JENA ECONOMIC RESEARCH PAPERS

2013 – 021

Providing negative cost public projects under a fair mechanism: An experimental analysis

by

Werner Güth
Anastasios Koukoumelis
M. Vittoria Levati
Matteo Ploner

www.jenecon.de

ISSN 1864-7057

The JENA ECONOMIC RESEARCH PAPERS is a joint publication of the Friedrich Schiller University and the Max Planck Institute of Economics, Jena, Germany. For editorial correspondence please contact markus.pasche@uni-jena.de.

Impressum:

Friedrich Schiller University Jena
Carl-Zeiss-Str. 3
D-07743 Jena
www.uni-jena.de

Max Planck Institute of Economics
Kahlaische Str. 10
D-07745 Jena
www.econ.mpg.de

Providing negative cost public projects under a fair mechanism: An experimental analysis

Werner Güth[a], Anastasios Koukoumelis[a],

M. Vittoria Levati[a,b,*], Matteo Ploner[c]

[a] *Max Planck Institute of Economics, Kahlaische Str. 10, 07745 Jena, Germany*
[b] *Department of Economics, University of Verona, Via dell'Artigliere 19, Verona, Italy*
[c] *DECO-CEEL, University of Trento, Via Inama 5, 38100 Trento, Italy*

Abstract

This paper experimentally examines a procedurally fair provision mechanism allowing members of a small community to determine, via their bids, which of four alternative public projects to implement. Previous experiments with positive cost projects have demonstrated that the mechanism is efficiency enhancing. Our experiment tests whether the mechanism remains conducive to efficiency when negative cost, but less efficient, projects are made available. We find that this is not the case. On the other hand, we detect no significant difference in bid levels depending on whether mixed feelings are present or absent, and on whether the others' valuations are known or unknown.

JEL Classification: C72, C92, D63, H44

Keywords: Public projects, Bidding behavior, Procedural fairness, Experiment

*Corresponding author at: Department of Economics, University of Verona, Via dell'Artigliere 19, Verona, Italy. Tel.: +39 045 8028640.

E-mail addresses: gueth@econ.mpg.de (W. Güth), koukoumelis@econ.mpg.de (A. Koukoumelis), levati@econ.mpg.de, vittoria.levati@univr.it (M. V. Levati), matteo.ploner@unitn.it (M. Ploner).

1 Introduction

People are often called upon to decide on the provision of public projects that benefit some parties but harm others. Examples include the so-called NIMBY ("Not In My BackYard") projects, e.g. the construction of power plants and airports, which increase social welfare, albeit at the expense of those that reside in their vicinity.[1] Güth et al. (2011) and Cicognani et al. (2012) maintain that such projects raise mixed feelings and suggest a mechanism for their provision which is procedurally fair. The mechanism is derived axiomatically (Güth and Kliemt 2013) and requires the involved individuals to bid for a number of available projects.[2] Each bid that an individual reports expresses the maximal amount that he is willing to pay for a specific project.

While employing a fair provision mechanism seems to be extremely important in deciding whether to provide a project which has positive and negative valuations, the existing experimental tests of the mechanism (Güth et al. 2011; Cicognani et al. 2012) have dealt with projects that impose a positive cost of provision on all community members. The main finding of these studies is that the mechanism is rather effective in implementing the most efficient project, i.e., the project that is generating the highest social net benefit (defined as the sum of the group members' valuations for the project minus its provision cost). There exist, however, public projects whose "costs" are negative, in the sense that they generate revenues (e.g., drilling for oil, mining) or they replace other more expensive projects (e.g., people that invest in residential solar panels cut down on energy, but may also benefit from rebate programs and tax credits applicable to renewable energy equipment). How the procedurally fair provision mechanism performs in the presence of negative cost projects has not so far been explored, and it is the topic of this paper. Specifically, our experiment

[1] Situations where the loss to some people outweighs the gain to others have been studied by, e.g., Delaney and Jacobson (2012).

[2] Auction mechanisms for implementing public goods—where players tender bids instead of casting votes—are available since the 1970s (Smith 1977).

intends to answer the following questions: Is the procedurally fair provision mechanism still conducive to efficiency when less efficient projects that entail negative costs become available? To what extent does bidding behavior for negative cost projects depend on the presence of mixed feelings? Do the people that are harmed by a negative cost project bid differently from the people that benefit from it? Do the results depend on whether information about induced valuations is private or public? We believe that these issues are worth studying in the light of the growing importance that projects with negative costs are assuming in areas such as renewable energy sources, biotechnology, and climate change.[3]

In the fair provision mechanism under scrutiny, the bids submitted by all interested parties determine which public project gets implemented and the consequent individual payments. The fairness of the latter is assured by a basic equality axiom requiring that all individual group members are treated equally according to an objective criterion, namely their publicly observable bids. This holds even if the implemented project is not ex post valued the same by all group members. Thus, our approach differs from that of other authors who define fairness with respect to final outcome (the so-called allocative fairness).[4] The procedurally fair provision mechanism only guarantees that everyone (a) has equal power, via his bids, to influence which project is collectively provided, and (b) receives an equal share of the "surplus with respect to bids" (namely, the difference between sum of bids and cost) associated with the project that is finally selected. The mechanism can be somewhat related to a legal system "in which the laws are public knowledge ... and apply equally to everyone" (Carothers 1998) independently of wealth, social status, and other idiosyncratic traits.

[3]In the latter case, considerations of fairness are particularly relevant. Müller (1999), for instance, is interested in determining a procedurally fair compromise in the context of global warming negotiations, and Ringius et al. (2002) acknowledge that climate change negotiations need to find a scheme of burden sharing that can be accepted as fair by most governments.

[4]Chassang and Zehnder (2012) highlight the distinction between procedural and allocative fairness.

