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Procedurally Fair Co-Determination with Endogeneous Value Uncertainty: An Experiment

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Abstract: We present an experimental test of a procedurally fair co-determination mechanism where group members reduce their value uncertainty before submitting bids for a joint project. The results suggest a relatively efficient mechanism, with unprofitable projects being largely rejected and profitable ones accepted. Repeated interactions tended to enhance the efficiency, while uncertain information reduced it. The subjects invested surprisingly little search effort to reduce the uncertainty about the costs and benefits, and appeared to trade off search costs against higher bids.

Keywords: corporate governance; joint venture; experiment; auction; uncertainty

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1. Introduction

Imagine a joint project involving several parties who jointly have to decide on a major investment and how its costs are shared. Even when the investment itself is clearly defined, the project's profitability may be difficult to gauge.[1] However, a better understanding of its potential benefits can be gained by searching, collecting, and analyzing all the available information. We discuss and present an experimental test of a fair co-determination mechanism where costly information search allows subjects to endogenously reduce value uncertainty.

Fair co-determination in corporate governance aims to integrate dispersed information from all relevant parties. Effective information collection reduces the risk of rejecting profitable projects or implementing unprofitable ones. We define a project as profitable when its total ex post benefits exceed the total ex post costs across all parties, and unprofitable otherwise. Co-determination is crucial for major investment decisions or policy changes with significant stakeholder impact. Instead of relying on veto rights, projects should be accepted only when the expected total benefits exceed the expected total costs, ensuring the decisions align with collective interests.

To address and simplify the complexity of the problem, our co-determination mechanism restricts parties to numerically state their benefits by submitting a bid. A bid exceeding the expected benefits is referred to as overbidding, while one that falls short is termed underbidding.

We specifically focused on fair co-determination for group decisions under *value uncertainty*, and where parties can endogenously influence their uncertainty. Each party can reduce the uncertainty about individual project benefits by privately engaging in a costly information search.

Information search is costly and represents a hidden action. Strategic uncertainty and informational uncertainty arise as parties have an incentive to search less than what would be optimal and underbid their values. Our experimental data reveal surprisingly low individual search efforts and frequent underbidding, consistent with risk and uncertainty aversion and strategic incentives. Contrary to the assumptions of purely self-interested behavior, subjects with very low values tend to overbid their values, potentially incurring personal losses to contribute to the common good (for related results, see Alberti et al., 2023).

We derive no theoretical equilibrium solution to the problem of optimal bidding and searching, as deriving one would require numerous simplifying assumptions about behavior.[2] Instead, we examined the empirical characteristics of our practicable, fair co-determination mechanism in comparison with two plausible benchmarks: an expected value benchmark and a no-loss benchmark. The observed outcomes generally fell between these benchmarks.

This paper is structured as follows: Section 2 reviews the relevant literature. Section 3 introduces and theoretically describes our co-determination mechanism. Sections 4 and 5 present the experimental design and our testable hypotheses. Section 6 presents and discusses the experimental results on efficiency (Section 6.1) and on the uncertainty effect (Section 6.2). Section 7 concludes this paper.

2. Relating Our Study to the Literature

Our research contributes to the literature on joint venture and corporate governance.[3] Early work in this area primarily focused on how to align the interests of potentially opportunistic firm managers with the interests of shareholders (Fama & Jensen, 1983; Jensen & Meckling, 1976). Fama and Jensen (1983) emphasized the importance of managerial competence and experience for efficient decision-making.[4] Fama and Jensen (1983) acknowledged that the agency problem, arising from the overlap of decision management and decision control, can harm residual claimants and suggested the separation of management and control of the most important decisions. This early literature assumed that corporate decisions are made by one rational agent with full awareness of the investment risks and rewards, and that moral hazard is the central problem. This contrasts with the modern view of corporate governance, which recognizes project selection as a multi-agent rather than an individual decision problem.

More recently, behavioral approaches to corporate governance have expanded to consider decisions involving the specialized knowledge of multiple agents (see the survey by Van Ees et al., 2009). Landier et al. (2013) explored the impact of managerial independence on decision-making quality, finding that a high proportion of independent executives (strong internal governance) predicts high future performance (returns).

Our study is related to Landier et al. (2009), who theoretically studied organizational decision-making with two agents: a decision-maker and an implementer. These agents have differing information levels about the project values and conflicting preferences. The decision-maker selects the investment project, while the implementer privately chooses between a high and low effort level in the project implementation. Information about the project profitability can be private, and successful project implementation may require a costly unobserved effort from the implementer. Both agents obtain private benefits when their preferred project materializes. The experimental results of Landier et al. (2009) confirmed that divergent preferences can enhance the efficiency in corporate decision-making by improving information sharing about project profitability. Similar to Landier et al. (2009), we also consider heterogeneous agents and a costly information search in joint project selection. However, our study differs by granting veto power to multiple agents.[5] Furthermore, we focus on how empirical value uncertainty and insufficient search affect corporate decision-making, using suitable experiments.[6]

Various studies have experimentally examined fair mechanisms using incentivized bidding for other collective action tasks: Güth et al. (2014) focused on the collective public ranking of alternatives via bidding, while Cicognani et al. (2015) and Güth et al. (2014) studied public project provision, showing that payoff-based social preferences (Fehr & Schmidt, 1999) are largely crowded out. Procedural fairness in bidding mechanisms often ensures the implementation of the socially best project. Güth et al. (2014), however, observed significant deviations from efficient project implementation when two projects were competing (instead of one). In contrast to these studies, our focus is on a fair bidding mechanism for the group decision-making of privately informed agents, which, despite its fairness, offers incentives for underbidding.

Alberti et al. (2023) used a closely related experimental setup with a manager (shareholder representative), who states surplus claims and decides whether to invest. Our main novelty is that parties must incur search efforts to obtain precise information about project values. Our setup incorporates endogenous and varying levels of investment value uncertainty, which are pervasive in real-world settings. Similar to Alberti et al. (2023), the decision for or against the project hinges on the group members' bids, but the project's profitability is determined ex post, after complete resolution of the value uncertainty. Our data enabled us to assess the efficiency of our co-determination mechanism by examining the likelihood of accepting profitable and rejecting unprofitable projects. Efficiency was affected by the search effort invested in reducing endogenous value uncertainty.

3. The Co-Determination Mechanism

We consider $N \geq 2$ parties, denoted $i = \{1, 2, \ldots, N\}$, who are also referred to as bidders. These parties are asked to reveal their perceived value for a particular project. The distribution from which individual values v_i are independently drawn is common knowledge. After the project's implementation, the bidder's value will be known with certainty, but ex ante, the value is uncertain. To obtain more precise information about the (expected) value, a party must invest in a costly information search. For all i, we assume increasing search costs $C(e_i)$, where $e_i \geq 0$ represents the bidder's search effort, and that a finite search can completely resolve the uncertainty.[7] Given the acquired information about their own value, bidder i states their bid b_i, which expresses i's willingness to pay if the project is implemented.[8]

The fair co-determination mechanism works as follows: let I denote the group's profitability benchmark for investments (e.g., the break-even level). The bidders state their bids b_i, which determine the project implementation. If the profitability benchmark is met or exceeded, i.e.,

$$\frac{\sum_i^N b_i}{N} \geq I \tag{1}$$

the project is implemented; otherwise, it is abandoned and the status quo is maintained. A project is considered profitable when the sum of the (ex post) values exceeds the profitability benchmark, and unprofitable otherwise. The bidder's (ex post) payoff depends on the outcome as follows:

$$\pi_i(b_i, e_i) = \begin{cases} v_i - b_i + E_i - C(e_i) + \frac{\sum_{i=1}^N b_i}{N}, & if(\sum_i^N b_i \geq I) \\ E_i - C(e_i), & otherwise \end{cases} \tag{2}$$

where $v_i \in [\underline{V}; \overline{V}]$ is i's individual value, E_i is the initial endowment, and $C(e_i)$ is the individual cost of the information search. When Equation (1) is not satisfied (i.e., the project is abandoned), the payoff is the status quo: endowment minus the search cost, as shown in the second line of Equation (2).

The basic properties of the fair co-determination mechanism, which shares the basic properties of the first-price auction (Güth, 2011), can be readily identified.

(1) If we assume a full uncertainty resolution (thus disregarding individual uncertainty effects by setting $C(e_i) = E_i$ for all i), the mechanism ensures equal treatment based on the bids. This means that if individual bids equal the individual values, all bidders i earn the same payoff; thus, the mechanism guarantees a fair share of the surplus according to the bids. Also, in the presence of uncertainty, assuming symmetric E_i and e_i, replacing values with value expectations would lead all bidders to expect the same payoff.

(2) Without bid restrictions, the mechanism grants individual veto power. By bidding sufficiently low, any individual bidder can reject the project, and thus, maintain the status quo.[9]

(3) The mechanism is overbidding-proof while providing incentives for underbidding.[10] Overbidding the (expected) value can lead to (expected) losses, whereas underbidding one's value can increase the individual gain but risks losing a profitable project.

Note that throughout this paper, we refer to over- and underbidding in two ways: first, relative to the ex post individual values and, second, relative to the expected individual values after the information search. Overbidding refers to a bid exceeding the (expected) individual value, and underbidding refers to a bid falling short of it. When necessary, we explicitly specify whether we refer to expected values or ex post values to avoid confusion.

We derive no theoretical equilibrium solution to the problem of optimal bidding and search, as the potential asymmetry in behavior is mathematically challenging.[11] Instead, we propose two plausible behavioral benchmarks for the group decision problem: the expected-value benchmark and the minimum-value benchmark. Both benchmarks lead to efficient group decision-making when the uncertainty is fully resolved.

First, the expected-value benchmark assumes that, given the levels of uncertainty, each bidder submits a bid equal to their expected value. This approach tends to result in a relatively high acceptance rate of profitable projects but also leads to accepting unprofitable ones unless the search effort eliminates all uncertainty.

Second, the minimum-value benchmark follows a no-loss principle, where each bidder submits the lowest possible value contained in their information set. While this approach prevents the acceptance of unprofitable projects, it also leads to the rejection of profitable projects unless the search efforts resolve all uncertainty.

The full resolution of uncertainty could be a viable solution, particularly for parties highly averse to uncertainty. However, applying the rule of full uncertainty resolution and value bidding would imply that individuals consider the common good beyond pure self-interest and would not constitute a Nash equilibrium.

To assess the search effort that symmetric agents would exert to maximize their individual payoff when using the benchmark bids, we conducted simulations using the matchings and (ex post) values identical to those in our data. The simulations showed that low search levels would be optimal for symmetric payoff maximization: a search level of 1 yielded the highest simulated group payoff within the expected-value benchmark, while a search level of 2 maximized the group payoff within the minimum-value benchmark.[12] These results contrast sharply with the full resolution of uncertainty required to consistently achieve efficient outcomes at the bidding stage. To surpass 0.99 efficiency, search levels of 4 and 5 were required for the expected-value and minimum-value benchmarks, respectively.[13] Overall, these simulation results suggest a trade-off between the search effort and higher bids. The minimum-value benchmark, representing lower bids that avoid losses, requires a higher optimal search level than the expected-value benchmark, which implies higher bids.[14]

4. Experimental Design

Three subjects, $N = 3$, endowed with $E_i = E = 3$ Francs (i.e., our experimental cash units) interacted in a period. Each subject's value v_i was uniformly distributed over the set of integers $\{1, \ldots, 64\}$ and independently drawn. One of the three subjects was randomly selected as the only negative evaluator,[15] and their drawn value received a negative sign. These positive or negative value sets were initial private information and presented the state of maximal uncertainty in the experiment. We chose this design with one negative and two positive values[16] because we expected the total to be frequently close to zero, which was the implemented profitability benchmark $I = 0$. This ensured that the decision-making would be non-trivial while (ex post) unprofitable projects would be infrequent. In expected terms, nine out of ten projects were (ex post) profitable and only one was unprofitable for the group of bidders.

