Figure B.4: Task B in Part 2 of the experiment.

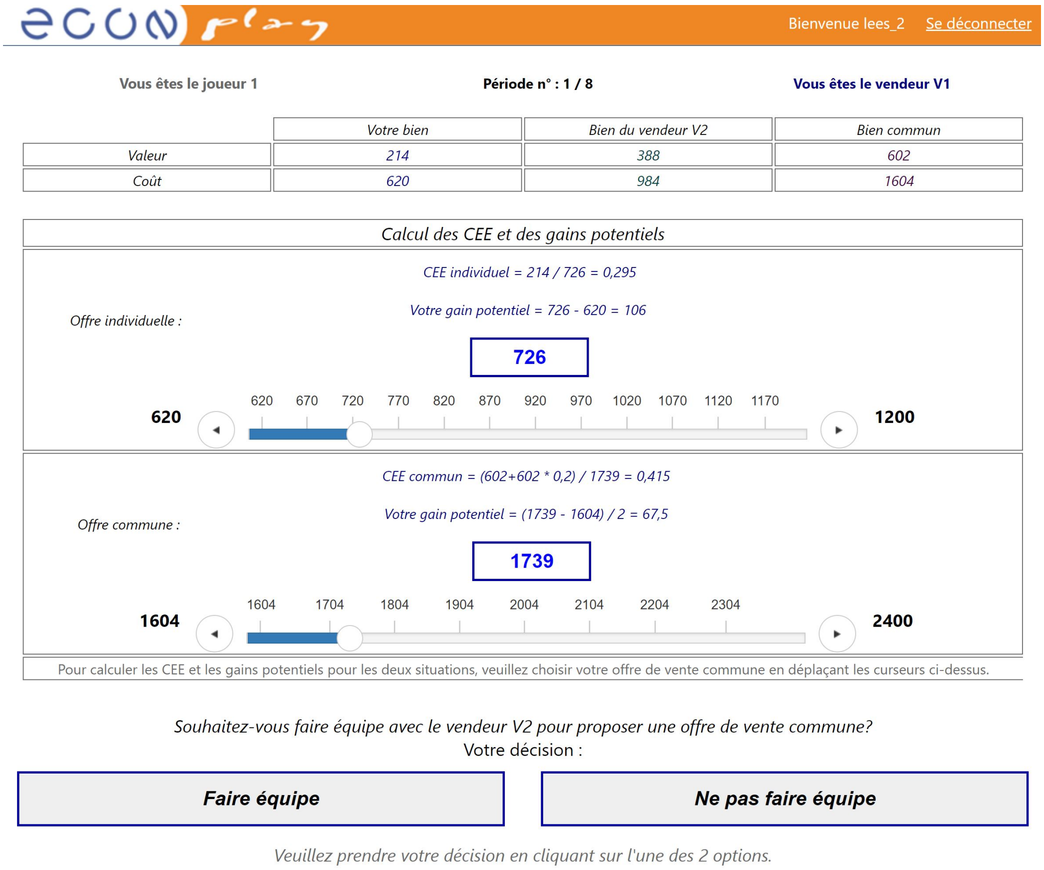


Figure B.5: Part 3 of the experiment (voluntary joint bid).

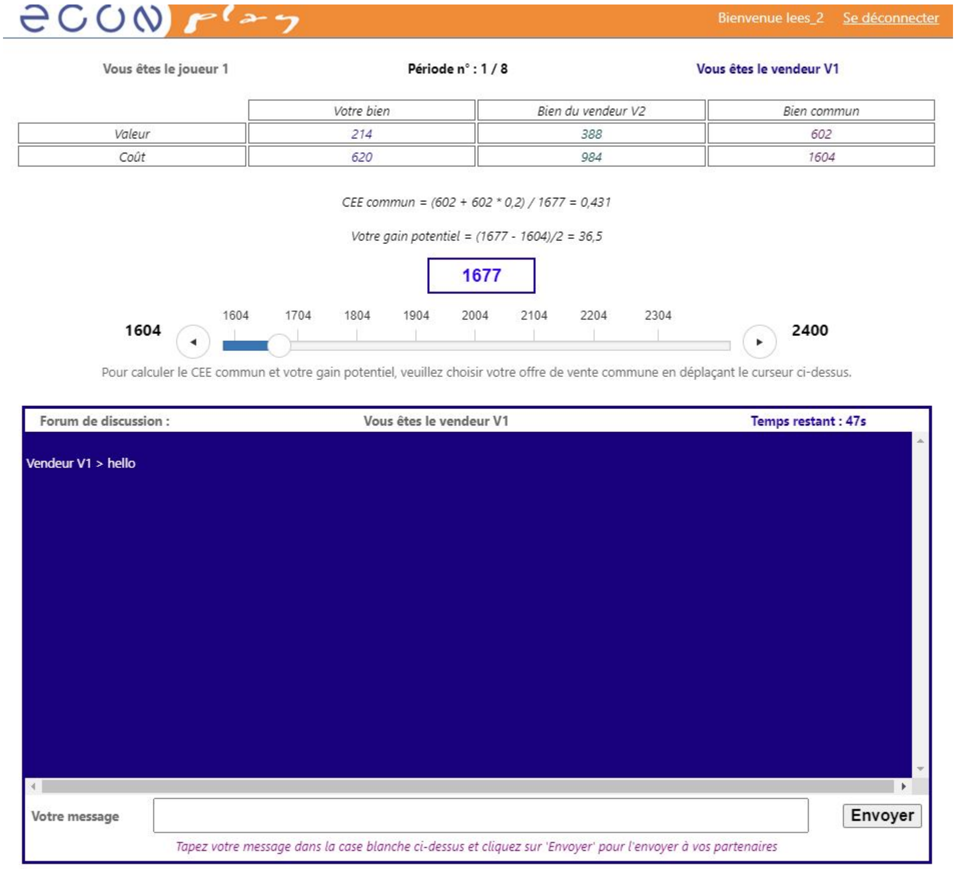


Figure B.6: Communication via a chat box (voluntary joint bid).