The results from the experiment reported in this paper suggest that once we introduce negative cost projects the mechanism is no more conducive to efficiency. Participants favor negative over positive costs, indeed they select the most efficient among the negative cost projects. This result holds irrespective of whether mixed feelings are present or not. Neither does it depend on whether the others' valuations are commonly known or not.

The paper is organized as follows. Section 2 presents the provision mechanism and reviews the related experimental work. Section 3 lays out our experimental design and procedures. Section 4 presents our results. Section 5 concludes.

2 The provision mechanism: theory and experimental evidence

Let $\Omega = \{P_1, P_2, \ldots, P_m\}$ be a finite set of m (≥ 2) indivisible public projects, and let $N = \{1, \ldots, n\}$ denote a group of n (≥ 2) individuals facing the problem of determining which $P_\ell \in \Omega$ ($\ell = 1, \ldots, m$), if any, should be provided. We assume that the cost of providing any particular $P_\ell \in \Omega$, denoted by $C(P_\ell) \in \mathbb{R}$, is commonly known and that if no project is provided, then $C(\emptyset) = 0$.

Each individual $i \in N$ can influence the choice of P_ℓ by specifying a monetary bid for each project, i.e., by reporting how much each project is worth to him. Thus, each i submits a bid vector $\boldsymbol{b}_i = (b_i(P_\ell) \in \mathbb{R} : P_\ell \in \Omega)$. Without loss of generality, it is assumed that $b_i(\emptyset) = 0$ for all $i \in N$. The bid vectors of all n group members result in the bid profile $\boldsymbol{b} = (\boldsymbol{b}_1, \ldots, \boldsymbol{b}_n)$. The difference between the sum of bids for P_ℓ and its cost (i.e., $\sum_{i=1}^{n} b_i(P_\ell) - C(P_\ell)$) is referred to as the surplus that P_ℓ generates with respect to bids. We denote it by $S^{\boldsymbol{b}}(P_\ell)$.

For all possible profiles $\boldsymbol{b}$, the provision mechanism specifies which project $P_\ell^* := P_\ell^*(\boldsymbol{b}) \in \Omega$ will be provided and which amount $c_i(P_\ell^*, \boldsymbol{b}) \in \mathbb{R}$ is to be paid by each group member i. The analysis to derive the mechanism is performed in objective terms, namely in terms of observable monetary bids, so as to guarantee an equitable allocation of the money that the collectivity (and therefore each one of its members) is willing to pay for implementing a given project. Hence, fairness is defined with respect to the public bids, rather than with respect to the induced—and usually privately known—valuations for the public projects. The following three axioms, in particular, characterize the provision mechanism.

(A.1) *Profitability with respect to bids* requires that the chosen P_ℓ^* satisfies

$$\sum_{i=1}^{n} b_i(P_\ell^*) - C(P_\ell^*) = \max_{P_\ell \in \Omega}\{0, S^{\boldsymbol{b}}(P_\ell)\},$$

i.e., P_ℓ^* maximizes the non-negative surplus with respect to bids. This axiom ensures that, according to the submitted bids, no other project preferred to P_ℓ^* by at least one bidder leaves all others indifferent.[5]

(A.2) *Equal net benefit with respect to bids* affirms that if P_ℓ^* is provided, then

$$b_i(P_\ell^*) - c_i(P_\ell^*, \boldsymbol{b}) = b_j(P_\ell^*) - c_j(P_\ell^*, \boldsymbol{b}) \quad \forall i, j \in N \text{ and } \boldsymbol{b}.$$

In words, the difference between bid and payment should be the same for all group members. This axiom guarantees that all bidders are treated equally with respect to the maximum amount they stated they were willing to pay for the provided project.[6] Thus, if i posts a positive bid for P_ℓ^*, while j is reluctant to spend money on it (meaning $b_j(P_\ell^*) \leq 0$), j could be compensated by i for bringing about the implementation of P_ℓ^*.

This requirement plays a fundamental role in rendering the provision mechanism procedurally fair. Similarly to democratic elections that work

[5] A similar requirement characterizes Smith's (1977) and Oprea et al.'s (2007) provision mechanisms.

[6] The axiom also implies envy-free net payoffs according to bids: given his bids, no agent prefers another agent's net payoff to his own (Güth 1986).

on the "one person, one vote" principle, and where all votes are weighted equally, the mechanism at issue disregards the values that bidders attach to the various projects and treats all bidders identically according to their (objective) submitted bids.

(A.3) *Cost balancing* defines a necessary condition of collective action: if project P_ℓ^* is provided, then the sum of all relevant payments must cover its cost.[7] Formally,

$$\sum_{i=1}^{n} c_i(P_\ell^*, \boldsymbol{b}) = C(P_\ell^*).$$

Thus, if there is no $P_\ell \in \Omega$ such that $\sum_{i=1}^n b_i(P_\ell) \geq C(P_\ell)$, no public project is provided and $c_i(P_\ell^*, \boldsymbol{b}) = 0$ for all $i \in N$.[8] If, instead, there exists a $P_\ell^* \in \Omega$ such that $\sum_{i=1}^n b_i(P_\ell^*) \geq C(P_\ell^*)$ and $\sum_{i=1}^n b_i(P_\ell^*) - C(P_\ell^*) > \sum_{i=1}^n b_i(P_k) - C(P_k)$ for all $P_k \in \Omega$, then (A.1) selects P_ℓ^* and (A.2) allows writing

$$b_i(P_\ell^*) - c_i(P_\ell^*, \boldsymbol{b}) = \Delta \quad \forall i \in N. \tag{1}$$

Aggregating over all n group members yields $\sum_{i=1}^n b_i(P_\ell^*) - \sum_{i=1}^n c_i(P_\ell^*, \boldsymbol{b}) = n\Delta$ or, using (A.3), $\Delta = \frac{\sum_{i=1}^n b_i(P_\ell^*) - C(P_\ell^*)}{n}$. Substituting for Δ in Eq. (1) and rearranging, one obtains

$$\begin{aligned} c_i(P_\ell^*, \boldsymbol{b}) &= b_i(P_\ell^*) - \frac{\sum_{j=1}^n b_j(P_\ell^*) - C(P_\ell^*)}{n} \\ &= b_i(P_\ell^*) - \frac{S^{\boldsymbol{b}}(P_\ell^*)}{n} \quad \forall i \in N. \end{aligned} \tag{2}$$

Hence, the procedurally fair provision mechanism selects the public project that generates the maximal non-negative surplus with respect to bids, and imposes the payment given in Eq. (2) on each group member.