After learning about the sign of their own initial value set, each subject could invest in the search effort to partially or fully resolve their own value uncertainty by reducing the length of the integer interval. The way in which the search effort e_i resolved uncertainty at a unit cost of one half is shown in Table 1.

Table 1. Information search effort levels, length of uncertainty intervals, and corresponding costs.

e_i	0	1	2	3	4	5	6
$l(e_i)$	64	32	16	8	4	2	1
$C(e_i)$	0	0.5	1	1.5	2	2.5	3

The second row of Table 1 specifies the length $l(e_i)$ of bidder i's discrete uncertainty interval, i.e., the set of integers it contained. The corresponding search costs are shown in the last row of Table 1. At the outset of the period and also with zero effort, the uncertainty interval contained 64 integers, revealing only the sign of the value. Each additional unit of search effort halved the uncertainty interval, following the formula $l(e_i) = \frac{64}{2^{e_i}}$ for $e_i = \{0, \ldots, 6\}$. In other words, the ex ante uncertainty interval was divided into 2^{e_i} subsets, each containing a consecutive set with an equal number of integers. Exerting maximal search effort ($e_i = 6$) revealed precisely the value at a cost of 3 Francs, equivalent to the periodic endowment E_i.[17] At an intermediary search level of $e_i = 4$, the value interval of integers was divided into 16 subsets, where each contained four consecutive integers. A subject that chose effort level $e_i = 4$ and an (ex post) value of, say, $v_i \in \{17, \ldots, 20\}$ Francs would be informed that their value lay between 17 and 20 Francs. Individual bids were constrained to the interval $[-64; 64]$ and could be submitted with two decimal places, although values were integers.

The experiment implemented two between-subject treatments: *endogenous uncertainty* and *exogenous uncertainty*, with the latter being the control treatment. Figure 1 illustrates the flow chart of each experimental period. Under exogenous uncertainty, e_i was randomly and independently chosen by the computer in each period, with the corresponding cost deducted from the subject's endowment before being told the set of possible values and the bid submission. In the endogenous uncertainty treatment, in contrast, the subjects were informed of the sign of their value before making their costly search effort choice e_i.

We also varied the "Partners" and "Strangers" treatments within subjects, with each subject playing for 20 periods of either condition. To account for order effects, half of the subjects began with the first 20-period phase of the Partners condition and played the Strangers condition in their second 20-period phase, whereas for the other half, the order of conditions was reversed (see the rematching order in Table 2). In the Partners condition, it was common information that the fixed groups of three subjects interacted repeatedly, whereas in the Strangers condition, two groups of three were randomly formed each period from a group of six. The subjects were informed that the composition of the group would be random and that it was unlikely they would interact with the same two others in consecutive periods.

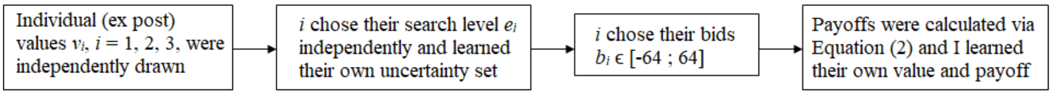


Figure 1. Timeline of the experimental period.

In the experiment, a group of six was treated as an independent observation. However, in the Partners treatment, a group of three could also be considered as independent when interacting in the first 20 out of 40 periods. Since our data analysis focused on groups of six, we had 20 independent observations.

Table 2. Treatments.

	Uncertainty Treatment		
Rematching Order	**Endogenous**	**Exogenous**	**Periods**
Partners 1–Strangers 2	3	3	20–20
Strangers 1–Partners 2	7	7	20–20
Total	10	10	40

This table presents the number of independent observations that involved groups of six in the two between-subject uncertainty treatments: one with an endogenous choice of the uncertainty level and the control treatment with a randomly given exogenous uncertainty level. The within-subject variations involved rematching under the Partners and Strangers conditions. In the Partners treatment, fixed groups of three subjects interacted repeatedly for 20 periods, with this setup being common information. In the Strangers treatment, two groups of three subjects were randomly rematched each period. "Partners 1–Strangers 2" indicates sessions where the subjects first participated in the Partners condition followed by the Strangers condition, while "Strangers 1–Partners 2" denotes the reverse order. Note that in the Partners condition over the first 20 periods, the number of independent observations for groups of three was twice the indicated one.

The subjects interacted repeatedly but never received feedback information about the others' information searches and uncertainty sets. They received, however, feedback information on the average bid of their group, in addition to their own value, and their own payoff at the end of the period.[18]

Procedures

The experimental sessions were conducted in the laboratory of the Luxembourg Institute for Socio-Economic Research in 2019 and 2020. The participants were recruited using the Online Recruitment System for Economic Experiments (ORSEE) (Greiner, 2015). The experiment was computerized with zTree (version 3.73) (Fischbacher, 2007). The six experimental sessions lasted 1.5 h each.

The participants first received written instructions (see the Appendix A) and were asked to read them carefully. The instructions were read aloud by the experimenter. Questions were privately answered with reference to the related points in the instructions. The experiment was programmed to allow for within-subject variation within each treatment. All the participants faced both conditions: they repeatedly interacted with constant partners (Partners setting) for 20 periods, and they interacted in periodically formed new random groups for another 20 periods (Strangers setting).

The subjects checked their understanding via a comprehension test of the fair co-determination mechanism (payoff function) before starting the experiment. The comprehension test tried to ensure that all participants understood what a negative value implied. In particular, each participant was asked to submit three bids, one negative and two positive, and to calculate the average bid of the group, as well as the payoff of each individual group member. In the cases of false answers or queries, the experimenter privately guided the participants until every participant successfully completed the test. That is, only after the successful completion of the comprehension test was the experiment launched. After each phase of 20 periods, the experimenter asked a randomly selected participant to draw a number from 1 to 20 from an opaque urn of 20 numbers in order to define the payoff period of all the participants. After the first phase, a second set of instructions was provided to the participants. The second set of instructions elaborated on the procedures of the second 20 periods. Similarly to the first part of the experiment, the instructions for the second 20 periods were read aloud by the experimenter and questions were answered privately.

All payoffs were displayed in cash units, denominated as Francs, where we applied the exchange rate of 3:1 for converting Francs into Euros. After the second 20 rounds, all the participants of the endogenous treatment answered a computerized questionnaire. The questionnaire included questions relative to personal characteristics of the participants (i.e., age, gender) and standard cognitive reflection tasks, as well as some more general questions (i.e., conformity questions on honesty, leadership, trust). The average participant in our endogenous treatment was 24 years old, had a CRT score of 0.55, self-identified as risk-neutral, and 63 percent were female.[19] Finally, the participants were privately paid the payoff of one randomly selected period from each successive phase, plus a show-up fee of 10 Francs.

5. Testable Hypotheses

This section outlines our testable hypotheses.

As stated above, the co-determination mechanism implies no incentive to overbid but provides incentives to underbid the value, as each bidder pays their bid at the project implementation.[20] However, the incentive to underbid is limited since too much underbidding risks rejecting a potentially profitable project, and thus, may result in foregone payoffs. From a practical perspective, the important empirical question is whether the mechanism predominantly selects profitable group projects while rejecting unprofitable ones. So, the first part of our behavioral discussion addresses the efficiency of group decision-making.

Hypothesis 1 (Hypothesis EFF1)**.** *Our procedurally fair bidding mechanism promotes efficient rather than inefficient corporate governance:*

(a) Profitable projects are more likely to be accepted than rejected.

(b) Profitable projects are more likely to be accepted than non-profitable ones. Unprofitable projects are more likely to be rejected than profitable ones.

Note that distinguishing clearly between profitable and non-profitable projects is (ex ante) difficult under value uncertainty, which, by chance, can lead to the acceptance of (ex post) non-profitable projects and the rejection of profitable ones. Therefore, we measured efficiency based on the sum of the (ex post) actual individual values and not on the basis of the (ex ante) expected values. For instance, if the players bid close to expected values, which, however, are below the unknown actual values, profitable projects can be rejected. Conversely, if the expected values are above the (ex post) actual values, non-profitable projects can be accepted. To evaluate the efficiency levels observed in the data, we conducted simple simulations using the expected-value and minimum-value benchmarks described above, applied to the observed search levels. For each benchmark model, we thus obtained an average efficiency level for every independent observation. These benchmark efficiencies serve as reference points for assessing the efficiency observed in the actual data.

We expected the treatment conditions, uncertainty and repeated interaction, to impact the prospects of efficiency-enhancing group decision-making. Specifically, we hoped to confirm the following:

Hypothesis 2 (Hypothesis EFF2)**.** *The efficiency levels are negatively impacted by uncertainty and positively by repeated interactions (i.e., the efficiency levels should be higher with more precise information, as well as in the Partners rather than in the Strangers treatment), but not impacted by the order of the two rematching protocols.*

The former claim was inspired by reputation effects,[21] letting individuals initially mimic cooperative behavior but resorting to opportunistic endgame behavior when interacting with the same others. The latter part focuses on the effects of informational uncertainty. When precisely informed, the value interval is a singleton, i.e., the subject knows the value with certainty. We say that a subject has uncertain information when their value interval includes more than one integer. We assumed (as is common in the social sciences) that individual risk aversion implies that uncertainty impacts bidding in the following way:

Hypothesis 3 (Hypothesis UNC3)**.** *Subjects with uncertain information underbid the expected value, hereafter referred to as underbidding, meaning that* $b_{i,t} < Ev_{i,t}$ *or* $\frac{b_{i,t}}{Ev_{i,t}} < 1$.

Assuming individual aversion to uncertain information, we predicted that underbidding will be exacerbated with an increased level of uncertainty, specifically the following:

Hypothesis 4 (Hypothesis UNC4)**.** *The higher the level of uncertainty, the greater the extent of the underbidding:* $\Delta(\sum_i v_{i,t} - b_{i,t})/\Delta(\sum_i e_{i,t}) < 0$.

Assuming that individuals prefer smaller over larger uncertainty intervals, subjects of the endogenous uncertainty treatment will, on average, opt for lower levels of uncertainty compared with the randomly assigned ones.[22]

Hypothesis 5 (Hypothesis UNC5)**.** *The chosen levels of informational uncertainty in the endogenous uncertainty treatment are, on average, lower than in the exogenous uncertainty treatment.*

6. Experimental Results

In this section, we present tests of our hypotheses using the experimental data. We begin by examining the efficiency of decision-making and then proceed to analyze the effects of value uncertainty on collective decision-making and efficiency.

6.1. Efficiency Analysis

We measured the efficiency of the mechanism by its share of (ex post) efficient group decisions: if a profitable project was accepted or if a non-profitable project was rejected, the group decision was efficient; otherwise, it was inefficient.

Observation 1. *With our co-determination mechanism, efficient group decisions were more frequent than inefficient ones:*

(a) Profitable projects were more frequently accepted than rejected.

(b) Profitable projects were more frequently accepted than non-profitable ones. Unprofitable projects were more frequently rejected than accepted.

(c) A comparison of the data with the behavioral benchmarks revealed that the efficiency was lower than in the expected-value benchmark but met or exceeded the minimum-value benchmark.

These observations confirm Hypothesis EFF1.

Support: Figure 2 illustrates the distribution of relative frequencies of project acceptance conditional on the project profitability. Table 3 provides the average efficiency levels ordered by treatment, including the two-tailed Wilcoxon signed-ranks test results. The overall average efficiency was 0.75, meaning that in three out of four cases, the correct group decision was made, while in one out of four cases, the wrong group decision was made. The difference is significant (Table 3 reports a p-value of 0.000 (z = 3.922) overall). More detailed test results for each treatment are shown in Table A2 in Appendix B.

