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Auteurs

Jens Abildtrup, Géraldine Bocquého, Kene Boun My
Anne Stenger, Tuyen Tiet

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Contact :
jaoulgrammare@beta-cnrs.unistra.fr

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

Jens Abildtrup[a,b] Géraldine Bocquého[a,b] Kene Boun My[a]
Anne Stenger[a] Tuyen Tiet[c*]

[a]*BETA, CNRS, INRAE, University of Strasbourg, Strasbourg (France)*

[b]*AgroParisTech, CNRS, INRAE, BETA, University of Lorraine, Nancy (France)*

[c]*Ho Chi Minh University of Banking, Ho Chi Minh City (Vietnam)*

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Abstract

We conduct a lab experiment to investigate the impact of voluntary and mandatory joint-bidding schemes on the performance of conservation auctions. Our results suggest that joint bidding increases auction performance compared to the single-bidding baseline. Within the voluntary joint-bidding conditions, a bonus payment incentive improves auction performance by encouraging the subjects to give low bids. However, voluntary joint bidding performs worse than mandatory joint bidding, even with the bonus incentive. Therefore, when implementing voluntary joint bids to ensure high acceptability from landowners compared to mandatory ones, policymakers should carefully consider performance issues.

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

JEL codes: C57, C90, D70, Q50.

* *Corresponding author*. Address: Ho Chi Minh University of Banking, 36 Ton That Dam Street, Saigon Ward, Ho Chi Minh City, Vietnam, E-mail: `tuyentt@hub.edu.vn`

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 to adopt 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, they can be very heterogeneous among producers depending on land characteristics and their management practices. Conservation auctions appear as a potential solution to overcome this problem of asymmetric information, among other options like screening contracts or gathering information on observable behaviors (Ferraro, 2008). Indeed, conservation actions are an allocation mechanism that helps to reduce rent-seeking behavior by revealing prices closer to producers' costs (Latacz-Lohmann and Van der Hamsvoort, 1997; Kits et al., 2014). Conservation auctions are a type of procurement or reverse auction. For example, they are implemented by the Biodiversity Finance Initiative of the United Nations and the Conservation Reserve Program in the US.

Conservation auctions have been investigated in the literature under various features, including pricing rule (discriminatory or pay-as-bid vs. uniform), bid visibility (sealed vs. open), the value of the item being traded (private vs. common), repetition (single-shot vs. repeated), information feedback (single-round or multiple-round), bid selection criteria (e.g., total bid or net environmental benefit or bid-per-area ratio or bid-per-value ratio). However, conservation auctions are recent, as well as their experimental study (Schilizzi, 2017), and many questions remain about the optimal design of these highly complex mechanisms. In identifying key insights and contributions from the experimental literature on the performance of conservation auctions, in terms of auction format, implementation rules, bidder characteristics, and outcomes (bidder behavior as well as auction performance), Schilizzi (2017) pinpointed pending issues like the market potential for conservation auctions at large scale 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.

To reduce informational rent, conservation auctions require reaching enough competition among sellers. At the same time, some environmental benefits are spatially supra additive, which advocates for collaboration between sellers. Indeed, existing literature has suggested that a conservation measure that some landowners would adopt 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 neighbors' efforts to enroll their own parcels of land, known as agglomeration, network, or edge benefits. It would then enhance the performance of the conservation projects by harnessing complementarities across bidders. Individual agglomeration bonuses for contiguous plots enrolled under single bids and joint bidding in teams are two possibilities to get bidders to collaborate and consequently obtain higher environmental outcomes.

Usually, an agglomeration bonus (or contiguity bonus as put by Banerjee et al. (2012)) 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 a joint project, for which there exists a regulation in Europe (Albano et al., 2009). Joint bidding is a way to create interdependence between group members and potentially decrease transaction costs for governments. Rondeau et al. (2016) suggested that joint participation in forestry auctions for public wooded lots increases allocative efficiency and also seller revenue. Participants with complementary private values for the goods in the bundles for sale are likely to better value the bundles and submit higher bids if they bid jointly rather than separately. Joint bidding seems relevant in environmental protection, especially when landowners 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). One study suggested that joint bidding is preferable to a single bid since it reduces payments for taking conservation measures (Calel, 2012). Besides, depending on bonus schemes and ranges, allowing for joint bidding can improve environmental outcomes by encouraging spatial coordination and increasing competitiveness between bidders (bonuses encourage moderation of bids) (Banerjee et al., 2021).

However, joint bidding can also induce hold-out and collusion (Ferraro, 2008), thus reducing competition between sellers and in fine auction performance. Indeed, in the real world, as it is impossible to outlaw communication between sellers who bid in a team, participants are likely to share their private information. Moreover, joint bidding questions explicitly individuals' willingness to associate in a voluntary way and their ability to find relevant willing associates. In addition, the joint-bidding scheme in a voluntary context raises specific questions about economic and environmental performance: Are there enough sellers willing to joint-bid? Who decides to joint bid regarding the cost and value of their environmental item? What is the effect of a bonus payment incentive?

Do voluntary programs generate better results than mandatory ones in environmental conservation in general? At least two questions are constantly worth investigating: How can we achieve a higher environmental state of service? And is it cost-effective? To achieve environmental objectives, most of the regulations tend to be mandatory ones, not allowing any flexibility and being rather costly in implementation and control. In addition, such mandatory schemes tend to produce adversarial relationships (Borck and Coglianese, 2009). Nevertheless, even if governments tend to develop voluntary environmental programs, for instance, to reduce costs for governments or conflicts between firms and governments, their environmental effectiveness actually relies on community pressure and regulatory threats, with, at best, small impacts on firm behavior(Coglianese and Nash, 2016). Looking at the agricultural sector in particular, it was shown that the environmental effectiveness of voluntary programs requires incentivizing participation, ensuring additionality, monitoring environmental outcomes, and reducing free riding for group voluntary schemes, but these conditions are not always sufficient (Segerson et al., 2013).

Only a handful of studies examined the sensitivity of people's bids to whether they occur in a mandatory or voluntary context. On the demand side of environmental conservation, examples include Wiser (2007), Stithou and Scarpa (2012), and Carneiro and Carvalho (2014). Wiser (2007) and Carneiro and Carvalho (2014) found support for a higher willingness to pay (WTP) under a collective payment mechanism than under a voluntary one. On the contrary, when a collective mechanism is used, Stithou and Scarpa (2012) reported a lower Willingness-to-Pay (WTP).