[7] We impose this axiom, although one does not have to rule out taxing or subsidizing public project provision. See Güth et al. (2012) for an experiment investigating the robustness of procedurally fair bidding to the introduction of taxes and subsidies.

[8] If no project is provided, (A.2) and the assumption $b_i(\emptyset) = 0$ imply $0 - c_i(P_\ell^*, \boldsymbol{b}) = 0 - c_j(P_\ell^*, \boldsymbol{b})\ \forall i, j \in N$. Thus, $c_i(P_\ell^*, \boldsymbol{b}) = c_j(P_\ell^*, \boldsymbol{b}) = 0$ due to $C(\emptyset) = 0$ and cost balancing.

Since $S^{\boldsymbol{b}}(P_\ell^*) \geq 0$ is equally distributed among all n group members, no one has to pay more than his bid, i.e., the bid constitutes an upper bound for the group member's payment. Actually, by bidding either negatively or even sufficiently low for a specific project $P_\ell \in \Omega$, each member can either prevent it from being implemented or demand compensation in case it gets implemented.

Although the analyzed provision mechanism gives no attention to how true valuations influence submitted bids, implementing the mechanism in the laboratory involves inducing valuations for the alternative public projects. For each $i \in N$, let $v_i(P_\ell) \in \mathbb{R}$ denote i's induced valuation for $P_\ell \in \Omega$. Then, if P_ℓ^* is provided, the monetary payoff $\pi_i(\boldsymbol{b})$ of each $i \in N$ is the difference between i's valuation for P_ℓ^* and i's payment as specified in Eq. (2); if no project is provided, i's monetary payoff is zero. Formally:

$$\pi_i(\boldsymbol{b}) = \begin{cases} 0 & \text{if } \sum_{i=1}^n b_i(P_\ell) < C(P_\ell) \quad \forall P_\ell \in \Omega, \\ v_i(P_\ell^*) - b_i(P_\ell^*) + \dfrac{S^{\boldsymbol{b}}(P_\ell^*)}{n} & \text{if } \sum_{i=1}^n b_i(P_\ell^*) \geq C(P_\ell^*) \quad \text{and} \\ & \quad S^{\boldsymbol{b}}(P_\ell^*) > S^{\boldsymbol{b}}(P_k) \quad \forall P_k \in \Omega. \end{cases} \tag{3}$$

The sum of all players' induced valuations for a project minus its provision cost (i.e., $\sum_{i=1}^n v_i(P_\ell) - C(P_\ell)$) defines that project's social net benefit, which is taken as a measure of the project's efficiency.

It is obvious that any bid vector prescribing overbidding for a project is weakly dominated, i.e., the mechanism is overbidding proof. However, the mechanism is not incentive compatible because it is not underbidding proof.[9] Assuming that the induced valuations for the public projects are commonly known, we have a well-defined game with strategies $\boldsymbol{b}_i$ and payoffs $\pi_i(\boldsymbol{b})$ as specified above. This game has an abundance of pure strategy provision equilibria in which individual bids (1) add up to the cost of the provided project

[9]Imposing, additionally, incentive compatibility would result in impossibility statements (see Güth 2011). Note that legal mechanisms typically do not satisfy incentive compatibility (public tenders, for instance, rely on the lowest bid-price rule with overbidding incentives).

P^*_ℓ, and (2) result into a non-positive surplus with respect to bids for the other projects.[10] If valuations are privately known (i.e., if bidders know only their own valuations), a well-defined Bayesian game requires commonly known prior beliefs concerning the others' valuations.

Two papers report experiments using the fair provision mechanism illustrated above. Güth et al. (2011) consider the simplest possible scenario: the subjects, organized into groups of two, face two public projects (a project that raises mixed feelings and a less efficient public good) and have common knowledge of the induced valuations. The authors find that the most frequently provided project is the socially efficient one, and that unsuccessful provision is due to coordination failure rather than the existence of mixed feelings. Cicognani et al. (2012) enrich Güth et al.'s experimental setting; they increase the number of group members to three and consider five alternative sets of seven projects each. Additionally, they examine the efficacy of the provision mechanism in informationally limited settings: bidders have no knowledge about any valuation other than their own (which implies that they cannot calculate the social benefit associated with each project). Besides confirming the efficacy of the mechanism in achieving efficient outcomes, Cicognani et al. observe that the imposed restrictions on information about valuations do not affect bidding behavior significantly.

3 The experimental design

3.1 Parameters and treatments

Recall that we are interested in four specific research questions. (*i*) Does the availability of negative cost projects endanger the provision of the most efficient, albeit costly, project? (*ii*) Do negative costs affect bidding behavior differently depending on whether the public projects raise mixed feelings or not? (*iii*) Does

[10] An illustration of the equilibrium when $m = 2$ can be found in Güth et al. (2011).

the behavior of the party that values the negative cost project less (the low-value bidder) differ from that of the party that values it more (the high-value bidder)? (*iv*) Does private, rather than public, information about induced valuations influence bid levels when the cost of some projects is negative? The design and parameters are chosen to address these issues in a thorough manner, keeping though the environment as simple and realistic as possible.