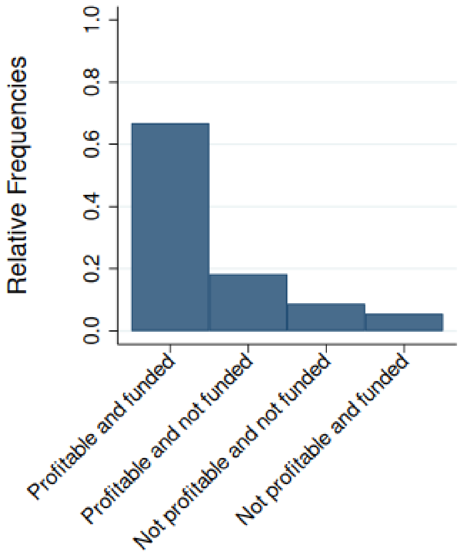


Figure 2. Relative frequencies of accepted and rejected, profitable, and non-profitable projects.

Table 3. Relative frequencies of efficient group decisions.

Treatment		**Profitable Projects**		**Unprofitable Projects**		**Decision**	
Uncertainty	**Matching**	**Accepted**	**Rejected**	**Rejected**	**Accepted**	**Efficient**	**Inefficient**
Endogenous	Partners	0.71 >>>	0.16	0.09 >>>	0.04	0.80 >>>	0.20
	Strangers	0.63 >>>	0.20	0.09	0.07	0.73 >>>	0.27
	Subtotal	0.67 >>>	0.18	0.09 >>	0.05	0.76 >>>	0.24
Exogenous	Partners	0.65 >>>	0.19	0.08	0.07	0.73 >>>	0.27
	Strangers	0.66 >>>	0.19	0.07	0.06	0.74 >>>	0.26
	Subtotal	0.66 >>>	0.19	0.08	0.07	0.74 >>>	0.26
Total	Partners	0.68 >>>	0.18	0.08 >>	0.05	0.77 >>>	0.23
	Strangers	0.65 >>>	0.20	0.08	0.07	0.73 >>>	0.27
Overall		0.66 >>>	0.19	0.08 >>	0.06	0.75 >>>	0.25

>>> indicates a significant difference (larger) at 0.01 and >> at 0.05 according to the two-tailed Wilcoxon signed-ranks test. The reported numbers represent averages, while the test examined the differences in the distributions. Profitable projects were those for which the sum of the values was positive; unprofitable projects were those for which the sum of the values was negative. Zero-profit projects are not considered in this table. Efficient decisions were the accepted profitable projects and rejected unprofitable ones. Inefficient decisions were the rejected profitable and accepted unprofitable projects.

The share of profitable projects was 0.85, of which 0.66 were accepted and 0.19 were rejected. Therefore, approximately 0.78 of the profitable projects were accepted and 0.22 were rejected. This difference is significant (see Table 3 and Hypothesis EFF1.a). More detailed test results are reported in Table A3 in Appendix B.

A share of 0.14 in Table 3 involved unprofitable projects,[23] of which 0.06 were accepted and 0.08 were correctly rejected. The conditional relative frequencies of 0.58 of correctly rejected and 0.42 falsely accepted ones differed significantly (overall: $p = 0.046$), particularly for the Partners treatment ($p = 0.040$), but not significantly for the Strangers treatment ($p = 0.399$), despite the correct sign, as indicated in Table 3. The detailed test results are reported in Table A4 in Appendix B.

The conditional frequency of accepting profitable projects was 0.72, notably higher than the 0.42 rate observed for unprofitable projects. In line with Hypothesis EFF1.b, this difference is significant, with p-values below 0.01 for each treatment and overall.

To evaluate the efficiency level of 0.75, we conducted simulations using our two theoretical benchmarks. We assumed the search levels, group composition, and (ex post) values of the subjects from the experimental data, and applied the expected-value and minimum-value benchmarks, respectively, to generate simulated group decisions for each observed group decision. Comparing the efficiency of the simulated group decisions with the actually observed efficiency showed the stated result. If the subjects had consistently submitted bids equal to the expected value, given their search levels, the overall efficiency level would have been 0.807, higher than the actually observed level of 0.75. The Wilcoxon signed-ranks test confirmed the statistical significance of this difference ($p = 0.032$).

Conversely, the minimum-value benchmark, which implements the lower bound of the value interval in the simulation, yielded a lower efficiency in the simulation. The simulated overall efficiency level across our 20 independent observations was 0.719. However, the Wilcoxon signed-ranks test indicated no significant difference between the observed efficiency and the minimum-value benchmark simulation ($p = 0.296$).[24]

Observation 2. *The efficiency levels were higher in the Partners than in the Strangers treatment. There were no significant differences between the endogenous and exogenous uncertainty treatments, and there was no significant Partner–Stranger treatment order effect. The size of the uncertainty interval had a weak effect on the efficiency.*

This observation partially confirms Hypothesis EFF2.

Support: Table 3 shows the relative frequencies of efficient decisions. Efficient group decisions occurred in 0.77 of cases in the Partners treatment and 0.73 of cases in the Strangers treatment. The two-tailed Wilcoxon signed-ranks test shows that this difference is significant, yielding a p-value of 0.083. There was no treatment-order effect.[25]

The relative frequencies of the efficient outcomes in the endogenous and exogenous uncertainty treatments were 0.76 and 0.74, respectively (see Table 3). The difference was not significant (Mann–Whitney test, $p = 0.649$).

Uncertainty had no apparent effect on the share of efficient group decisions (see Table A7). Thus, Hypothesis EFF2 was partially supported: repeated interactions and treatment order showed the expected effect, but the anticipated uncertainty effect did not materialize.

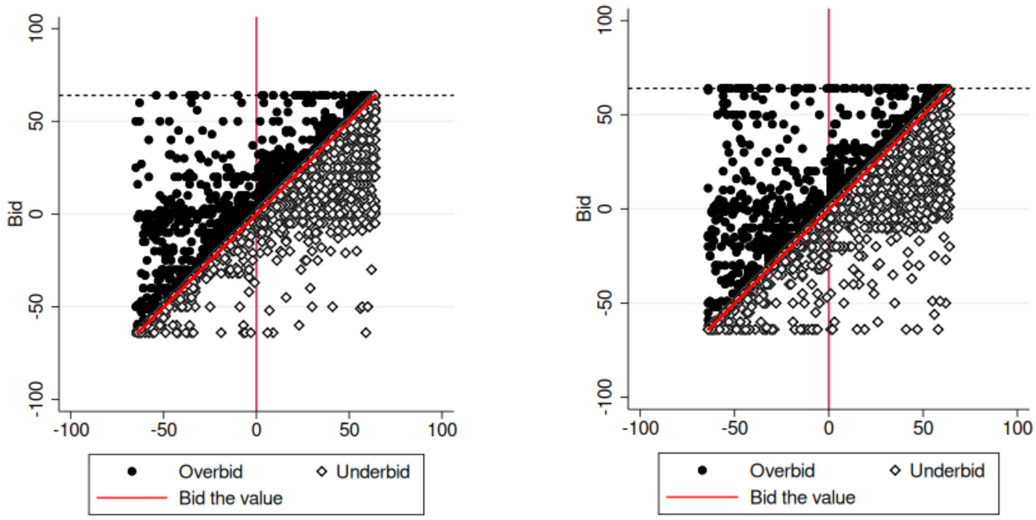
6.2. Uncertainty Effect Analysis

This section reports our findings on the effects of uncertainty, addressing our Hypotheses UNC3–UNC5.

Observation 3. *With both uncertain and precise information, subjects underbid their expected value when it was positive and overbid their expected value when it was negative.*

This observation confirms Hypothesis UNC3 for positive values but not for negative ones.[26]

Support: Figure 3 presents the scatter plot of individual bids in our treatments, classifying them (ex post) as under-, over- or value bidding.[27] It is evident that (ex post) underbidding was a frequent response for positive values and overbidding for negative ones. This pattern was the same for value uncertainty, as well as for value certainty.



Endogenous Exogenous

Figure 3. Distributions of bids across uncertainty treatments.

Across all treatments, 0.88 of subjects had uncertain information, with 0.58 facing a positive and 0.30 a negative value interval. These subjects knew their value was contained in a set including 2 to 64 integers, where the expected value was the interval's midpoint. The remaining 0.12 of subjects had precise information about their individual private value, with 0.04 facing negative and 0.08 positive values.

Table 4 reports the conditional relative frequencies of overbidding and underbidding the expected value for subjects with positive or negative values, separately for uncertain and precise information, and indicates the significant test results. For positive values, 0.355 of the bids were at or above the expected value, whereas 0.645 were below. This difference is significant (Table 4, $p = 0.000$, $z = -3.584$).[28] This finding supports Hypothesis UNC3.

However, there was the converse effect of overbidding the expected value when the subjects had a negative value. Given a negative value, bidding at or above the expected value occurred with a conditional relative frequency of 0.673 and underbidding with 0.327. The difference is significant (Table 4, $p = 0.000$, $z = 3.472$). This finding contradicts Hypothesis UNC3.

The observation of overbidding negative values and underbidding positive values extended to precise information, as indicated in Table 4.

Overbidding the value may seem counter-intuitive, but confirms the experimental result of Alberti et al. (2023), who suggested that, given a low value, subjects tend to overbid their value because they would not want to stand in the way of accepting an overall profitable project.

Table 4. Conditional relative frequencies of over- and underbidding the expected value.

Treatment		**Uncertain Information**				**Precise Information**					
		$V_i < 0$		$V_i > 0$		$V_i < 0$			$V_i > 0$		
Uncertainty	**Matching**	$b_i \geq E(V_i)$	$b_i < E(V_i)$	$b_i \geq E(V_i)$	$b_i < E(V_i)$	$b_i > V_i$	$b_i < V_i$	$b_i = V_i$	$b_i > V_i$	$b_i < V_i$	$b_i = V_i$
Endogenous	Partners	0.696 >>	0.304	0.371 <	0.629	0.769 >>>	0.126	0.105	0.021 <<<	0.815	0.163
	Strangers	0.675 >>>	0.325	0.280 <<<	0.720	0.688 >>	0.125	0.187	0.211 <	0.456	0.333
	Subtotal	0.684 >>	0.316	0.325 <<<	0.675	0.742 >>>	0.120	0.138	0.098 <<<	0.657	0.244
Exogenous	Partners	0.674 >>>	0.326	0.351 <<<	0.649	0.439	0.230	0.311	0.062 <<<	0.624	0.314
	Strangers	0.650 >>	0.350	0.418 <	0.582	0.436 >	0.253	0.311	0.083 <<<	0.642	0.275
	Subtotal	0.662 >>	0.338	0.385 <<	0.615	0.440	0.243	0.316	0.072 <<<	0.635	0.294
Total	Partners	0.685 >>>	0.315	0.361 <<<	0.639	0.595 >>>	0.181	0.224	0.042 <<<	0.719	0.239
	Strangers	0.662 >>>	0.338	0.349 <<<	0.651	0.562 >>>	0.189	0.249	0.147 <<<	0.549	0.304
Overall		0.673 >>>	0.327	0.355 <<<	0.645	0.591 >>>	0.182	0.227	0.085 <<<	0.646	0.269

>>> and <<< indicates a significant difference (larger and smaller, respectively) at 0.01, >> and << at 0.05, and > and < at 0.1 according to the two-tailed Wilcoxon signed-ranks test. The reported numbers represent averages, while the test examined the differences in the distributions. This table records the average conditional relative frequencies of the subjects underbidding and weakly overbidding their expected individual value $E[V_i]$ when they had *uncertain* information about the value, and strictly under-/overbidding the value or bidding the value when the information was precise. When the information was uncertain, the subjects knew the value interval that contained 2–64 integers in which their individual value was contained. The expected value was the midpoint of the value interval. The interval was a singleton when precisely informed.