The effects of communication on performance in experiments, in general, and in experimental auctions, in particular, are ambiguous. Communication between landowners and the government can enhance public good provision by helping build trust between private and public actors. Communication between bidders can positively impact environmental performance, depending on how people interact (e.g., face-to-face) and on group size concerning social dilemmas. More specifically, due to the complexity of joint bid submissions, communication helps bidders transmit information and coordinate with their partners. However, as mentioned earlier, communication between bidders can also induce collusion and contribute to decreasing auction cost-effectiveness (Tóth et al., 2010; Balliet and van Lange, 2013; Rabotyagov and Lin, 2013; Vogt et al., 2013). Nevertheless, collusion is not automatic, and communication can overall improve environmental outcomes and global performance (Krawczyk et al., 2016).

The main objective of our study is to investigate the effect of voluntary and mandatory joint bidding on the performance of conservation auctions. Participants are free to bid jointly or not in the voluntary setting, whereas they are obliged to bid mandatorily in teams. Banerjee et al. (2021) did compare agglomeration bonus schemes with voluntary joint bidding, but they did not consider mandatory joint bidding. Our study also aims to assess the impact of communication between bidders on auction performance. Last, since in joint-bidding auctions, participants' bidding behavior depends 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 well-being of others) in determining the auction outcomes.

We conduct conservation auctions in a lab experiment using pay-as-bid pricing and a between-subject design. 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 only in the second treatment of the mandatory context and in both voluntary contexts. A bonus payment is implemented as an incentive to collaborate in the second treatment of the voluntary context. We look at auction performance both through conservation cost-effectiveness and total environmental performance. We also analyze individual behavior and its determinants through the bidding price and under the voluntary context through the decision to join a team.

Our results show that conservation auctions are more cost-effective than the single-bid baseline when participants are obliged to bid jointly and even more when they can communicate. When joint bidding remains a voluntary decision, the improvement in auction cost-effectiveness is lower, even when a bonus incentive is paid.

The remainder of this study is organized as follows. In Section 2, we discuss the theoretical framework and formulate the work hypotheses. Section 3 describes the experimental design. Estimation results are presented in Section 4. Section 5 is devoted to the 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 ($b_i > 0$) corresponding to the complementary environmental benefit from coordinating with a neighbor. The heterogeneity in the environmental value can be justified by, e.g., the diversity in the size of the plots and the number of species on the plots.

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 can be written as follows:

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

In the mandatory joint-bidding context, each producer submits a joint bid with his or her neighbors. For simplicity, we consider each producer assigned to a team of two. Thus, N producers result in $K = \frac{N}{2}$ joint bidding teams. Each team member i gives a team bidding price $p_{i,d}$ for their team d to provide jointly two environmental items. The average of the two prices gives the final joint bidding price p_d of the team. Thus, we have $p_d = \frac{p_{i,d}+p_{j,d}}{2}$ for all $i, j \in d$. The winning team would earn an expected payoff as follows:

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

For a given landscape structure, the regulator or auctioneer uses a conservation auction to optimize the total environmental benefits within a limited budget. The auction winners are selected based on the cost-effectiveness of their offers (i.e., how much environmental quality is gained per euro spent). Let v_s, b_s, and p_s be, respectively, the environmental value, environmental bonus value, and price for the individual items in the case of single bidding or the duets of items in the case of joint bidding. We consider that the regulator uses the pay-as-bid pricing rule to optimally select the single items and pairs of items s that maximize the following function:

$$\max_s V = \sum_s \frac{v_s + b_s}{p_s}, \tag{3}$$

$$s.t., \sum_s p_s \leq W,$$

where W is the regulator's budget constraint. In the right-hand expression of Equation (3), the ratio between the total environmental value and the price of offer s is the Cost-Effectiveness Score (CES) of offer s . It should be noted that a higher bidding price results in a lower CES.The auction performance is measured as the mean CES of the selected offers and is referred to as auction cost-effectiveness.

The regulator evaluates the benefits of spatial coordination between two bidders if both connected bidders win the auction, either through single or joint bidding. However, adjacent bidders only receive a bonus payment if they win through a joint bid. The bonus payment can incentivize adjacent landowners to collaborate to achieve a common target and cover the additional transaction and cognitive costs a joint-bidding process entails (Banerjee et al., 2021). Moreover, it may encourage adjacent landowners to submit more competitive bids because the lower bidding prices would be compensated. Therefore, our first hypothesis is as follows:

Hypothesis 1: Joint bidding could be more effective than single bidding in promoting auction performance.

We also test the voluntary joint-bidding context, which allows bidders to get into a joint-bidding scheme or not, in the spirit of Banerjee et al. (2021). In other words, participants can decide to join a team with their assigned partner or play as a single bidder. The selection rule described by Equation (3) applies. From Equations (1) and (2), we observe that bidders prefer joint bidding to single bidding if and only if

$$E[\pi^J_{i,d}(p_{i,d})] \geq E[\pi^S_i(p_i)]. \tag{4}$$

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 (4) 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, single 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 prices p_d and p_i such that $Pr[x_d = 1] = Pr[x_i = 1]$, single 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 low environmental values and high costs are more likely to join a team.

To further incentivize joint participation in the voluntary joint-bidding context, bidder i can also receive a bonus payment if he or she joins team d and the team wins the auction. Following Banerjee et al. (2021), we assume the bonus payment is proportional to the generated environmental benefits. As such, the total bonus payment of team d equals $M_d = \sum_{i \in d} b_i \delta$, where $\delta > 0$ is the parameter of the bonus payment. Thus, bidder i's expected payoff in the team d is written as follows:

$$E[\pi^J_{i,d}(p^J_{i,d})] = \frac{1}{2}\left(p^J_d + \sum_{i \in d}(b_i\delta - c_i)\right) Pr[x_d = 1]. \tag{5}$$

It is straightforward that a bonus payment incentive would promote joint participation. However, for the same environmental benefit, it is more costly for the regulator to acquire two adjacent items from a joint bid than from two single bids. However, as previously mentioned, bonus payments could encourage bidders to collaborate and incentivize them to submit more competitive bids. Therefore, our third hypothesis is as follows:

Hypothesis 3a: A bonus payment could incentivize joint bidding participation.