To minimize the coordination problems inherent in the game, we consider groups of two bidders, $N = \{1, 2\}$. If the provision mechanism performs well in the presence of negative cost projects even for minimally sized groups, then more realistic experiments with $n > 2$ could be called for. If, instead, the effectiveness of the mechanism in achieving efficiency does not extend to such a simple environment, it is highly improbable that larger groups would yield better results.

Each group member is confronted with two alternative sets of projects. Each set, denoted by Ω^s $(s = 1, 2)$, consists of four indivisible public projects: $\Omega^s = \{P_1^s, P_2^s, P_3^s, P_4^s\}$. Table 1 displays the induced valuations, costs, and implied social net benefits of the constituent projects of Ω^s, $s = 1, 2$.[11]

[Table 1 about here.]

The most efficient project in Ω^1 is P_2^1, a mixed feelings project with a conventionally signed cost. A comparison of the provision rates of the projects in Ω^1 allows us to determine whether—in line with the findings of Güth et al. (2011) and Cicognani et al. (2012)—the project that is generating the highest social benefit remains the most frequently implemented one even when there exist less efficient projects that entail negative costs (question (*i*)).

The Ω^2 projects are arranged into two tiers of efficiency: the upper tier projects, P_2^2 and P_4^2, cost a positive amount (20 ECUs), and the lower tier projects, P_1^2 and P_3^2, entail a negative cost (−25 ECUs). Additionally, while P_1^2

[11] All variables are expressed in ECUs (Experimental Currency Unit) with 1 ECU = €0.2.

and P_2^2 raise mixed feelings, P_3^2 and P_4^2 are public goods. By comparing $b_i(P_2^2)-b_i(P_1^2)$ to $b_i(P_4^2)-b_i(P_3^2)$, we can assess whether the possibility of carrying out a negative cost project affects bidding behavior differently depending on whether mixed feelings are present or not (question (*ii*)).

In each set of projects, bidder 1 is the low-value bidder, and bidder 2 is the high-value bidder. Keeping the same roles throughout each set allows us to investigate whether low-value bidders are more likely to be affected by the presence of negative cost projects than high-value bidders (question (*iii*)).

Finally, to address the impact of private information about valuations in the presence of negative cost projects (question (*iv*)), we distinguish between two treatments that differ only in the level of information supplied to the participants. In the treatment labeled $PUBL$, valuations are public information. In the treatment labeled $PRIV$, valuations are private information to the individual participants.

3.2 Procedures

The experiment was programmed in z-Tree (Fischbacher 2007) and conducted in the experimental laboratory of the Max Planck Institute of Economics (Jena, Germany). Participants were recruited—using the ORSEE software (Greiner 2004)—from the undergraduate population at the Friedrich Schiller University of Jena. Upon entering the laboratory, they were randomly assigned to visually isolated computer terminals and received written instructions (reproduced in the appendix), which were also read aloud by a research assistant. The experiment started only after each participant had correctly answered a series of control questions and had gone through three practice periods.[12]

The experimental task presented to the participants was to collectively provide a public project for each Ω^s using the mechanism described in Section 2.

[12] The practice periods did not involve any interaction (the other's decision was selected randomly by the computer). Their sole aim was to familiarize the participants with the situation and its incentives (no payments were associated with them).

Participants had therefore to submit two bid vectors, each one of them containing four bids (one bid per project). They were informed that, on the basis of the bids of the individual group members, only one of the projects in each set would finally be carried out. Specifically, participants knew that the project yielding the highest non-negative difference between sum of bids and cost in each group would be provided, and that if two or more projects tied for first place, then the tie would be broken randomly. Bids were integer numbers between -500 and 500 ECUs.[13] The payoff function (3) was explained in detail, and several examples were provided.

Participants in the $PUBL$ treatment were informed about their own and the other's induced valuations for the four projects in each set, as well as about the cost of the projects, by a table that differed from Table 1 in that it did not display the social net benefit of the projects. In the $PRIV$ treatment, the information on the other's induced valuation was omitted. The two treatments were run one-shot in a between-subject design. Each member of the pair was assigned the role of either low-value bidder (player 1) or high-value bidder (player 2). To exclude possible order effects, the two sets of projects were presented on the same screen in a randomized manner (Ω^1 appeared on the left of the screen for half the participants and on the right side of the screen for the remaining ones) and the four projects in each set were randomly reordered (renumbered 1 to 4) for each subject. At the end of the session, one set was chosen at random and subjects were paid according to their bid vectors for that set.

We ran two sessions per treatment ($PUBL$ and $PRIV$). Each session involved 32 participants matched in pairs, so that the analysis relied on 64 individuals (32 low-value and 32 high-value bidders) in each of the two treatments. Sessions lasted about 2 hours. Average earnings were €15.42 (inclusive of a €5.00 show-up fee).

[13] Bids were restricted to a bounded set in order to protect participants from excessive under and overbidding.

4 Results

The results are presented in the order of our research questions. To address question (i), that is whether the provision of the most efficient project is consistent, we look at the provision rates of the projects that constitute Ω^1 and Ω^2. They are displayed, separately for the two information conditions, in Table 2.

[Table 2 about here.]

The Ω^1 projects can be ordered in terms of their efficiency. P_2^1, the most efficient project in the set, is clearly not the most frequently implemented one, and this holds regardless of the information condition (P_2^1 is actually the least often provided project in $PUBL$). Provision rates are the highest for the two negative cost projects: P_1^1 is implemented 43.7% of the times in $PUBL$ and 40.6% of the times in $PRIV$, and P_3^1 is implemented 31.2% of the times in both $PUBL$ and $PRIV$. It appears that first of all, participants are attracted to negative costs. Then, given equality in negative costs, they favor efficiency. In Ω^2, where the two revenue-generating projects are equally efficient, they remain the most frequently implemented ones, and their provision rates are—within each treatment—alike. These findings suggest a positive answer to question (i): under the described procedurally fair mechanism, introducing negative cost projects jeopardizes the provision of the most efficient, but costly, project.