To test this suggestion, we conducted a probit regression analysis to ensure that the bidding behavior for negative values did not simply mirror that for positive values. We conducted a regression of underbidding on the expected value, separately for positive and negative values.

Observation 3 (a). *The tendency to underbid increased with the expected value for both the positive and negative value domains.*

Support: Table 5 presents the results of the probit regression analysis of underbidding on the expected value. The expected value was a significantly positive determinant of underbidding: The higher the expected value, the larger the underbidding. This result held for both negative and positive value domains. Hence, overbidding negative values was not simply a mirror image of underbidding positive values.

Indeed, overbidding was collectively non-detrimental. Owing to overbidding, twice as many profitable as non-profitable projects were accepted. The Wilcoxon signed-ranks test shows this difference is significant (p = 0.000, z = 3.672). Negative-value bidders were frequently responsible for the acceptance of projects, both in view of their overbidding magnitude and their relative frequency. Without their overbidding, many more projects would have been rejected.

Observation 4. *The higher the level of value uncertainty, the lower the relative frequency of underbidding.*

This observation contradicts Hypothesis UNC4.

Support: The probit regression analysis, presented in Table 6, examined the relationship between the (binary) decision to underbid the expected value and the search level. The binary variable was 1 when the subject underbid, and 0 otherwise. The uncertainty was measured by the length of the discrete value interval, inversely related to the search level. The data show that for positive and negative individual values, the likelihood of underbidding the expected value significantly decreased when the interval, and thus value uncertainty, was large due to reduced search. This observation rejects Hypothesis UNC4.

Table 5. Expected value (size) effect on *underbidding behavior*. Probit regression results.

	Overall	$V_i < 0$	$V_i > 0$	$V_i < 0$	$V_i > 0$
Expected value	0.0176 ***	0.005 **	0.024 ***	0.005 **	0.022 ***
	(0.000)	(0.033)	(0.000)	(0.024)	(0.000)
Uncertainty level				−0.009 ***	−0.007 ***
				(0.000)	(0.005)
Strangers				0.131 **	−0.078
				(0.039)	0.121
Strangers first				−0.093	−0.018
				0.131	(0.726)
Constant	−0.013	−0.312 **	−0.235 ***	−0.166	0.009
	(0.820)	(0.024)	(0.000)	(0.331)	(0.931)
Observations	4770	1590	3180	1590	3180
Clusters	20	10	10	10	10
Wald $chi^2(1)$	109.54	4.55	186.58	78.60	241.26
Pseudo R^2	0.164	0.004	0.163	0.023	0.171

*** indicates a significant result at 0.01, and ** at 0.05, according to the two-tailed *t*-test (*p*-value in parentheses). The two columns at the right include the control variables to reduce the omitted variable bias. Probit regression on the bidding behavior with robust standard errors; underbidding is bidding below the uncertainty interval median (value); the uncertainty level is the length of the uncertainty interval {1, 2, 4, 8, 16, 32, 64}.

This pattern is illustrated in Figures 4 and 5, where the relative frequency of underbidding remained stable on average, while the relative frequency of overbidding decreased with higher search levels in all conditions. Consequently, underbidding was relatively less common compared with overbidding at lower search levels, but became relatively more frequent at higher search levels.

The data thus suggest that underbidding depended on the individual search effort and its related cost. If the search cost was high, underbidding became more likely than when the search cost was low. Thus, the subjects compensated themselves for high search costs by underbidding at the final stage.[29] This effect was slightly less clear in the endogenous treatment, where high search efforts were chosen less frequently than by chance in the exogenous treatment.

Observation 5. *The chosen uncertainty levels (search levels) in the endogenous treatment were not lower (higher) than in the exogenous treatment.*

This observation is at odds with Hypothesis UNC5.

In Figures 4 and 5, the relative frequencies of underbidding are reported for each cell of the experimental 2 × 2 design, separately for negative and positive values. Figure A3 in Appendix B displays the cumulative distribution of relative frequencies for the deliberately chosen search levels that determined the individual value uncertainty in the endogenous treatment, as well as the exogenous treatment, where the uncertainty level was exogenously and randomly determined. The chart shows that the subjects chose small intervals of 1 or 2 integers less frequently than chance. As Table 7 records, the subjects opted for certainty (interval length of 1, precise information) about the value with a relative frequency of 0.098 and an interval length including two values with a relative frequency of 0.052. Both frequencies differed significantly from the exogenous treatment,[30] where the *p*-values were 0.034 and 0.000, respectively. Similar results were obtained when considering the negative and positive values separately. The average chosen uncertainty level was 19.88 in the endogenous treatment and 17.50 in the exogenous treatment. This difference was not significant. Therefore, Hypothesis UNC5, which posits that participants in the endogenous treatment would exert a higher search effort than those in the exogenous treatment due to uncertainty aversion, is not supported by the data.

Table 6. Uncertainty effect on *underbidding behavior*. Probit regression results.

	Overall	**Endogenous**	**Exogenous**	**Endogenous**	**Exogenous**
$V_i < 0$					
Uncertainty level	−0.009 ***	−0.013 ***	−0.006 ***	−0.012 ***	−0.006 ***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Strangers				0.151	0.107 *
				(0.191)	(0.095)
Strangers first				−0.098	−0.099
				(0.357)	(0.171)
Constant	−0.329 ***	−0.295	−0.359 ***	−0.320	−0.367 ***
	(0.002)	(0.100)	(0.009)	(0.216)	(0.001)
Observations	1590	800	790	800	790
Clusters	20	10	10	10	10
Wald $chi^2(1)$	22.09	10.58	11.48	38.24	22.59
Pseudo R^2	0.017	0.029	0.007	0.032	0.008
$V_i > 0$					
Uncertainty level	−0.019 ***	−0.012 ***	−0.030 ***	−0.012 ***	−0.030 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Strangers				0.117	−0.150 **
				(0.192)	(0.015)
Strangers first				0.138	−0.100
				(0.119)	0.106
Constant	0.773 ***	0.701 ***	0.856 ***	0.579 ***	0.987 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	3180	1600	1580	1600	1580
Clusters	20	10	10	10	10
Wald $chi^2(1)$	54.37	17.49	233.81	21.13	259.56
Pseudo R^2	0.081	0.030	0.163	0.035	0.167

*** indicates a significant result at 0.01, ** at 0.05, and * at 0.1 according to the two-tailed *t*-test (*p*-value in parentheses). The two columns at the right include the control variables to reduce the omitted variable bias. Probit regression on the bidding behavior with robust standard errors; underbidding is bidding below the uncertainty interval median (value); the uncertainty level is the length of the uncertainty interval {1, 2, 4, 8, 16, 32, 64}.

It appears that the participants' aversion to uncertainty was not as strong as we anticipated, and their willingness to pay for uncertainty reduction was lower than anticipated. The most likely explanation for the limited search effort is the exponential increase in marginal costs for uncertainty resolution.[31] With a relatively low search effort compared with the full uncertainty resolution, the participants in the experiment could reduce their uncertainty from an initial range of 64 integers to an interval of 32. However, eliminating a comparable amount of uncertainty beyond this point would require paying five times the initial cost. The exponential increase in marginal costs for uncertainty resolution likely discouraged many participants, leading them to accept some level of uncertainty. As suggested by our simulation approach, relatively low search levels could maximize the group payoff in the symmetric benchmark models.

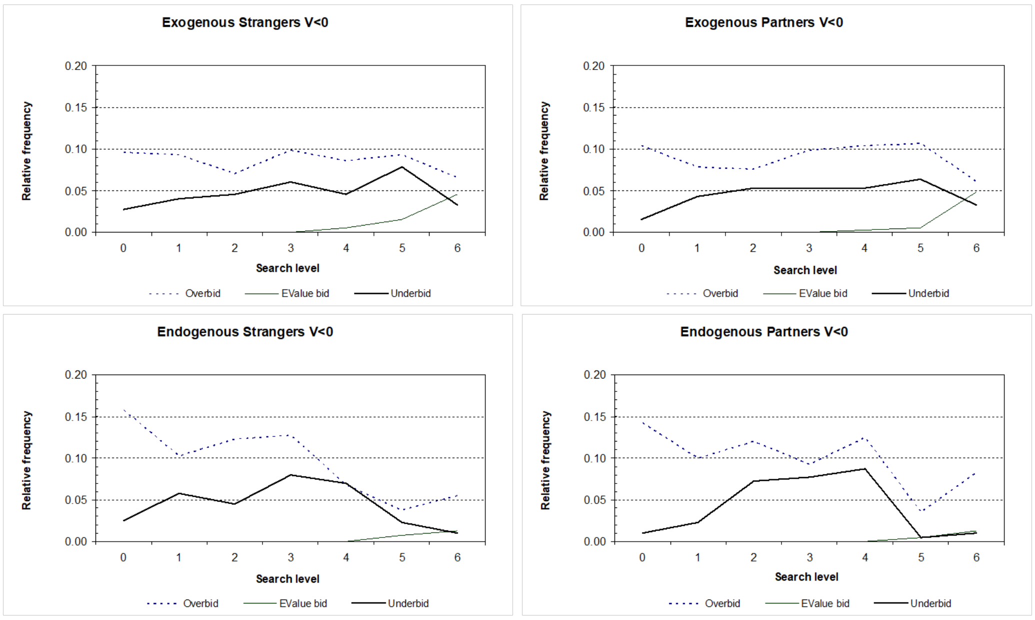


Figure 4. Search levels and bidding behavior given negative values. This figure presents the relative frequency of (ex ante) underbidding, overbidding, and expected value bidding across the four treatment conditions for bidders with a negative value, broken down by search level. A search level of 0 represents complete value uncertainty, while a search level of 6 indicates full resolution of the value uncertainty. The relative frequencies at each level sum to 1 across all the search levels in each chart.

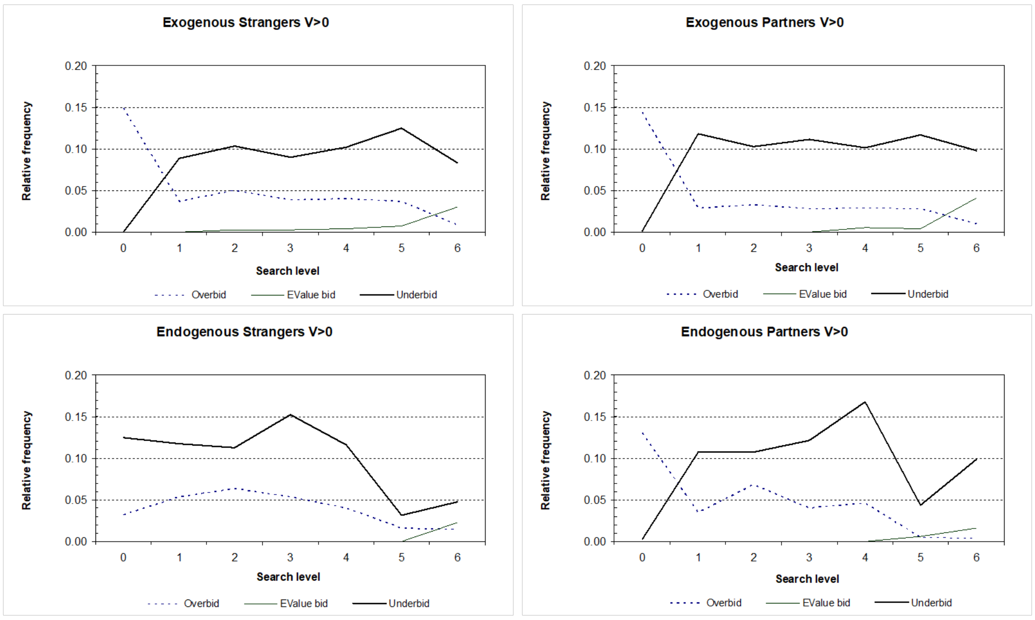


Figure 5. Search levels and bidding behavior given positive values. This figure presents the relative frequency of (ex ante) underbidding, overbidding, and expected-value bidding across the four treatment conditions for bidders with a positive value, broken down by search level. A search level of 0 represents complete value uncertainty, while a search level of 6 indicates full resolution of the value uncertainty. The relative frequencies at each level sum to 1 across all the search levels in each chart.