Hypothesis 3b: A bonus payment could encourage higher auction performance.

Finally, in our experiment, we also examine the impact of communication on auction performance in the context of mandatory joint bidding. On the one hand, the existing literature has highlighted the high risk of collusion due to communication in joint-bidding procurement auctions. On the other hand, it is hard to prevent neighbor landowners from communicating with each other. Moreover, since the submission of joint bids rather than single bids entails additional complexity, communication between team partners can positively impact the auction performance. 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 the performance of joint bidding.

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 either single bids or joint bids with their partners.

<table>
<tr><th rowspan="2"></th><th rowspan="2">Single bid (baseline)</th><th colspan="2">Joint bid</th></tr>
<tr><th>Mandatory</th><th>Voluntary</th></tr>
<tr><td rowspan="2">Treatment</td><td rowspan="2">No treatment (T0)</td><td>No communication (T1)</td><td>Communication (T3)</td></tr>
<tr><td>Communication (T2)</td><td>Communication and Bonus payment incentive (T4)</td></tr>
</table>

Figure 1: Four treatments and one control treatment.

The five treatments were tested during 15 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 before they can bid. 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 the subjects' questions before the beginning of each part. The detailed experimental instructions are reported in Appendix C.

In the first part of the experiment, subjects are invited to participate in a simple risk elicitation task with five different lotteries (Eckel and Grossman, 2008) (see the detailed information in Figure B.2 in Appendix B). This simple risk elicitation task aims to capture subjects' sensitivity to risk.

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 owns an environmental item. At the beginning of each period, subjects receive information about the item's environmental value, cost, and bonus environmental value. Depending on the treatments, they are also informed about 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 more than one) to ensure balanced matching and rule out strategic joint-bidding decisions (Fehr and Gächter, 2000) (See Table A.1 in the Appendix for further information).

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 for a low price (see Equation (3)). The public buyer has a budget that can be used to offer only four contracts with the highest CES (i.e., Cost-effectiveness score). Specifically, the public buyer calculates the CES of submitted items/combination of items and selects the four submitted items with the highest CES in every auction round. The information about the budget is announced at the beginning of the auction.

Depending on the bidding price and experimental treatment, subjects' payoffs can be calculated using Equations (1), (2) and (5). Before making the decisions, subjects could simulate their potential payoff using a simulator (see Figure B.5 in Appendix B). When communication is allowed, subjects in a team have two minutes to discuss with their partner via a chat box before making the decision (see Figure B.5 in Appendix B). After the chat, each subject in a team is invited to give his or her team a joint bidding price for the two items, and the average of the two bids is calculated as the final joint bid 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.3 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 behavior, i.e., bidding price and the decision to participate in joint bids. Note that the environmental performance is the total environmental benefits from the selected items, and auction efficiency is calculated based on the CES in Equation (3), which is the ratio between the total environmental value and the price of the offer.

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 indicate that joint bidding auction mechanisms (either voluntary or mandatory) provide more cost-effective auction efficiency than the baseline.

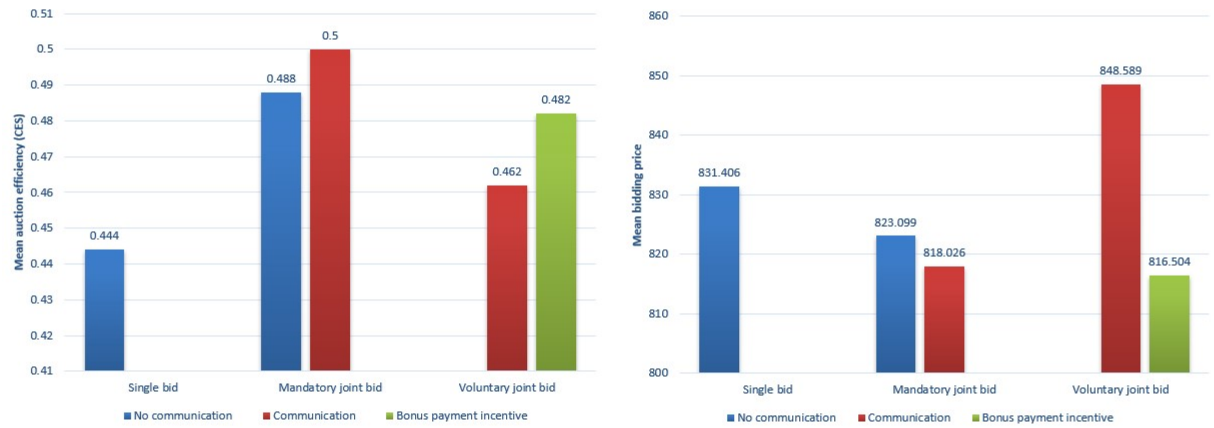

Figure 2: Histogram of mean auction efficiency (CES) and bidding price.

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

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

	Mean differences between pairs of treatments			
	T0 vs. T1	T1 vs. T2	T2 vs. T3	T3 vs. T4
Environmental value	-38.580***	-5.294	15.921***	-1.207
	(0.000)	(0.731)	(0.003)	(0.577)
Efficiency (CES)	-0.044***	-0.012	0.038***	-0.020***
	(0.000)	(0.266)	(0.000)	(0.006)

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

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).

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 compared to Treatment T3 (see Figure 2 and Table 1). Results of Table B.1 (in the Appendix) also show that bonus payment incentives help encourage bidders playing in a team to submit a lower bidding price than those without the bonus treatment (i.e., Treatment T4). Thus, implementing the voluntary joint bidding auction could harm the auction efficiency unless there is a bonus payment incentive to encourage bidders to submit a more efficient bid.