To answer question (ii), that is whether negative costs affect bids for mixed feelings projects and for public goods differently, we compare $b_i(P_2^2) - b_i(P_1^2)$ (both P_2^2 and P_1^2 cause mixed feelings, but $C(P_2^2) > 0$ and $C(P_1^2) < 0$) with $b_i(P_4^2) - b_i(P_3^2)$ (both P_4^2 and P_3^2 qualify as public goods, but $C(P_4^2) > 0$ and $C(P_3^2) < 0$). The graphical summaries of the distributions of the two series, shown in Figure 1, do not indicate notable differences. Indeed, it is not possible to reject the null hypothesis that the $b_i(P_2^2) - b_i(P_1^2)$ and $b_i(P_4^2) - b_i(P_3^2)$ groups of independent observations have identical distributions ($p = 0.247$ for $PUBL$ and 0.809 for $PRIV$; two-sided Wilcoxon rank sum test). We conclude that the answer to our second research question is negative.

[Figure 1 about here.]

Turning to question (*iii*), that is whether negative costs affect low- and high-value bidders differently, Table 3 reports, separately for each information condition, project set, and type of bidder, summary statistics of the relative deviations of the observed bids from the induced valuations (i.e., the variable $R_i(P_\ell^s) = \frac{b_i(P_\ell^s) - v_i(P_\ell^s)}{|v_i(P_\ell^s)|}$ where $s = 1, 2$ and $\ell = 1, \ldots, 4$). As far as negative cost projects are concerned (i.e., P_1^s and P_3^s), it follows from the reported mean and median values that low-value bidders tend to overbid (relative deviations are positive) and high-value bidders tend to underbid (relative deviations are negative). In contrast, in the case of projects that entail positive costs there is a generalized tendency to underbid.

[Table 3 about here.]

On the basis of two-sided Wilcoxon rank-sum tests, the null hypothesis that the $R_i(P_\ell^s)$ values of the two types of bidders have identical distributions can be rejected (i) at the conventional 5% level for P_1^1 and P_1^2 in $PUBL$ and for P_3^2 in $PRIV$, and (ii) at the 10% level for P_3^2 in $PUBL$ and for P_1^1, P_3^1, and P_1^2 in $PRIV$. If we pool the data from both information conditions, the differences in $R_i(P_\ell^s)$ (with $l = 1, 3$) between low- and high-value bidders are always highly significant (all p-values ≤ 0.033).[14] To sum up, the bidding behavior of low- and high-value bidders differs significantly in the case of negative costs (low-value bidders tend to overbid relative to their induced valuations and high-value bidders tend to underbid), whereas no systematic differences in relative underbidding are observed in the case of positive costs.

The fourth and last research question pertains to the impact of private information on bid levels when some projects have negative costs. Figure 2

[14] For all the other comparisons, these differences are not significant.

suggests that the average surplus with respect to bids does not differ between the two information conditions. Wilcoxon rank sum tests confirm that switching from public to private information does not affect bids for the same project (all p-values exceed 0.528), which provides a negative answer to question (*iv*).

[Figure 2 about here.]

5 Conclusions

Financing public projects is usually perceived as burden sharing, despite the fact that many of the activities that the public authorities undertake generate revenues, that is, in our terminology, have negative costs. Herein we use the experimental method to explore whether a procedurally fair provision mechanism, that proved to be successful in achieving efficient outcomes when only standard positive cost projects were at stake, remains effective when projects entailing negative costs are considered.

Our results question the functionality of this mechanism when negative cost projects are present. More specifically, individuals tend to prefer negative cost to more efficient positive cost projects, although the most frequently provided negative cost project is the one generating the highest social net benefit. In other words, agents have a sort of lexicographic preferences in which priority is given to negative cost, followed by efficiency. Additionally, we observe that negative cost projects that raise mixed feelings do not yield different bid levels than negative cost public goods. This finding may be attributed to the fairness of the provision mechanism, guaranteeing that all players are treated equally according to their bids. Yet, our data indicate that the behavior of low-value and high-value bidders differs significantly in the case of negative costs: while the former tend to overbid, the latter tend to underbid. It appears, therefore, that those who value the negative cost project less want to increase the chances of implementing it. Finally, the results do not depend on whether subjects are informed or uninformed of the others' induced valuations for the projects.

To sum up, our study contains both bad and good news for the provision mechanism at issue. The bad news is that the mechanism does not maximize social net benefits in the presence of negative cost projects. The good news is that the mechanism is not sensitive to either the existence of mixed feelings or the extent of supplied information.

References

Carothers, T. (1998). The Rule of Law Revival, *Foreign Affairs* **77**(2): 95–106.

Chassang, S. and Zehnder, C. (2012). A Theory of Informal Justice, Unpublished results. `http://www.princeton.edu/~chassang/papers/archives/informalJustice.pdf` (accessed 11.05.2013).

Cicognani, S., D'Ambrosio, A., Güth, W., Pfuderer, S. and Ploner, M. (2012). Community projects: An experimental analysis of a fair implementation process, Jena Economic Research Papers 2012/015, Jena.

Delaney, J. and Jacobson, S. (2012). The Good of the Few: Reciprocity in the Provision of a Public Bad, Unpublished results. `http://web.williams.edu/Economics/wp/DelaneyJacobsonGoodOfFew.pdf` (accessed 11.05.2013).

Fischbacher, U. (2007). Zurich Toolbox for Readymade Economic Experiments, *Experimental Economics* **10**(2): 171–178.

Greiner, B. (2004). An Online Recruitment System for Economic Experiments, *in* K. Kremer and V. Macho (eds), *Forschung und wissenschaftliches Rechnen 2003. GWDG Bericht 63*, Gesellschaft für Wissenschaftliche Datenverarbeitung, Göttingen, pp. 79–93.