Table 7. Relative frequency of *uncertainty level*.

	Overall		$V_i < 0$		$V_i > 0$	
Interval Length	**Endogenous Treatment**	**Exogenous Treatment**	**Endogenous Treatment**	**Exogenous Treatment**	**Endogenous Treatment**	**Exogenous Treatment**
1	0.098 $<<$	0.138	0.091 $<<<$	0.143	0.102	0.136
2	0.052 $<<<$	0.167	0.056 $<<<$	0.181	0.051 $<<<$	0.159
4	0.181	0.143	0.175	0.148	0.185	0.141
8	0.186	0.142	0.189	0.155	0.184	0.135
16	0.178 $>>$	0.139	0.180	0.124	0.176 $>>$	0.146
32	0.152	0.133	0.141	0.127	0.157	0.136
64	0.152	0.138	0.168	0.121	0.145	0.147
Avg. length (std.dev.)	19.88 (7.040)	17.50 (1.748)	20.53 (7.058)	16.15 (1.830)	19.53 (7.217)	18.17 (2.304)

$<<<$ indicates a significant difference (smaller) at 0.01 and $<<$ (smaller) and $>>$ (larger) at 0.05 according to the two-tailed Mann–Whitney test. The reported numbers represent averages, while the test examined the differences in the distributions. The uncertainty level was the length of the interval in which the subject's value was contained. The uncertainty level was the deliberate individual choice in the endogenous treatment, whereas it was a random choice in the exogenous treatment. The relative frequency of each interval length is reported, and the average level and (standard deviation) are reported for the endogenous treatment and the exogenous treatment, overall and separately for negative ($V_i < 0$) and positive ($V_i > 0$) values.

Comparing the individual search choices across treatment conditions confirmed that the value uncertainty was a bit lower for Partners than for Strangers. The average length of the discrete uncertainty interval for Partners was 18.23 with positive values and 19.17 with negative values. For Strangers, the respective numbers were 20.83 and 21.90. The differences across treatments, Partners and Strangers, were not significant; the p-values of the Wilcoxon signed-ranks tests were 0.169 for positive and 0.386 for negative values. In contrast, the search levels chosen in the endogenous treatment differed significantly between Partners and Strangers. The Wilcoxon signed-ranks test p-value result was 0.075 overall in the endogenous treatment; separately, the results were 0.093 and 0.169 for positive and negative values, respectively. The difference is visible in Figures 4 and 5, with the modal search level being 4 in the Partners condition, while it was 3 in the Strangers condition.

7. Conclusions

When determining whether a collective action is worthwhile, the key factor is the combined knowledge of the group members. Letting group members express what they privately know via individual bids is an obvious and often employed institutional practice in both commerce and politics.

We have discussed and experimentally tested a procedurally fair co-determination mechanism that uses equally weighted bids to determine whether group projects are collectively accepted or rejected. The mechanism allows for veto power and is based on equal treatment according to bids. Since individual overbidding is dominated under certain information, the risk of collectively accepting an unprofitable joint project is limited, but could become crucial when value information becomes uncertain. This risk could be mitigated by enabling group members to reduce the uncertainty through investments in searching for more precise individual information while also limiting opportunism by encouraging repeated interactions, which create chances for reciprocity-based conditional cooperation.

We investigated these aspects by allowing the group members to reduce their uncertainty at a cost through information searches about project values, which enabled the participants, in one condition, to endogenously determine their own desired level of uncertainty. In the other condition, uncertainty was imposed randomly and exogenously. In our view, the combination of veto power and procedural fairness renders the mechanism rather attractive, and we consider these treatments to be realistic aspects of decision-making in corporate governance and joint ventures. The other condition, which was varied experimentally, appeals to the "shadow of the future". In our setup, this meant that the participants who engage in repeated interactions could conceal selfish motives and exhibit cooperative behavior—at least until the interaction nears its end, when future dealings would become less relevant and the influence of the "shadow of the future" would diminish.

Our experimental results revealed a relatively high efficiency of the procedurally fair mechanism. Most unprofitable projects were rejected, and profitable projects were generally accepted. The obtained efficiency fell between our two simulated benchmarks, which corresponded to bidding the expected value and the minimum value, respectively. Furthermore, repeated interactions (Partners) enhanced efficiency relative to random (Strangers) rematching, whereas value uncertainty had a negative effect on the efficiency. These results are intuitive and in line with our hypotheses. The considerable efficiency of the mechanism was one contribution of this study.

Another contribution was the analysis of the uncertainty effect. In line with one of our hypotheses, the subjects underbid their expected individual value in the positive-value domain when knowing their value with certainty, as well as when uncertain about their value. Contrary to this hypothesis, however, the subjects often overbid their expected value in the negative-value domain. This finding is consistent with Alberti et al. (2023), who observed that bidders with low values tended to overbid to enhance the prospects of accepting collectively profitable projects. Our data confirm this observation.

However, the data contradict two of our hypotheses on uncertainty effects. First, we hypothesized that underbidding increases with the level of uncertainty, as subjects would try to avoid losses. Yet, we observed the opposite: underbidding decreased with the level of uncertainty. As the level of uncertainty was inversely linked to search costs, the subjects seemed to account for higher costs by compensating with increased underbidding. It seems that the subjects did not treat the search effort as a sunk cost by separating it from the bidding decision. Instead, the subjects rather viewed the search effort and bidding as two components of voluntarily contributing to the common good and well-being, which in our setup meant promoting collective investing in profitable projects and avoiding non-profitable ones.

Not anticipating that subjects would trade off their payoffs between their two decisions in this way, we hypothesized (based on the behaviorist's intuition of uncertainty aversion) that they would opt for a lower level of uncertainty than randomly assigned. The subjects intentionally chose high uncertainty levels, potentially to save on information search costs, which were more certain than the gains that accrued from group decision-making.

Both non-hypothesized effects—the trading off of search and bidding costs and the insufficient search in the presence of uncertainty—were consistent with the symmetric payoff maximization in our simulated behavioral benchmarks.

A potential welfare and policy implication of our study is that search efforts should be disclosed, for example, through reporting, to enhance the transparency between the evaluating parties.

A limitation of this study, which future research could beneficially address, is the lack of comparison with alternative co-determination mechanisms. Further experimental studies could examine how other fair mechanisms, such as majority voting, or even "unfair" mechanisms, compare with the approach investigated here, and thus provide deeper insights into the behavioral implications of co-determination mechanisms.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A. Instructions

You are about to participate in an experiment on group decision-making. Please switch off your mobile phones now and keep them switched off until the end. Please do not talk to anyone during the session. If you have a question, please raise your hand; a monitor will come by to answer your question.

In the experiment you participate in two related tasks. We describe the first task, and later you will be informed about the second task. In the first task, you will make decisions over 20 periods in groups of three. {**Participants in the Partners 1-Strangers 2 rematching order read**: In each period, the other two participants of your group will be the same; that is, you play repeatedly with the same two others}. {**Participants in the Strangers 1–Partners 2 rematching order read**: In each period, the other two participants of your group will be randomly determined; it is unlikely that you play repeatedly with the same two others}.

The identity of the other two participants in your group will not be revealed to you at any time.

You and the other two participants simultaneously decide on the financing of a joint project. The joint project has a positive value for two group members and a negative value for one group member. Positive values are independent randomly drawn integers from the interval 1 to 64, and the negative value is an independent randomly drawn integer from the interval −1 to −64. All numbers refer to Francs, the currency we use in this experiment. At the beginning of each task you receive a lump sum payment of 10 Francs to cover potential losses.

At the beginning of each period, each of you will be informed if your individual value is positive or negative. You are able to purchase at a cost more precise information about your value. For this purpose you are endowed with 3 Francs in each period. Before you make the financing decision on the joint project, therefore, each of you chooses the precision of the information about the value. The information cost increases with the precision of the information about the value, and reduces your endowment of 3 Francs, in the following way.

Buy precision level	0	1	2	3	4	5	6
Information cost	0	0.5	1	1.5	2	2.5	3
Interval precision	64	32	16	8	4	2	1
Your endowment after cost reduction	3	2.5	2	1.5	1	0.5	0

Example: Assume your randomly drawn value is −14 Francs.

If you buy precision level	your information about your value will be
0	your value is . . .between −1 and −64
1	. . .between −1 and −32
2	. . .between −1 and −16
3	. . .between −9 and −16
4	. . .between −13 and −16
5	. . .between −13 and −14
6	−14

Of course, at the time when you make your purchase decision about information precision you are unaware about your value, in the example of −14 Francs.

Following the revealed information about your value, you submit your financing bid. All bids must be in the interval −64 to 64.

After bidding, the average bid within your group is computed (=(bid1 + bid2 + bid3)/3). Only if the average bid in your group is positive, the project is financed.

If the project is financed, your payoff is determined as follows:

Your value − your bid + average bid of your group + (3 − your information costs).

If the average bid is negative, the project is not financed, and your payoff is as follows:

3 − your information costs.

Since the understanding of the payoffs from the project is crucial for your earnings in the experiment, we ask you to fill in an onscreen comprehension test.

You make all your decisions at the computer. You make the purchase decision on the precision of your value on the first screen. You insert your bid on the second screen.

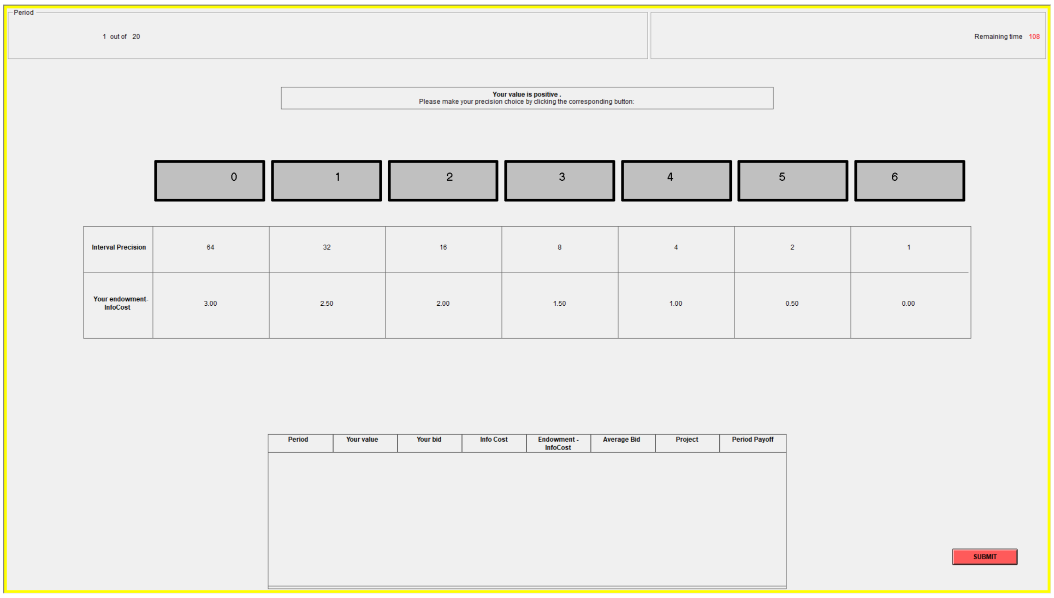
After each period you will receive feedback information about your value, your purchase decision, your bid decision, the average bid decision in your group, and your payoff in the previous period and all earlier periods. Note that you will never learn the exact value, bids and information choices of the two other group members.