4.2 Individual bidding behavior

Econometric specifications

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. Specifically, the linear bid specifications are used to estimate linear functions for each subject i

bidding pattern in each auction, as follows:

$$Bid_i = \beta_0 + \beta_k \sum_{k=1}^{K} Treatment_k + \eta_l \sum_{l=1}^{L} Item_l + \lambda_m \sum_{m=1}^{M} Control_m + \epsilon_i, \tag{6}$$

where Bid_i represents subject i' bidding price; 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; Variable $Item_l$ includes "Value", "Cost" and "Bonus value" that are continuous variables used to control for subjects' heterogeneity in the value of items' cost and quality; Variable $Control$ includes: "Period" is used to control for the time trend; "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; And other control variables, including "Female", "Age", "Environmental attitude", etc., are used to capture subjects' demographic and psychological characteristics. 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
Team	=1 if a subject is in a joint bidding team.	0.258	0.437	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 with Cronbach alpha = 0.6684.	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

Subjects' probability of joining a joint bidding team (Pr_{join_i}) and their probability of winning the auction ($Pr_{winning_i}$) are defined as follows.

$$Pr_{join_i} = Pr(Join_i = 1 | Treatment\_T4, Control_i) = F(\alpha_H High\_value + \alpha_L Low\_value + \alpha_{HL} High\_value * Low\_value + \alpha_{T4} Treatment\_T4 + \gamma_m \sum_{m=1}^{M} Control_m). \quad (7)$$

$$Pr_{winning_i} = Pr(Win_i = 1 | Team, Control_i) = F(\alpha'_H High\_value + \alpha'_L Low\_value + \alpha'_{HL} High\_value * Low\_value + \alpha'_{team} Team + \gamma'_m \sum_{m=1}^{M} Control_m). \quad (8)$$

It should be noted that in Equation (7), we investigate the impact of Treatment T4 on subjects' probability to join, while the impact of Team (i.e., a dummy variable takes a value 1 if subjects joined a bidding team) on subjects' probability of winning the auction is studied in Equation (8). Variable "High value" is a dummy variable taking a value of 1 if a subject received a high-value item. Variable "Low cost" is a dummy variable taking a value of 1 if a subject received a low-cost item. The interaction terms of high-value and low-cost items are also introduced to capture the impacts of different item values and cost combinations on the dependent variables. Other control variables are defined similarly to Equation (6).

Estimation results

The estimation results with bootstrapped standard errors are reported in Tables 3 and 4. 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 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. Therefore, Hypothesis 3b is 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. Thus, Hypothesis 3a is not satisfied. We also observe that subjects with a low-cost and high-value bidding item seem less likely to join a team with their partners than others (See Results of Table 5). This is a strategic situation because the high-cost and low-value participants always have a low chance of winning (i.e., these participants are in a worst-case scenario) if they play as a single bidder, while low-cost and high-value participants are in a better situation than others (i.e., high probability of winning if they play as a single bidder). Thus, joining a team, in this case, seems to be a good or bad decision depending on the cost and value of each subject's bidding items. Therefore, Hypothesis 2 is satisfied.

Results of Model (8) and (9) in Table 4 indicate that "High value", "Low cost" and the interaction term "High value*Low cost" positively impact the probability of winning. This result means that subjects having high-value and low-cost items have a higher probability of winning than others. Variable "Team" is also positively significant, suggesting that subjects playing in a team are more likely to win the auction than those playing as a single bidder. Moreover, the bonus value is statistically significant, suggesting that bonus value is also a key factor influencing the subjects' probability of winning the auction.

Table 3: Estimation results of individual bidding behavior.

		Mandatory		Voluntary	
	Full sample	No communication (T0 and T1)	Communication (T1 and T2)	Communication (T2 and T3)	Communication & Bonus (T3 and 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 (Treatment T1)	-0.066***	-0.011**	-	-	-
	(0.015)	(0.005)			
Mandatory & Com (Treatment T2)	-0.080***	-	-0.015***	-	-
	(0.015)		(0.005)		
Voluntary & Com (Treatment T3)	-0.015	-	-	0.035***	-
	(0.012)			(0.007)	
Voluntary & Com & Bonus (Treatment T4)	-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. The independent variable "Treatment T0" is a baseline.
Bootstrapped standard errors in parentheses with 500 bootstrap replications.
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

5 Discussions and conclusions

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 indicates that the voluntary joint bidding auction does not seem more effective than the mandatory

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***	2.093***	1.042***
	(0.257)	(0.350)	(0.235)	(0.305)
Low cost	-1.543***	-1.122***	2.220***	1.248***
	(0.259)	(0.348)	(0.208)	(0.268)
High value*Low cost	-	-0.921**	-	1.945***
		(0.429)		(0.412)
Bonus value	5.164	5.163	4.324***	4.650***
	(164.942)	(163.067)	(0.740)	(0.746)
Team	-	-	16.076***	17.080***
			(3.030)	(3.041)
Voluntary & Com & Bonus (Treatment T4)	0.184	0.219	-	-
	(0.272)	(0.274)		
Control variables				
Period	0.024	0.027	0.022	0.015
	(0.058)	(0.058)	(0.037)	(0.038)
Risk	-0.023	-0.012	0.055	0.043
	(0.086)	(0.087)	(0.062)	(0.063)
Altruism	-0.582**	-0.570**	0.404**	0.386**
	(0.266)	(0.267)	(0.177)	(0.180)
Age (in log)	-0.132	-0.264	-0.519	-0.585
	(0.906)	(0.910)	(0.638)	(0.659)
Female	-0.366	-0.318	0.094	0.040
	(0.275)	(0.276)	(0.193)	(0.197)
Environmental attitude	0.003	-0.001	0.0005	0.004
	(0.025)	(0.026)	(0.017)	(0.017)
Descriptive norm	-0.156	-0.161	-0.023	-0.001
	(0.392)	(0.396)	(0.249)	(0.251)
Injunctive norm	-0.298	-0.246	-0.322	-0.403
	(0.408)	(0.410)	(0.268)	(0.270)
Intercept	2.426	2.720	-2.152	-1.467
	(3.167)	(3.186)	(2.160)	(2.210)
Observations	960	960	960	960
Number of subjects	120	120	120	120
Log likelihood	-186.808	-185.275	-414.544	-403.121

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

one in promoting auction efficiency. Particularly, Results in Table 5 (in the Appendix) show that subjects receiving a high-value and low-cost item (i.e., the best situation) are making rational bidding decisions by being more likely to play solo rather than joining a bidding team with their partners. This result indicates that the number of bidders participating in a voluntary joint bidding design is significantly lower compared to the mandatory design, and the reduction in the number of joint bidding teams makes the auction efficiency ambiguous. In other words, the inefficiency comes from more subjects deciding to play solo rather than in a team with their partners when we allowed subjects to choose whether to join a team (i.e., Voluntary joint bidding treatment or Treatment T3/T4). This result aligns with the existing literature that allowing joint bidding reduces

Table 5: Mean probability of joining a team by different sets of bidding items and treatments.