Güth, W. (1986). Auctions, Public Tenders, and Fair Division Games: An Axiomatic Approach, *Mathematical Social Sciences* **11**(3): 283–294.

Güth, W. (2011). Rules (of Bidding) to Generate Equal Stated Profits: An Axiomatic Approach, *Journal of Institutional and Theoretical Economics* **167**(4): 608–612.

Güth, W. and Kliemt, H. (2013). Consumer Sovereignty Goes Collective. Ethical basis, axiomatic characterization and experimental evidence, *in* M. Held, G. Kubon-Gilke and R. Sturn (eds), *Normative und institutionelle Grund-*

fragen der Ökonomik. Grenzen der Konsumentensouveränität. Jahrbuch 12, Metropolis-Verlag, Marburg, pp. 83–98.

Güth, W., Koukoumelis, A. and Levati, M. V. (2011). "One man's meat is another man's poison." An experimental study of voluntarily providing public projects that raise mixed feelings, Jena Economic Research Papers 2011/034, Jena.

Güth, W., Levati, M. V. and Montinari, N. (2012). Ranking alternatives by a fair bidding rule: A theoretical and experimental analysis, Jena Economic Research Papers 2012/005, Jena.

Müller, B. (1999). Justice in Global Warming Negotiations: How to Achieve a Procedurally Fair Compromise, Oxford Institute for Energy Studies, Oxford.

Oprea, R. D., Smith, V. L. and Winn, A. M. (2007). A compensation election for binary social choice, *PNAS* **104**(3): 1093–1096.

Ringius, L., Torvanger, A. and Underdal, A. (2002). Burden Sharing and Fairness Principles in International Climate Policy, *International Environmental Agreements: Politics, Law and Economics* **2**: 1–22.

Smith, V. L. (1977). The Principle of Unanimity and Voluntary Consent in Social Choice, *Journal of Political Economy* **85**(6): 1125–1139.

Table 1: The sets of projects, Ω^s, $s = \{1, 2\}$, presented to the players.

Set	P_ℓ^s	$v_1(P_\ell^s)$	$v_2(P_\ell^s)$	$C(P_\ell^s)$	$\sum_{i=1}^2 v_i(P_\ell^s) - C(P_\ell^s)$
Ω^1	P_1^1	-20	100	-25	105
	P_2^1	-20	160	20	120
	P_3^1	20	50	-25	95
	P_4^1	20	110	20	110
Ω^2	P_1^2	-10	90	-25	105
	P_2^2	-10	150	20	120
	P_3^2	15	65	-25	105
	P_4^2	15	125	20	120

Table 2: Rates of provision of the four projects in each Ω^s, $s = \{1, 2\}$, and information condition.

Project	Ω^1		Ω^2	
	PUBL	*PRIV*	*PUBL*	*PRIV*
P_1^s	43.7	40.6	31.2	40.6
P_2^s	**9.4**	**18.7**	**18.7**	**12.5**
P_3^s	31.2	31.2	46.8	40.6
P_4^s	12.5	6.2	**12.5**	**12.5**

Note The bold font identifies the most efficient project(s) in Ω^s.

Table 3: Summary statistics of the relative deviations of the observed bids from the induced valuations for each information condition and Ω^s, $s = \{1, 2\}$, separately for low-value and high-value bidders.

Treatment	Set	Bidder type		P_1^s	P_2^s	P_3^s	P_4^s
PUBL	Ω^1	Low-value	Mean	0.33	−1.63	0.19	−0.51
			Median	1.00	0.00	0.00	−0.50
			Std. Dev.	5.14	6.08	2.07	1.40
		High-value	Mean	−0.28	−0.42	−0.40	−0.40
			Median	−0.20	−0.38	−0.40	−0.32
			Std. Dev.	0.53	0.38	0.93	0.45
	Ω^2	Low-value	Mean	1.72	−1.48	0.58	−1.07
			Median	1.00	0.00	0.00	−0.33
			Std. Dev.	2.47	11.45	3.30	7.22
		High-value	Mean	−0.29	−0.36	−0.39	−0.39
			Median	−0.11	−0.33	−0.19	−0.32
			Std. Dev.	0.53	0.39	0.87	0.43
PRIV	Ω^1	Low-value	Mean	−0.15	−3.19	0.39	−2.36
			Median	0.50	−0.25	0.13	−0.38
			Std. Dev.	5.45	7.91	3.34	6.86
		High-value	Mean	−0.08	−0.25	−0.51	−0.28
			Median	−0.15	−0.25	−0.20	−0.22
			Std. Dev.	0.74	0.62	1.52	0.77
	Ω^2	Low-value	Mean	0.23	−7.69	1.07	−4.98
			Median	0.25	0.00	0.33	−0.33
			Std. Dev.	10.70	17.29	3.96	11.78
		High-value	Mean	−0.17	−0.25	−0.65	−0.26
			Median	−0.23	−0.30	−0.23	−0.18
			Std. Dev.	0.83	0.51	1.83	0.57