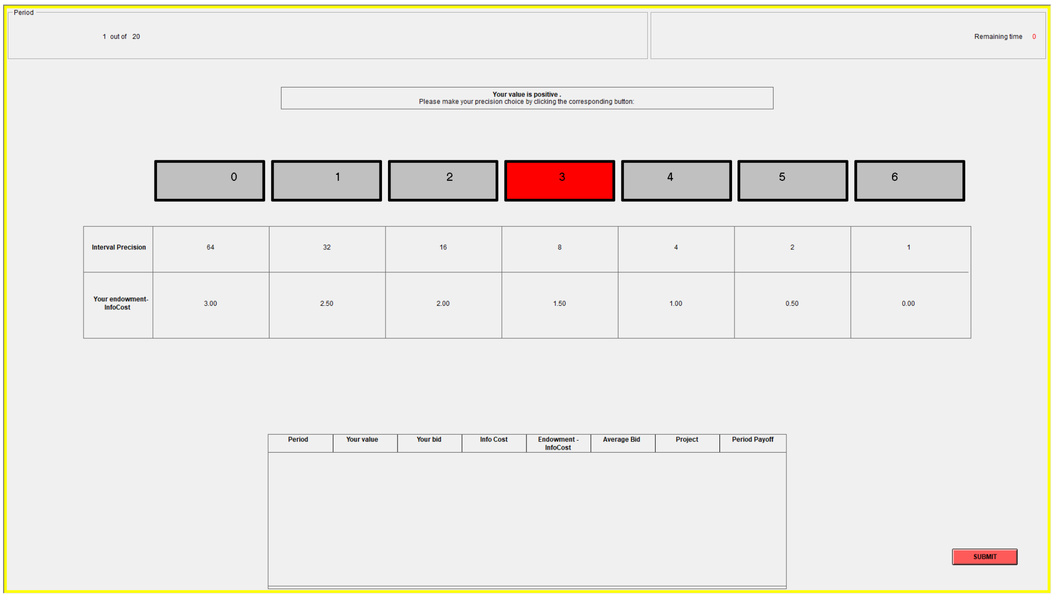
After the last period, one participant in the room will be asked to draw a chip numbered 1–20 from a bag. The drawn chip determines the payment decisive period for all participants. Your payoff in the first task of the experiment will be equal to your payment in the payment-decisive period.

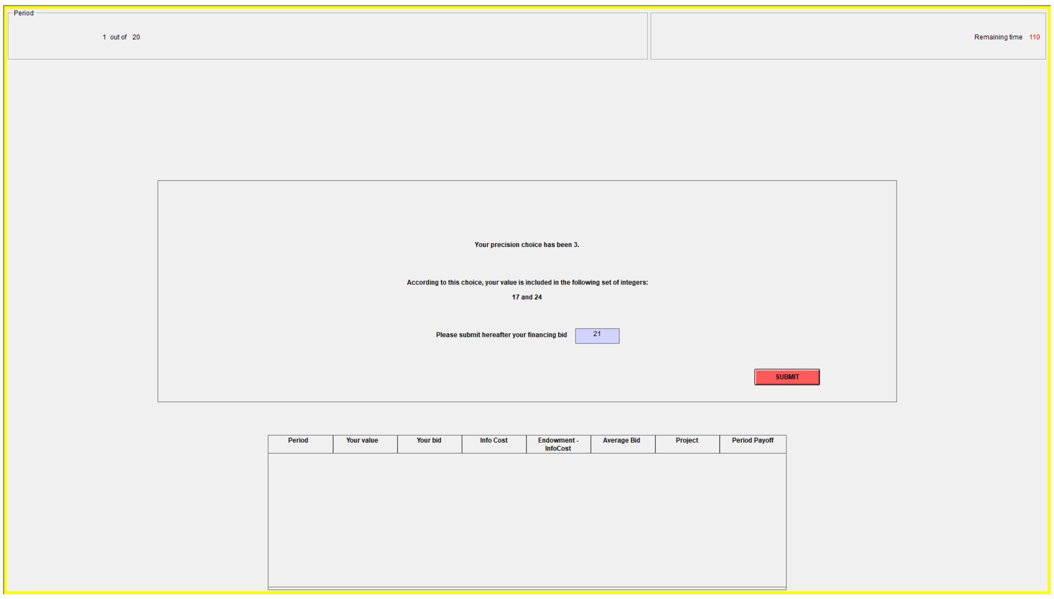
Following the end of the first task you will receive further information regarding the second task in the experiment.

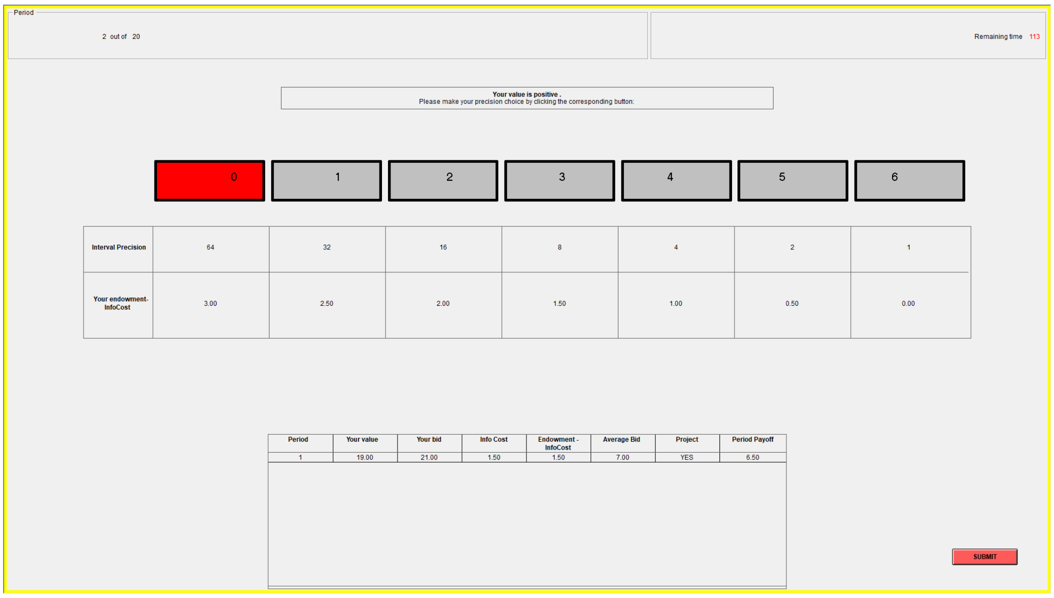
The cumulative earnings from both tasks will be paid out to you in private at your desk following the end of the experiment. The payment will be in Euro (including a 10 Euro participation fee). The following exchange rate applies: 1 Franc = 0.33 Euro.

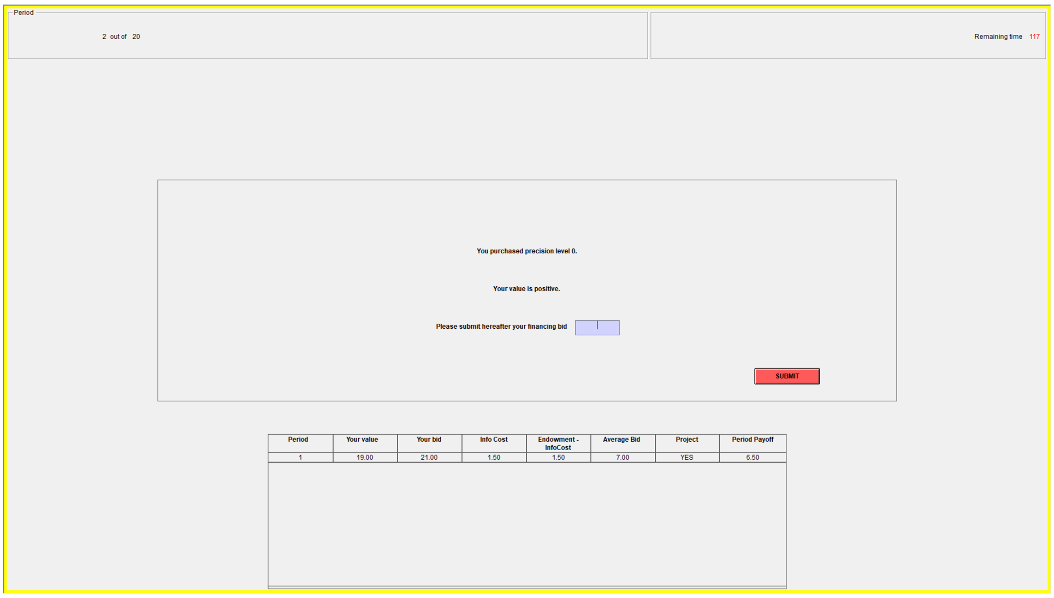
After the end of the first part, subjects received verbal instructions about the second part of the experiment: In the second task, you will again make decisions over 20 periods in groups of three. While the overall setup is unchanged, there is one significant difference: {**Participants in the Partners 1-Strangers 2 rematching order were told**: In each period, the other two participants of your group will be randomly determined; it is unlikely that you play repeatedly with the same two others}. {**Participants in the Strangers 1–Partners 2 rematching order were told**: In each period, the other two participants of your group will be the same; that is, you play repeatedly with the same two others}.

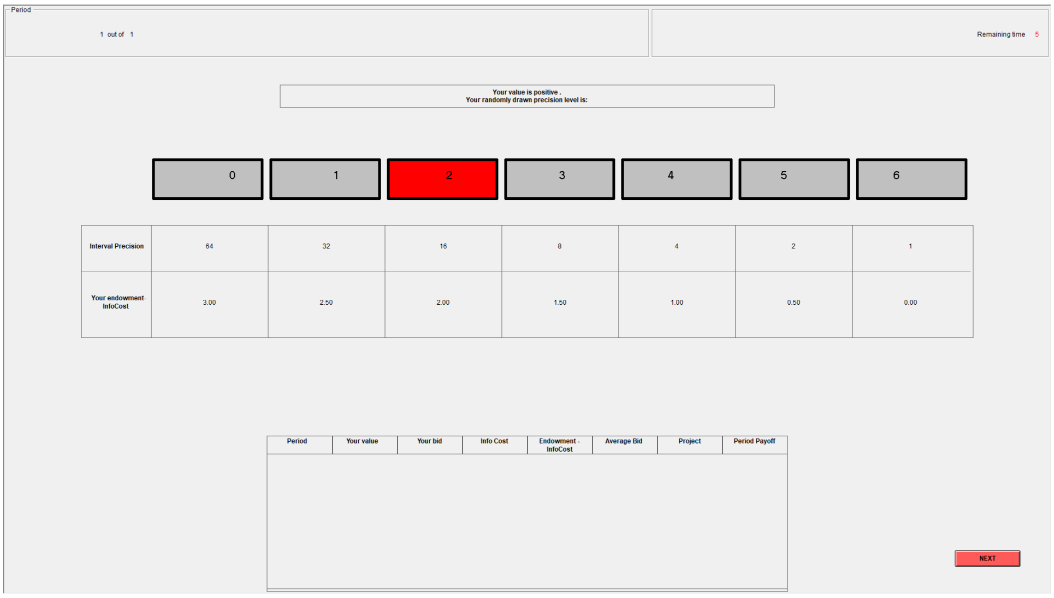

Period
1 out of 20
Remaining time 108
Your value is positive .
Please make your precision choice by clicking the corresponding button:
0 1 2 3 4 5 6
Interval Precision 64 32 16 8 4 2 1
Your endowment-InfoCost 3.00 2.50 2.00 1.50 1.00 0.50 0.00
Period Your value Your bid Info Cost Endowment - InfoCost Average Bid Project Period Payoff
SUBMIT


Period
1 out of 20
Remaining time 0
Your value is positive .
Please make your precision choice by clicking the corresponding button:
0 1 2 3 4 5 6
Interval Precision 64 32 16 8 4 2 1
Your endowment-InfoCost 3.00 2.50 2.00 1.50 1.00 0.50 0.00
Period Your value Your bid Info Cost Endowment - InfoCost Average Bid Project Period Payoff
SUBMIT