		Bidding item's value and cost			
		High value		Low value	
Mean probability (SD)	N	Low cost	High cost	Low cost	High cost
Treatment T3	489	0.575	0.800	0.853	0.916
		(0.496)	(0.401)	(0.350)	(0.277)
Difference-in-mean		-	0.225	0.278	0.341
P-value			<0.001	<0.001	<0.001
Treatment T4	489	0.694	0.924	0.858	0.900
		(0.462)	(0.265)	(0.351)	(0.301)
Difference-in-mean		-	0.230	0.164	0.206
P-value			<0.001	0.002	<0.001

Note: Standard deviations of the mean are in parenthesis. P-values of the difference-in-means are calculated based on the Wilcoxon Rank Sum test statistics. The full results are reported in Table A.4 in the Appendix.

the number of bidders participating in the action, resulting in an ambiguous impact on auction efficiency (Rondeau et al., 2016). Therefore, allowing voluntary joint bids would harm the auction efficiency since subjects having high-value environmental goods/services and low opportunity cost would optimize their payoffs by not accepting to make the team with others having a worse situation (i.e., low-value environmental goods/service and high opportunity cost).

Our result shows that a bonus payment incentive could not incentivize subjects to participate in a joint bidding auction. However, a bonus payment encourages them to 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 bonus payments cause higher sellers' markups (i.e., policymakers have to pay more to the jointly selected bids because of the bonus) in the case of voluntary participation than in the automatic case. Thus, our results suggest that bonus payment could not be effective in encouraging subjects to join a voluntary joint bid but harms auction efficiency since it increases the amount of payment that policymakers have to pay to conserve the joint environmental goods/services (Banerjee et al., 2021).

Therefore, these results raise several 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 higher acceptability among land owners than with more command and control type of regulations (e.g., mandatory joint bidding design). Moreover, providing bonus payments as an objective to encourage joint participation does not seem to be cost-effective since bonus payments raise higher sellers' markups. Thus, policymakers should carefully consider a well-designed voluntary joint bid with monetary incentives before implementation to ensure both the increased acceptability of land owners and the efficiency of joint bidding auctions. However, mandatory joint bidding design has low acceptability of land owners but results in high auction efficiency. Thus, the degree to which implementing a mandatory joint bidding design will adversely impact acceptability should also be carefully considered in field experiments.

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 indicated that a chat could facilitate spatial coordination and encourage collusion since it aims to increase information rents and minimize efficiency changes (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).

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. In contrast, 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, a more prominent group size is interesting for assessing 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 other 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: Balanced matching design for ten subjects in five couples and eight periods.

	Couple 1		Couple 2		Couple 3		Couple 4		Couple 5	
Period	Player 1	Player 2	Player 1	Player 2	Player 1	Player 2	Player 1	Player 2	Player 1	Player 2
1	HH	HH	LL	LL	LH	HH	LH	LH	LL	HH
2	HL	HL	LH	LL	HL	LH	HL	HH	HL	LL
3	HH	HH	HL	HH	HL	LL	LH	HH	LL	HH
4	LL	LL	HL	LH	LH	LL	LH	LH	HL	HL
5	LL	HH	HL	LL	HH	HH	LL	LL	HL	HL
6	LH	HH	LH	LL	HL	LH	LH	LH	HL	HH
7	LH	LL	HL	LH	LH	HH	LL	LL	HL	LL
8	LH	LH	HL	HH	HH	HH	LL	HH	HL	HL

Note: HH stands for high-value and high-cost items; HL stands for high-value and low-cost items; LH stands for low-value and high-cost items; LL stands for low-value and low-cost items.

Pair "HH-HH" for couple 1 in period 1 means that a subject having a high-value and high-cost item will be matched with another having also a high-value and high-cost item.

Table A.2: 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.3: 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

Table A.4: Mean probability of joining a team by different sets of bidding items and treatments.

		Bidding item's value and cost			
		High value		Low value	
Mean probability (SD)	N	Low cost	High cost	Low cost	High cost
Treatment T3	489	0.575	0.800	0.853	0.916
		(0.496)	(0.401)	(0.350)	(0.277)
Difference-in-mean		-	0.225	0.278	0.341
P-value			<0.001	<0.001	<0.001
Treatment T4	489	0.694	0.924	0.858	0.900
		(0.462)	(0.265)	(0.351)	(0.301)
Difference-in-mean		-	0.230	0.164	0.206
P-value			<0.001	0.002	<0.001
Treatment T3 (Only winners)	207	0.588	0.789	1.000	1.000
		(0.494)	(0.411)	(0.000)	(0.000)
Difference-in-mean		-	0.201	0.412	0.412
P-value			0.001	<0.001	<0.001
Treatment T4 (Only winners)	214	0.719	1.000	1.000	1.000
		(0.451)	(0.000)	(0.000)	(0.000)
Difference-in-mean		-	0.281	0.281	0.281
P-value			<0.001	<0.001	<0.001
Treatment T3 (Low-value and high-cost partners)	120	0.333	0.375	0.708	0.875
		(0.481)	(0.494)	(0.464)	(0.464)
Difference-in-mean		-	0.042	0.375	0.542
P-value			0.774	0.001	<0.001
Treatment T4 (Low-value and high-cost partners)	120	0.360	0.869	0.791	0.854
		(0.489)	(0.344)	(0.414)	(0.356)
Difference-in-mean		-	0.509	0.431	0.494
P-value			<0.001	0.002	<0.001
Treatment T3 (High-value and low-cost partners)	120	0.937	0.916	1.000	1.000
		(0.244)	(0.282)	(0.000)	(0.000)
Difference-in-mean		-	0.021	0.084	0.084
P-value			0.755	0.221	0.221
Treatment T4 (High-value and low-cost partners)	120	0.916	0.958	0.875	0.960
		(0.279)	(0.204)	(0.337)	(0.200)
Difference-in-mean		-	0.042	0.041	0.044
P-value			0.524	0.584	0.498

Note: Standard deviations of the mean are in parenthesis. P-values of the difference-in-means are calculated based on the Wilcoxon Rank Sum test statistics.