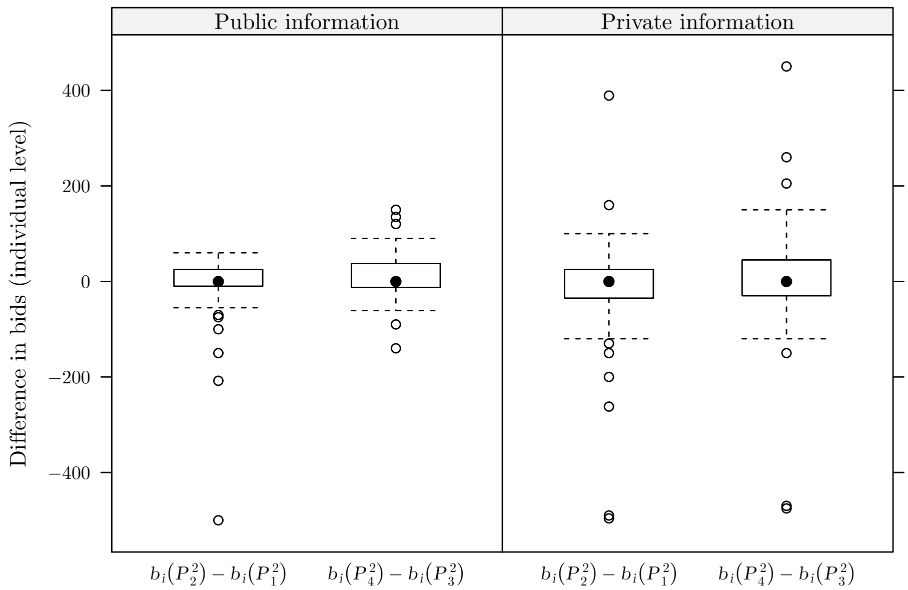

Figure 1: Boxplots of the differences in bids between projects with positive and projects with negative costs (Ω^2 only), separately for mixed feelings projects, P_l^2, $l = 1, 2$, and public goods, P_l^2, $l = 3, 4$.

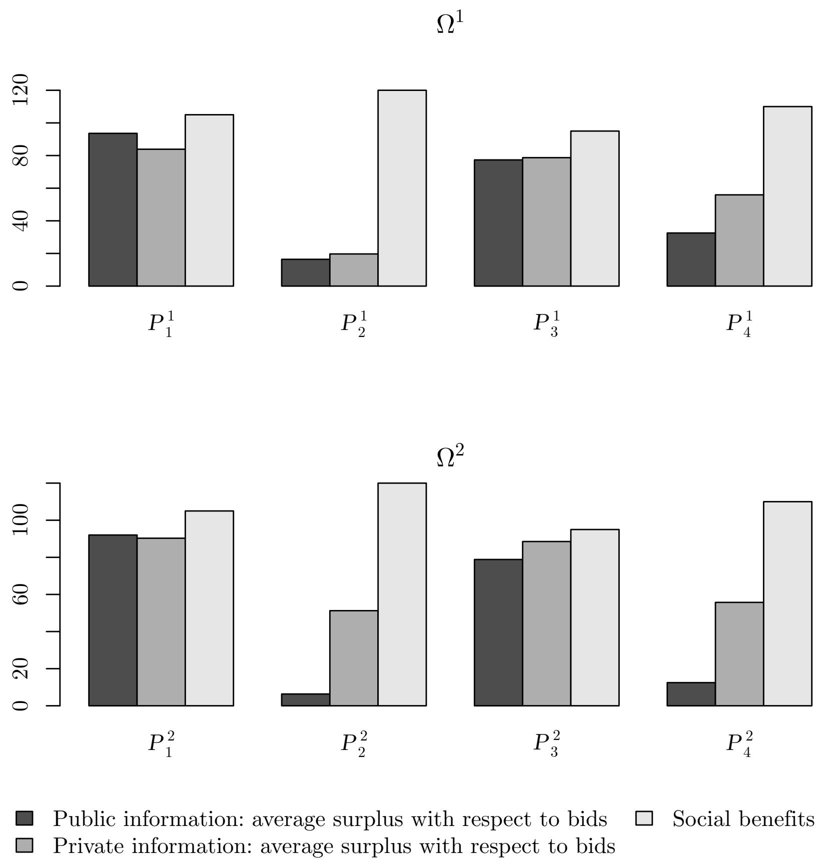

Figure 2: Average surplus with respect to bids and corresponding social benefits for each project, each Ω^s, and each information condition.

Appendix: Experimental instructions

This appendix reports the instructions (originally in German) that we used for the *PUBL* treatment. The instructions for the *PRIV* treatment were adapted accordingly.

INSTRUCTIONS

Welcome! You are about to participate in an experiment funded by the Max Planck Institute of Economics. Please switch off your mobile(s) and remain silent. It is strictly forbidden to talk to other participants. Please raise your hand whenever you have a question; one of the experimenters will come to your aid.

You will receive €5.00 for showing up on time. Besides this, you can earn more. But there is also a small possibility of ending up with a loss. The show-up fee and any additional amounts of money you may earn will be paid to you in cash at the end of the experiment. Payments are carried out privately, i.e., the others will not see your earnings.

In the course of the experiment, we shall speak of ECU (Experimental Currency Units) rather than euros. The conversion rate is 5 ECU per euro.

Detailed information on the experiment

You will be placed in a group of two persons (a pair). We will refer to the other person in your pair as the *other*. You and the *other* will face a one-shot situation involving two sets of projects, set A and set B. Each set includes four projects. You and the *other* will decide which one (if any) of the four projects in each set will be realized.

Cost and value of each project

Each project has a provision cost. For some projects this cost is negative, meaning that these projects generate revenues rather than cause costs.
In addition, each pair member attaches a value to each alternative project. This value can be positive or negative:

- a positive value means that you gain from the realization of the project;
- a negative value means that you lose from its realization.

You will be informed about your values and about the *other*'s values at the beginning of the experiment. The screen-shot informing you about the characteristics of the four projects in each set will look as follows (*original instructions included a screen-shot here*):

SET A

Project	Your value	*Other*'s value	Cost
1	−20	100	15
2	20	110	−15
3	40	120	20
4	−60	130	30

SET B

Project	Your value	*Other*'s value	Cost
1	30	90	30
2	20	80	50
3	−10	110	10
4	50	115	−10

Consider, for instance, project 1 in Set A. The values to you and to the *other* of this project are −20 and 100 ECU, respectively. The cost of the project is 15 ECU. This means that if project 1 in Set A is realized, you suffer a loss of 20 ECU, the *other* obtains a gain of 100 ECU, and both you and the *other* have to pay a cost of 15 ECU for its realization.