Period
1 out of 20
Remaining time 110
Your precision choice has been 3.
According to this choice, your value is included in the following set of integers:
17 and 24
Please submit hereafter your financing bid 21
SUBMIT
Period Your value Your bid Info Cost Endowment - InfoCost Average Bid Project Period Payoff


Period
2 out of 20
Remaining time 113
Your value is positive .
Please make your precision choice by clicking the corresponding button:
0
1
2
3
4
5
6
Interval Precision
64
32
16
8
4
2
1
Your endowment-InfoCost
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Period
Your value
Your bid
Info Cost
Endowment - InfoCost
Average Bid
Project
Period Payoff
1
19.00
21.00
1.50
1.50
7.00
YES
6.50
SUBMIT


Period
2 out of 20
Remaining time 117
You purchased precision level 0.
Your value is positive.
Please submit hereafter your financing bid
SUBMIT
Period
Your value
Your bid
Info Cost
Endowment - InfoCost
Average Bid
Project
Period Payoff
1
19.00
21.00
1.50
1.50
7.00
YES
6.50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1 out of 1
Remaining time 5
Your value is positive .
Your randomly drawn precision level is:
0
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Interval Precision
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Your endowment-InfoCost
3.00
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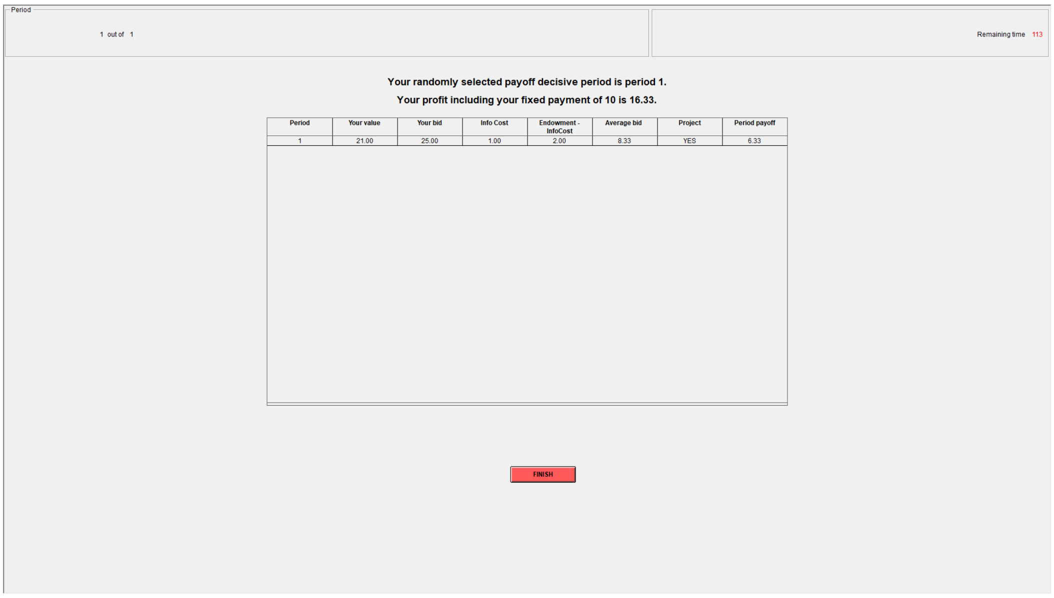
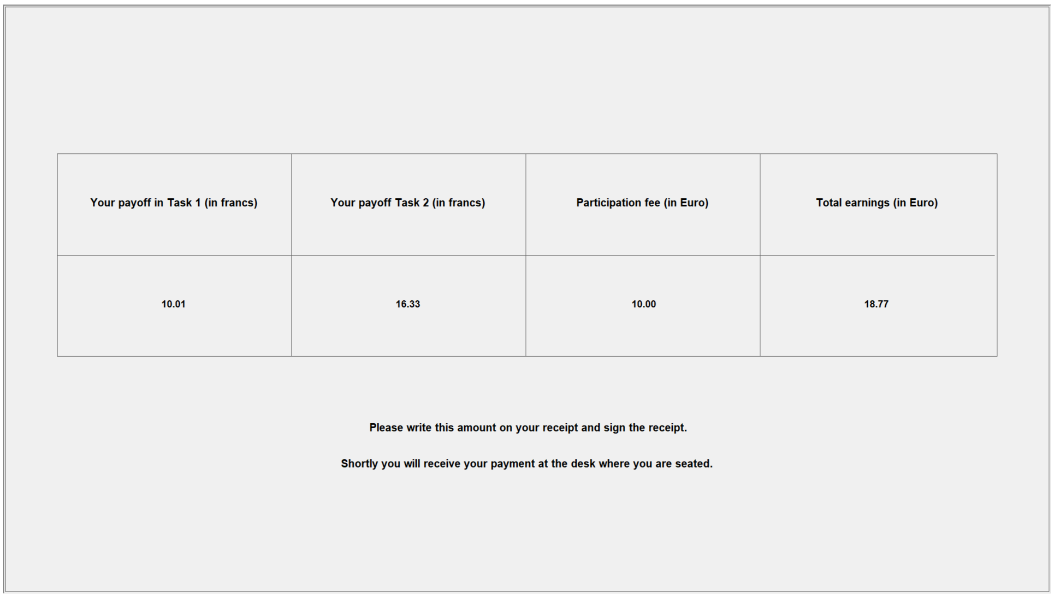




Appendix B. Additional Test Results

Table A1. Order effect on *efficiency*: test results.

Rematching Order	Efficiency per Treatment	
	Partners	Strangers
Partners 1–Strangers 2	0.792	0.742
Strangers 1–Partners 2	0.843	0.824
Z-stat.	[−0.664]	[−1.412]
p-value	(0.506)	(0.157)

The table reports *p*-values according to the two-tailed Mann–Whitney test results for the Partners (repeated interactions with the same cohort) and Strangers (random repeated interactions) treatments; in the test, the order of treatments grouping indicator for *Partners 1–Strangers 2* was 0 and for *Strangers 1–Partners 2* was 1. The results indicate no significant order effect.

Table A2. Hypothesis EFF1—efficient vs. inefficient decisions: test results.

		Endogenous		Exogenous	
Prob $> \|z\|$	**All Data**	**Partners**	**Strangers**	**Partners**	**Strangers**
p-value	0.000 ***	0.005 ***	0.005 ***	0.005 ***	0.005 ***
Z-statistic	[3.922]	[2.809]	[2.805]	[2.805]	[2.807]

*** indicates a statistically significant result at the 0.01 level, based on the two-tailed Wilcoxon signed-ranks test. The test was conducted on 10 independent observations from groups of six subjects in the Endogenous and Exogenous treatments, respectively. "All Data" refers to the 20 pooled observations from both treatments.

Table A3. Hypothesis EFF1(a)—profitable accepted vs. profitable rejected projects: test results.

		Endogenous		Exogenous	
Prob $> \|z\|$	**All Data**	**Partners**	**Strangers**	**Partners**	**Strangers**
p-value	0.000 ***	0.005 ***	0.005 ***	0.005 ***	0.005 ***
Z-statistic	[3.920]	[2.805]	[2.803]	[2.805]	[2.803]

*** indicates a statistically significant result at the 0.01 level, based on the two-tailed Wilcoxon signed-ranks test. The test was conducted on 10 independent observations from groups of six subjects in the Endogenous and Exogenous treatments, respectively. "All Data" refers to the 20 pooled observations from both treatments.

Table A4. Hypothesis EFF1(b)—unprofitable accepted vs. unprofitable rejected projects: test results.

	All Data		Endogenous		Exogenous	
Prob $> \|z\|$	**Total**	**Partners**	**Partners**	**Strangers**	**Partners**	**Strangers**
p-value	0.045 **	0.039 **	0.009 ***	0.721	0.475	0.958
Z-statistic	[−1.998]	[−2.056]	[−2.606]	[−0.357]	[−0.714]	[−0.052]

*** indicates a statistically significant result at the 0.01 level, and ** at 0.05, based on the two-tailed Wilcoxon signed-ranks test. The test was conducted on 10 independent observations from groups of six subjects in the Endogenous and Exogenous treatments, respectively. "All Data" refers to the 20 pooled observations from both treatments. The test results tend to be significant for the Partners matching but not for the Strangers matching.

Table A5. Overbidding vs. underbidding the expected value: test results.

	Uncertain Information				Precisely Informed			
	$V_i < 0$		$V_i > 0$		$V_i < 0$		$V_i > 0$	
$Prob > \|z\|$	Partners	Strangers	Partners	Strangers	Partners	Strangers	Partners	Strangers
Endogenous uncertainty								
p-value	0.046 **	0.006 ***	0.074 *	0.006 ***	0.008 ***	0.013 **	0.004 ***	0.086 *
Z-statistic	[1.990]	[2.703]	[−1.784]	[−2.701]	[2.620]	[2.472]	[−2.821]	[−1.713]
Pooled								
p-value	0.012 **		0.009 ***		0.005 ***		0.005 ***	
Z-statistic	[2.497]		[−2.599]		[2.763]		[−2.756]	
Exogenous uncertainty								
p-value	0.006 ***	0.028 **	0.005 ***	0.066*	0.331	0.080*	0.005 ***	0.005 ***
Z-statistic	[2.701]	[2.193]	[−2.803]	[−1.836]	[0.971]	[1.745]	[−2.756]	[−2.803]
Pooled								
p-value	0.012 **		0.012 **		0.168		0.005 ***	
Z-statistic	[2.497]		[−2.497]		[1.376]		[−2.803]	
All Data								
p-value	0.001 ***	0.000 ***	0.000 ***	0.001 ***	0.005 ***	0.002 ***	0.000 ***	0.000 ***
Z-statistic	[3.249]	[3.436]	[−3.323]	[−3.267]	[2.803]	[3.373]	[−3.909]	[−3.350]
Pooled								
p-value	0.000 ***		0.000 ***		0.001 ***		0.000 ***	
Z-statistic	[3.472]		[−3.584]		[3.175]		[−3.902]	

*** indicates a statistically significant result at the 0.01 level, ** at 0.05, and * at 0.1, based on the two-tailed Wilcoxon signed-ranks test. The test was conducted on 10 independent observations from groups of six subjects in the Endogenous and Exogenous treatments, respectively, and separately for the Partners and Strangers matching. For each independent observation, the average difference between the expected value and the bid was calculated, separately for negative and positive values. A positive Z-statistic indicates a tendency toward overbidding, while a negative value indicates underbidding. "Pooled" refers to pooled data across both matching protocols. Where indicated "All Data" the test was conducted on the 20 independent observations from both treatments.

Table A6. Endogenous treatment questionnaire—subjects' attributes ordered by rematching order.