Appendix B: Figures

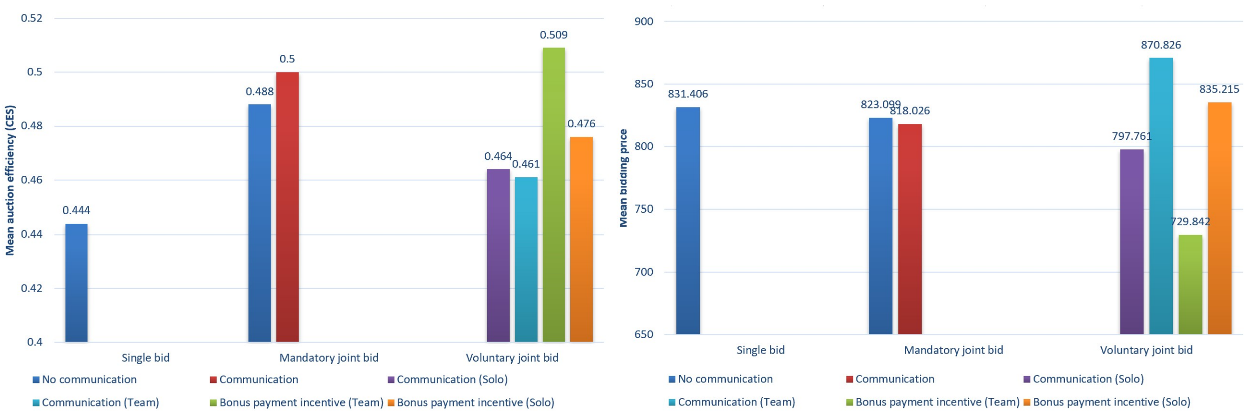
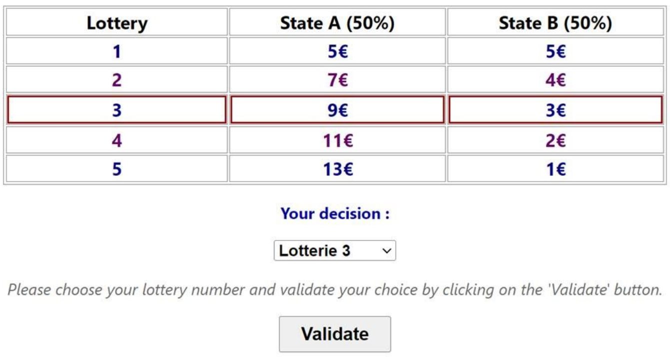


Figure B.1: Histogram of mean auction efficiency (CES) and bidding price in case of joint bidding in team and solo.



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

Your decision :

Lotterie 3

Please choose your lottery number and validate your choice by clicking on the 'Validate' button.

Validate

Figure B.2: Part 1 of the experiment.

Your decision as an A player	
Proposal	**Earnings for A and B**
1	10€ for A and 0€ for B
2	9€ for A and 1€ for B
3	8€ for A and 2€ for B
4	7€ for A and 3€ for B
5	6€ for A and 4€ for B
6	5€ for A and 5€ for B
7	4€ for A and 6€ for B
8	3€ for A and 7€ for B
9	2€ for A and 8€ for B
10	1€ for A and 9€ for B
11	0€ for A and 10€ for B

Your decision :

Proposal 6

Please choose your proposal and validate your choice by clicking on the 'Validate' button.

Validate

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

Your decision as a B player			
Proposal	**Earnings for A and B**	**Accept**	**Refuse**
1	10€ for A and 0€ for B	○	●
2	9€ for A and 1€ for B	○	●
3	8€ for A and 2€ for B	○	●
4	7€ for A and 3€ for B	○	●
5	6€ for A and 4€ for B	○	●
6	5€ for A and 5€ for B	●	○
7	4€ for A and 6€ for B	●	○
8	3€ for A and 7€ for B	●	○
9	2€ for A and 8€ for B	●	○
10	1€ for A and 9€ for B	●	○
11	0€ for A and 10€ for B	●	○

Votre décision :

Proposal 5

Please choose the proposal up to which you will refuse the proposal of player A and then validate your choice by clicking on the button 'Validate'.

Choose 'Accept All' to accept all of Player A's proposals.

Validate

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

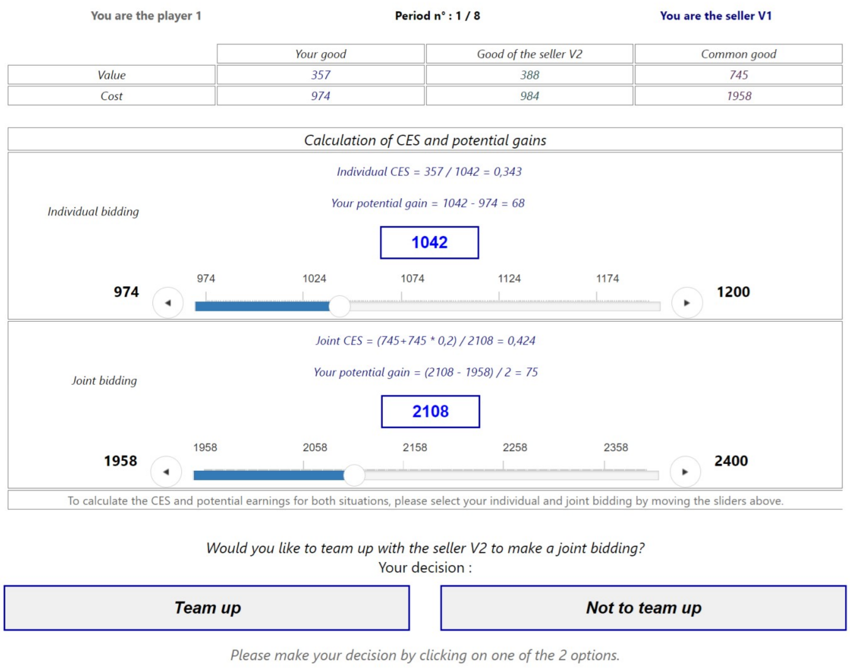


Figure B.5: Part 3 of the experiment (voluntary joint bid).