Consider now project 2 in Set A. The values to you and to the *other* of this project are 20 and 110 ECU, respectively. The cost of the project is −15 ECU. This means that if project 2 in Set A is realized, you and the *other* obtain a gain of, respectively, 20 and 110 ECU, and both you and the *other* receive a revenue of 15 ECU from its realization.

The characteristics of the other projects can be read in a similar way.

Notice that the numbers in the table above are just for illustrative purposes. They do not represent the costs and values actually associated with the projects in the experiment.

Your decision

Having learned the characteristics of the four projects in each set, you will have to submit a bid for each project. Hence, you will have to select and write eight bids: four for the projects in Set A, and four for the projects in Set B. Regardless of the values that you attach to the projects, your bids can be any integer number between −500 and 500 ECU.

Rules for the provision of a project

Given the costs of the projects, whether and which project in each set will be realized depends on the total number of ECU that you and the *other* bid on each project. We will refer to the difference between the sum of bids made by you and the *other* for a certain project and the cost of that project as the "surplus from the project". Thus:

Surplus from the Project = (Your bid + The other's bid) − Project's Cost.

Obviously, if the cost of a project is negative, it will be added to (rather than subtracted from) your pair's sum of bids.

For each set, the project with the largest non-negative surplus will be realized. If two or more projects tie for first place (i.e., they generate the same non-negative surplus), the tie is broken by a random choice.

If the surpluses of all projects in a set are negative, no project in that set will be realized.

Your experimental earnings

For each set, your earnings depend on whether and which project is realized.

- If no project is realized, you and the *other* earn zero.
- If one of the four projects is realized:
  - you receive your value of the project *plus* half the surplus from the project;
  - from this we subtract your bid for the project.

Thus, if we call the realized project P^*, your earnings summarized in a formula are

$$\text{Your value of } P^* \quad + \quad \frac{\text{Surplus from } P^*}{2} \quad - \quad \text{your bid for } P^*$$

Note that if your bid for the realized project P^* was negative, you ask for compensation rather than pay your bid.
Note also that if your bid for the realized project P^* exceeds your value of P^*, your earnings could be negative, i.e., you may suffer a loss.
The following examples should help you better understand the calculation of your earnings.

Example 1
Suppose that your bids and the *other*'s bids for the four projects in A are those shown below:

Project	Your value	*Other*'s value	Cost	Your bid	*Other*'s bid	Surplus
1	−20	100	15	−20	100	$-20 + 100 - 15 = 65$
2	20	110	−15	20	110	$20 + 110 + 15 = 145$
3	40	120	20	40	120	$40 + 120 - 20 = 140$
4	−60	130	30	−60	130	$-60 + 130 - 30 = 40$

The project with the largest non-negative surplus is project 2. Consequently, project 2 is realized and your earnings amount to $20 + \frac{145}{2} - 20 = 72.5$ ECU.
Note that in this case both you and the *other* have submitted bids equal to your values of the projects.

Example 2
Suppose now that your bids and the *other*'s bids are the following:

Project	Your value	*Other*'s value	Cost	Your bid	*Other*'s bid	Surplus
1	-20	100	15	-25	90	$-25 + 90 - 15 = 50$
2	20	110	-15	-10	40	$-10 + 40 + 15 = 45$
3	40	120	20	0	80	$0 + 80 - 20 = 60$
4	-60	130	30	-80	90	$-80 + 90 - 30 = -20$

The project with the largest non-negative surplus is project 3. Consequently, project 3 is realized and your earnings amount to $40 + \frac{60}{2} - 0 = 70$ ECU.
Note that in this case both you and the *other* have submitted bids <u>lower</u> than your values of the projects.

Example 3
Suppose finally that your bids and the *other*'s bids are the following:

Project	Your value	*Other*'s value	Cost	Your bid	*Other*'s bid	Surplus
1	-20	100	15	10	110	$10 + 110 - 15 = 105$
2	20	110	-15	25	80	$25 + 80 + 15 = 120$
3	40	120	20	50	90	$50 + 90 - 20 = 120$
4	-60	130	30	20	150	$20 + 150 - 30 = 140$

The project with the largest non-negative surplus is project 4. Consequently, project 4 is realized and your earnings amount to $-60 + \frac{140}{2} - 20 = -10$ ECU.
In this example, you suffer a loss because your bid for project 4 <u>exceeds</u> your value of project 4 plus half the surplus from project 4 (i.e., $20 > -60 + 70$).

The information you receive at the end of the experiment

After you and all the other participants have submitted your bids, you will be informed about (i) the *other*'s bid for each project, (ii) the surplus from each project, (iii) which project, if any, is realized in each set, (iv) your experimental earnings in each set.

Your final payoff

At the end of the experiment, one experimenter will randomly select one participant by drawing a chip from a bag that contains as many chips as the number of participants. This participant will in his turn randomly select one of the two sets by drawing a ball from a bag containing two balls, one labeled A and the other labeled B. All participants will be paid based on their bids for the projects in the randomly selected set.

In case of a negative payoff, losses up to €5.00 (= 25 ECU) will be covered by your show-up fee. There are two alternatives concerning losses in excess of €5.00. The first is to pay the difference from your own money. The second is to pay the difference by performing (before leaving the lab) a task which consists of counting the occurrences of a specific letter in a lengthy text. You will be compensated with €1.00 for each correctly counted sentence. The drill is introduced to allow you to repay your losses; there is no way of earning extra money from it.

Before starting you will have to answer some control questions which will ensure your understanding of these rules. Once everybody has answered all questions correctly, three practice rounds will help you familiarize yourself with the dynamics of the experiment. In these rounds the computer will choose the *other*'s decisions from a set of randomly generated values. The result of these rounds will not be relevant to your final payoff.

Please remain quietly seated during the whole experiment. If you have any questions, please raise your hand now. Please click "ok" on your computer screen when you have finished reading the instructions of this part of the experiment.