Rematching Order	**Group of 6**	**Male**			**Female**			**#Male**	**#Female**
		CRT Score	**Risk Lover**	**Age**	**CRT Score**	**Risk Lover**	**Age**		
Partners 1–Strangers 2	4	1	2.5	25.75	0.5	2	23	4	2
	5	1	2	20	0	3	20.2	1	5
	6	0.33	5.33	28	0.67	3.33	21	3	3
Subtotal		0.75	3.5	25.87	0.3	2.9	21	8	10
Strangers 1–Partners 2	1	0	4.25	23.25	0	3	21	4	2
	2	0	2	25	0.8	4.6	29.4	1	5
	3	0	3.5	26.5	0.75	4	22	2	4
	7	0.67	3.67	28.33	0	5.33	27.33	3	3
	8	0	2	19	1	3.6	23.8	1	5
	9	1	5	23.5	1.25	5.75	22.75	2	4
	10	1	1	19	0.4	3.6	24.4	1	5
Subtotal		0.36	3.57	24.36	0.68	4.29	24.68	14	28
Total		0.50	3.55	24.91	0.58	3.92	23.71	22	38

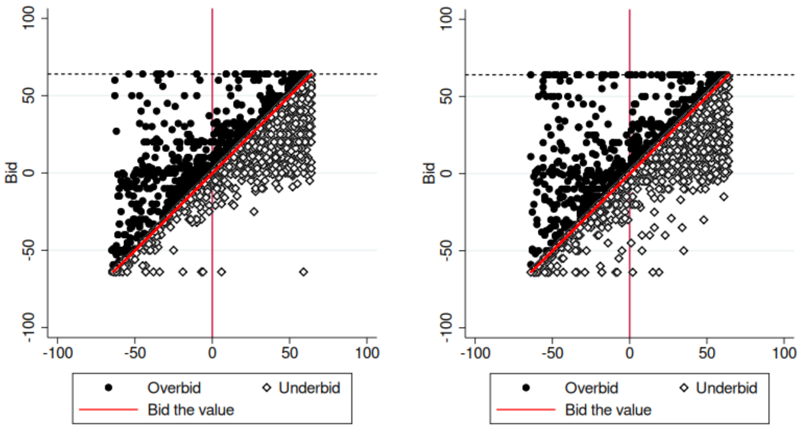
	CRT score	Risk lover	Age	#Subjects
Overall	0.55	3.78	24.15	60

This table presents the subjects' attributes collected in the questionnaire: Cognitive Reflection Test (CRT) scores ({0, 1, 2, 3}), risk-loving level (self-assessed on a Likert scale from 1 to 7) and age ordered by gender according to within-subject variations (due to rematching under the Partners and Strangers conditions) and groups of six (corresponding to the between-subject uncertainty treatments). This table includes data from the endogenous treatment only, as the questionnaire data for the exogenous treatment were unavailable.

Table A7. Uncertainty effect on *efficiency*. Probit regression results.

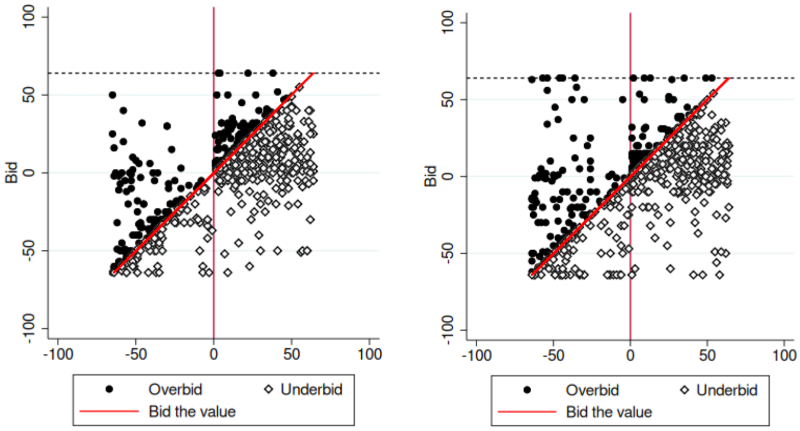
	Overall	**Endogenous**	**Exogenous**	**Endogenous**	**Exogenous**
Uncertainty level	−0.000	−0.002	0.000	−0.002	0.000
	(0.695)	(0.298)	(0.491)	(0.348)	(0.606)
Strangers				−0.034	−0.216
				(0.791)	(0.114)
Strangers first				−0.161	0.257 **
				(0.190)	(0.055)
Constant	0.901 ***	0.989 ***	0.826 ***	1.087 ***	0.816 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	4770	2400	2370	2400	2370
Clusters	20	10	10	10	10
Wald $chi^2(1)$	0.15	1.08	0.47	3.82	7.03
Pseudo R^2	0.000	0.001	0.000	0.004	0.008

*** indicates a significant result at 0.01, and ** at 0.05, according to the two-tailed *t*-test (*p*-value in parentheses). Probit regression on efficiency with robust standard errors; efficient outcome was 1, inefficient outcome was 0. The average uncertainty level was computed for each group of six subjects, e.g., if the intervals of the subjects were 64, 16, and 1, the sum was 81 and the average was 27.



Endogenous Exogenous

Figure A1. Distributions of bids across *efficient decisions* and uncertainty treatments.



Endogenous Exogenous

Figure A2. Distributions of bids across *inefficient decisions* and uncertainty treatments.

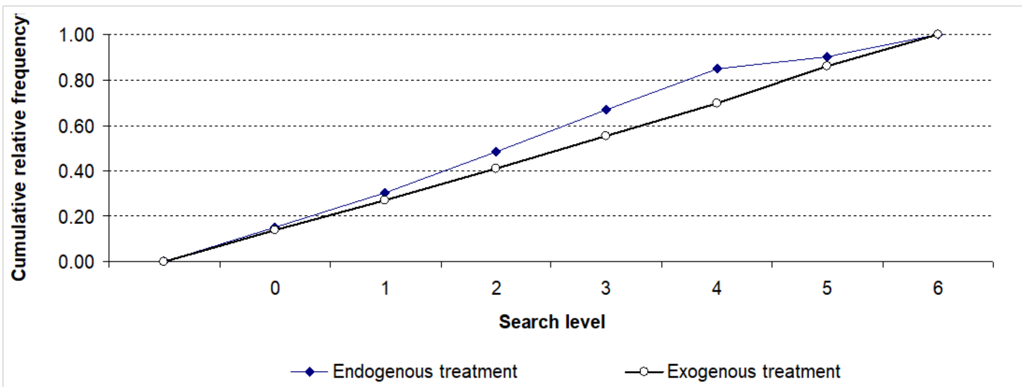


Figure A3. Cumulative relative frequency of the search levels in the experiment. The search level $e_i = \{0, 1, \ldots, 6\}$ determined the length of the discrete uncertainty interval $l(e_i) = 64/2^{e_i}$, in which the subject's value was contained. The search level was an intentional individual choice in the endogenous treatment, whereas it was a random choice in the exogenous treatment. The subjects intentionally chose precise information by exerting search levels 5 or 6 (information sets that included 2 or 1 potential values) less frequently and imprecise information, i.e., search levels 0 to 4 (information sets with 64 to 4 potential values), more frequently than according to a uniform random assignment of the interval length.

Notes

1 Note the uncertainty in our study is on the stakeholders' valuations, not on the future payoff of the project. See Bajoori et al. (2024) as an example of a paper that studies uncertain future payoffs.

2 Rather than focusing on equilibrium benchmarks that require well-defined games, we were interested in the efficiency enhancement of institutional information sharing by bidding, endogenous uncertainty reduction, and reputational concerns when repeatedly interacting with the same partners.

3 For a discussion of how corporate governance is related to political governance, see Alberti et al. (2022).

4 One might refer to the usually broad "behavioral repertoire" of top managers often cited as a justification for their significantly higher earnings compared with other employees.

5 Veto power is particularly relevant in venture capital relationships with independent agents. Cumming and Johan (2006) examined veto power and control rights, which are legally important in joint ventures, as well as the fairness aspects of group decision-making.

6 The project implementation decision rule depends on costly private investment into the information search, similar to the private signal agents received in Landier et al. (2009). Our mechanism expresses private incentives via monetary payoff functions.

7 A positive $C(.)$ indicates costly investing; a negative $C(.)$ could result from a state subsidy. $C(.)$ is common knowledge.

8 In a purely financial organizational setup, bids correspond to investment decisions on particular projects. The sum of the individual valuations can be interpreted as the discounted present value of the project, including all costs and benefits.

9 This mechanism, in principle, allows for individual veto power through sufficiently low (e.g., negative) bids. However, our experiment employs collective veto power, which is more realistic. This design choice primarily aims to avoid large losses for participants, which requires restricting overbidding via a sufficiently low upper bound on the bid intervals. Imposing a positive upper bound also helps to limit different demand effects for positive versus negative bids by ensuring symmetric absolute bid levels. Implementing a sufficiently low lower bound to guarantee individual veto power would have implied a large upper bound and the possibility of large losses if a low-value bidder bids maximally.

10 In the case of joint ownership, which was our focus, no simple price rule can guarantee incentive compatibility.

11 Our setup represents only a game form, not a well-defined, informationally closed Bayesian game. Individual search investments are not determined by a commonly known prior and remain private information about a bidder's idiosyncratic value uncertainty when bidding. Even if choice data can be explained by an equilibrating bidding game, it remains unclear whether this is due to the participants' game-theoretic reasoning or heuristic bidding converging to such an equilibrium (see Güth and Pezanis-Christou, 2021). In our view, even a simplified model cannot avoid the crucial aspect of our setup: that most participants do not know their private values when bidding.

12 These levels corresponded to a reduction in the uncertainty to one-half and one-quarter of the initial levels, respectively. At these levels, the efficiency of group decisions would be 0.921 with the expected-value benchmark and 0.868 with the minimum-value benchmark.

13 In the experiment, these levels corresponded to a reduction in the uncertainty to sets of four and two integers, respectively.

14 In line with this trade-off between the search effort and bidding, prospect theory would suggest that since search costs are sunk, loss-averse bidders may bid lower in the hope of being overcompensated for those search costs upon project implementation.

15 The assumption that everyone benefits, as is often the case in public good experiments, raises questions about the external validity; in the case of a new highway, those living nearby typically suffer from noise and air pollution.

16 Whereas public goods (bads) let everyone benefit (suffer), one usually observes their co-existence.

17 The subjects faced increasing marginal costs for uncertainty resolution. Going from $e = 0$ to 1 excluded 32 possible values, whereas the step from $e = 5$ to 6 excluded only one.

18 Feedback referring to all past periods was reported to each subject after the first period.

19 See Table A6 for the details. Due to time constraints, we were unable to collect the questionnaire data for the exogenous treatment. However, we believe that the reported numbers were representative of our overall sample.

20 Although the revelation principle allows for truthtelling equilibria in well-defined games, modifying rules, such as those governing beliefs, would require changing the mechanisms, raising questions about the practical applicability of such equilibration exercises.

21 Revealing opportunism too early would risk prematurely halting voluntary cooperation.

22 In the exogenous uncertainty treatment, the uncertainty levels were uniformly distributed in accordance with $e_i = \{0, \ldots, 6\}$.

23 The share of zero-profit projects was one percent. We left these projects out of consideration as we had no hypothesis for these projects.

24 A comparison of the two simulation approaches revealed that the efficiency levels were highly significantly different from each other ($p = 0.001$).

[25] The relative frequency of efficient group decisions in the Partners treatment (same cohorts with repeated interactions) was 0.792 when Partners preceded in order and 0.843 when Partners followed in order. The relative frequency of efficient group decisions in the Strangers treatment (random cohorts with repeated interactions) was 0.824 when Strangers preceded and 0.742 when Strangers followed. This difference was not significant, as shown by the Mann–Whitney test reported in Appendix B and Table A1.

[26] See also the related evidence of Alberti et al. (2023).

[27] In Appendix B, the scatter plots are shown separately for efficient and inefficient group decisions in Figures A1 and A2.

[28] Detailed test results, including *p*-values and z-values related to Table 4, are shown in Table A5 in Appendix B.

[29] This effect aligned with our benchmark behaviors. In the expected-value bidding benchmark, the agents engaged in less search effort compared with the minimum-value benchmark when maximizing symmetric payoffs. Underbidding was clearly more common in the latter benchmark than in the former.

[30] Exogenously determined uncertainty levels occurred with a probability of 0.143 each.

[31] We note a consistency of this effect with our simulation results. We found that symmetric payoff maximization led to an overemphasis of low search levels. Specifically, search levels of 4 and 5 were required to achieve 0.99 efficiency in the expected-value and minimum-value benchmarks, respectively. Therefore, fully resolving uncertainty may have appeared too costly relative to the benefits.

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