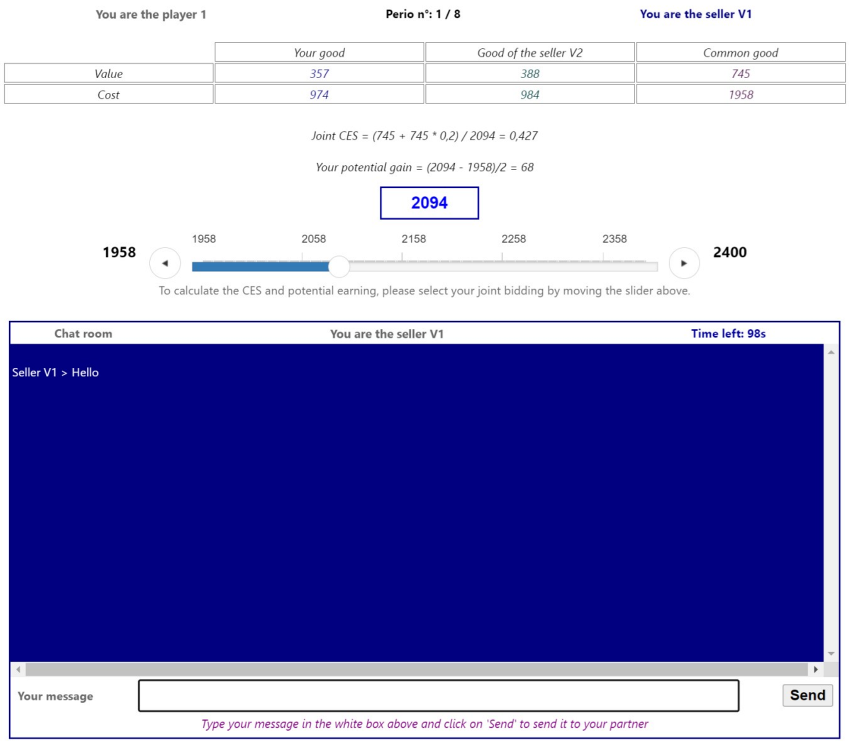


Figure B.6: Communication via a chat box (voluntary joint bid).

Appendix C: Experimental instructions

Thank you for participating in this experiment on decision making. In this experiment, you have the opportunity to win money. The amount of money you earn will depend on **your decisions and those of other participants**. We ask that you read these instructions carefully so that you understand the experiment. All your decisions will be **anonymous**. You will never enter your name on the computer. You will indicate your choices on the computer that has been assigned to you for the experiment.

From now on, you are not allowed to communicate with other participants. We also ask that you turn off your cell phone. If you have a question, raise your hand and an instructor will come and answer you privately.

This experiment consists of ***3*** parts. Attached are the instructions for part 1. You will receive specific instructions for each part once the previous part is completed. The instructions are the same for all participants.

The winnings you can accumulate by participating in this experiment are expressed directly in Euros for the first two games and in ECUS (experimental currency units) for the third game and will be converted into Euros according to the conversion rate of 10 ECUS = 1.5€. The total amount of the winnings that you will have accumulated during the 3 games will be paid to you in cash at the end of the experiment, in a private way.

PART 1

In this part, you will have only one decision to make. You will have to choose **a** lottery from ***5*** different lotteries. Your winnings in this game will depend on the outcome of the lottery.

For each lottery, there are two possible payoffs: the payoff for situation A and the payoff for situation B. Each situation has a ***50%*** chance of coming true.

In order to determine your winnings for this game, the computer will simulate the toss of a coin. If the coin lands on 'tails', situation A will occur and if the coin lands on 'heads', situation B will occur. Your winnings will be the same as the winnings of the winning situation for the lottery you have selected.

PART 2

In this game, there are two roles: player A and player B.

- Player A has to choose one way, among 11 proposals, to divide an amount of 10 € between himself and player B.

- Player B knows that Player A must make this choice and can either accept or reject the distribution chosen by Player A. If player B accepts the proposal, the players receive the amounts indicated in the proposal. If Player B rejects the proposal, both players receive nothing (0 €).

Your role (Player A or Player B) will be randomly determined by the computer at the end of the experiment.

In the meantime, you will make your decisions **as Player A and then as Player B**.

- *As Player A*, you must choose how you want to split the €10 between you and Player B from the 11 choices that will appear on your screen. From offer 1 to 11, Player A's winnings decrease from €10 to €0 per €1 and Player B's winnings increase from €0 to €10 per €1.

  You will therefore indicate the number of the proposal (between 1 and 11) that you have chosen.

- *As Player B,* you must decide for each of the 11 allocation proposals whether to accept or reject it.

  You will therefore indicate the proposal number up to which you wish to reject proposals and beyond which you wish to accept proposals.

  Example: if you indicate 2, it means that until proposal 2, you reject the proposals and from proposal 3, you accept the proposals.
  Once you have started to accept a proposal, you will not be able to refuse the proposals that follow. If you wish to accept all proposals, enter 0. If you wish to decline all proposals, enter 11.

At the end of the experiment, you will be paired with another participant and the computer will determine your respective roles.

Your earnings will depend on the role assigned to you by the computer:

- *If you are player A*, then you will win the amount indicated in the proposition you have chosen provided that player B, with whom you will be partnered, has accepted this proposition beforehand. Otherwise, you will both win €0.

- *If you are player B*, then you will win the amount indicated in the proposition chosen by player A, with whom you will be associated, only if you have accepted this proposition beforehand. Otherwise, you will both win €0.

PART 3

For this part, the conversion rate that applies is **10 ECU = 1.5 €.**

This 3ème part of the experience is composed of ***8*** periods. In each period you will be randomly assigned to a group of ***10*** players, including yourself.

In this Part 3ème , you and each of the other ***9*** members of your group represent a forest owner who sells wood from his or her forest. But your forest is also a source of ecosystem goods or services: it helps protect biodiversity, soils and groundwater quality, it contributes to carbon storage, and it provides recreational services. These goods or ecosystem services do not have a market, yet they have value because some people are willing to pay to preserve or enjoy these ecosystem services. However, the more wood you cut from your forest, the less the forest provides these environmental services. This is why programs have been put in place that allow forest owners to be compensated for providing these services and to make up for lost revenue from the sales of their wood. You, as a forest owner, can receive payment for your efforts to provide these non-timber goods.

You have the opportunity to offer these ecosystem assets for sale. You are not the only one to do so, you are in competition with ***9*** other forest owners who can also offer their ecosystem goods for sale. These ecosystem assets are sold to public buyers: state or representative, communities, public agency, etc.

In each of the ***8*** periods of the game, you and the ***9*** other members of your group must make an offer to sell ecosystem services from your environmental good. We will use the biodiversity offer here (we could have chosen another good but it is easier to visualize).

Biodiversity has a value (related to many factors such as the size of your forest, the number of forest species etc.). The service buyer will of course prefer to contract with an owner who provides a high level of biodiversity protection. There are also costs associated with biodiversity protection as you sell less wood from your forest. The cost associated with lost timber sales can be low or high depending on the type of forest.

Your decisions

At the beginning of each period, you will receive a value and a cost for your environmental asset.

The value and cost of your property varies from period to period and each vendor has a different value and cost than other vendors. The value of each environmental property is between 200 and 400 ECUS and its cost between 600 and 1000 ECUS.

In each period, you must make an offer to sell ecosystem services from your environmental good. Each bid for ecosystem services is also associated with an ***environmental efficiency ratio*** (***EEV***) that depends on the value of the environmental good and its bid for sale.

The ERC associated with your offer to sell will be equal to the value of your property divided by your offer to sell.

$$\boldsymbol{CEE} = \frac{\text{Valeur de votre bien}}{\text{Votre offre de vente}}$$

How to make your decision:

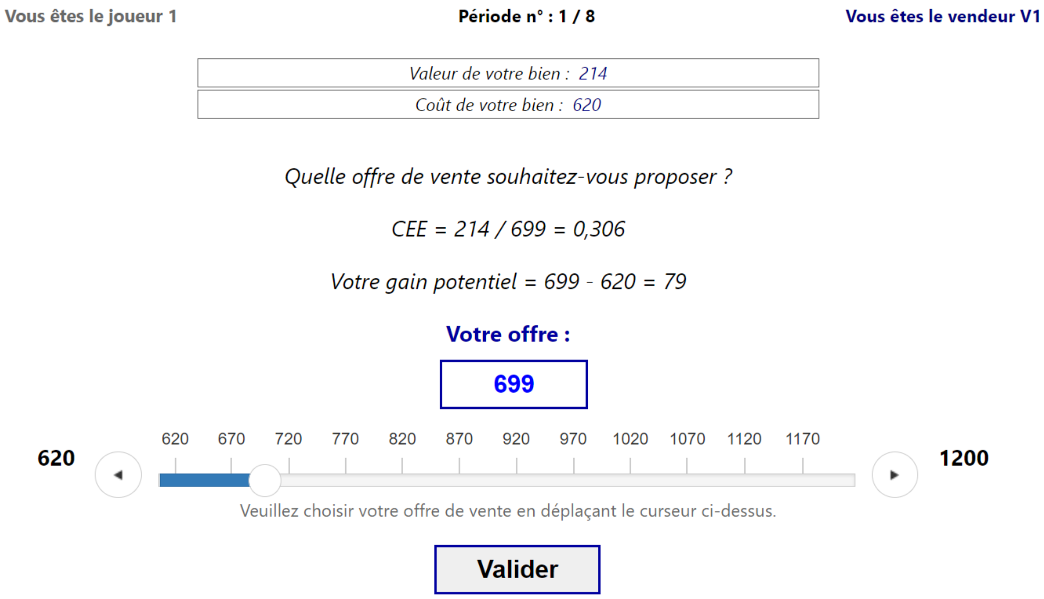
The picture below explains how to choose a sale offer.

On your screen, you will have a slider that allows you to choose your sales offer.

You will not be able to make a joint bid that is *less than* your cost, nor *more* than 1200.

By modifying the position of the cursor, you will also obtain on your screen, *the EWC associated with your environmental good as well as your potential gain if your offer is retained*.

Note, the arrows at the ends of the slider allow you to change your offer to the nearest unit, while clicking inside the slider will change your offer in steps of 50.



<u>Your earnings:</u>

At each period, only ***the 4 sales offers with the highest EWCs are retained***.

Two cases may then arise:

- If your offer to sell is not accepted, your gain will be zero.

- If you are successful, your profit for the period will be equal to your offer to sell - your cost.

$$\text{Gain offre} = \text{Offre de vente} - \text{Coût de votre bien environnemental}$$

Let's take two **random** examples:

Example 1. Suppose the value of your environmental asset is equal to 300 and your cost is equal to 600. Suppose you also made a sales offer equal to 700 and the top 4 winning sales offers all have an ERC greater than or equal to 0.5.

In this case your offer to sell will not be accepted because its EWC is equal to : 300 / 700 = 0.428 which is less than 0.5.

Your earnings for the period will be zero.

Example 2. Suppose the value of your environmental asset is equal to 300 and your cost is equal to 600. Suppose you also made a sales offer equal to 700 and the top 4 winning sales offers all have an ERC greater than or equal to 0.4.

In this case your offer will be accepted because its EWC is equal to : 300 / 700 = 0.428 which is greater than or equal to 0.4.

Your earnings for the period will then be equal to (700- 600) = 100 ECU.

At the end of each period, you will be informed if your offer to sell has been accepted or not, of the value of your EWC as well as your gain for the period.

At the end of the experiment, ***4*** *periods out of the* ***8*** will be paid according to the rate of conversion into euros. A participant will draw lots for the **4** periods in order to calculate the amount of the gain of this 3rd part. Each period has the same probability of being selected. The total win in euros for this part will be equal to the average of the winnings obtained for these 4 selected periods multiplied by 0.15.

Before you begin this section, you will be asked to complete an instructional comprehension quiz.