How to Allocate R&D (and Other) Subsidies: An Experimentally Tested Policy Recommendation[1]

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Abstract

This paper evaluates how subsidies or grants are typically awarded by governments, private charities, and foundations. We identify two sources of inefficiency: the selection based on a ranking of individual projects, rather than complete allocations, and the failure to induce competition among applicants in order to extract and use information about the necessary funding. In order to correct these inefficiencies we propose better mechanisms that include some form of an auction in which applicants bid for subsidies. Our proposals are tested in controlled lab experiments. The results of these experiments suggest that adopting our proposals may considerably improve the allocation.

JEL classification: D44, D45, H25, O32, O38

"Public money is like holy water; everyone helps himself."
Italian Proverb

1. INTRODUCTION

R&D subsidies are an important part of research policy. For example, the German government maintains a variety of R&D support programs. Some of them offer grants, others provide loans at subsidized interest rates or funding in return for a profit share. The German Federal Government spends €2.1 billion per year for these programs, and the States (*Bundesländer*) spend roughly another €4 billion. One fourth of these subsidies goes to private firms or their research institutes (see Blum et al. (2001) for more details). The remainder goes to universities and other public research centers. Typically, R&D support is organized in programs which pursue a specific aim such as promoting job creation in particular regions or improving the research intensity in a particular industry. Most programs are geared to support small and medium sized businesses.

In most programs the allocation of funds is organized as follows. Applicants submit written proposals at some due date; these are prescreened and short–listed, and then evaluated by a team of experts on the basis of their scientific and economic merit. Based on the expert advise, a committee grades projects, using a small set of grades such as A, B, and C. Finally, the committee selects projects. Each funded project receives a subsidy equal to a predetermined percentage of the scheduled refundable project cost.[1] And the committee selects projects in the order of the assigned grades, down from A to C, until the available budget is exhausted.[2]

In the present paper we will not debate the merit of subsidizing R&D activities. However, we object to the way in which projects are selected and subsidies are determined, and propose better ways to achieve the given purpose.

Specifically, we see two main deficiencies, and design procedures to cope with them:

1. Funding the best projects until the budget is exhausted is inefficient. Instead, the selection should be based on ranking of complete allocations of funds.

2. Funding the selected projects at a predetermined percentage of project cost is inefficient. Instead, one should induce applicants to compete by lowering their requests for funding.

In order to achieve these objectives, we propose to base the selection of projects on a ranking of allocations, and to embed that selection rule in a

[1] Typically only part of the project cost, such as personnel cost, are eligible for subsidies.

[2] A detailed description and analysis of the projects applied in Germany can be found in Blum et al. (2001) and in Becker et al. (2004).

simple auction mechanism.[3] In that mechanism firms compete with their requests for funding, which gives them an incentive to reveal their private information and lower their demand for subsidies.

The plan of the paper is as follows. In section 2 we discuss selection rules and show why one should select on the basis of a ranking of complete allocations. Two specifications of an auction mechanism are explained in section 3. Section 4 describes the design of a lab experiment to test the two mechanisms. Section 5 summarizes the results of the experiment. Section 6 concludes.

2. Ranking projects vs. ranking allocations

We analyze the following allocation problem: The government has offered an R&D subsidy program that grants subsidies according to some rule, within the limits of a given budget. Applicants have submitted project proposals, and the selection committee has evaluated them and has short–listed a set of projects $P := \{1, \dots, n\}$ which are judged as eligible for funding. Project i shall receive a subsidy of s_i if selected. The selection committee has to choose a subset of projects that shall be funded within the limits of the given budget B.

The standard selection rule is based on a ranking of individual projects, from the set of short–listed projects, as follows: 1) Each project is assigned a grade from a given set of grades (for the moment one may assume that each project has a distinct grade). 2) Projects are selected, moving from highest to lower grades, until the given budget is exhausted. As a result, no lower grade project ever crowds out a higher grade. This may seem to be a desirable property; however, it is generally not optimal.

As an illustration consider the example of four projects, $P = \{P_1, \dots, P_4\}$, which require the following subsidies if selected: $s = \{100, 50, 50, 50\}$ and a budget of 150. Suppose the selection committee has the preference order $P_1 \succsim P_2 \succsim P_3 \succsim P_4$. Then the selection based on the ranking of individual projects leads to the selection of projects $\{P_1, P_2\}$. However, if $\{P_2, P_3, P_4\}$ is preferred to $\{P_1, P_2\}$, it would be better to select $\{P_2, P_3, P_4\}$ since that allocation is also feasible at the given budget. This indicates that the selection based on the ranking of individual projects leads astray, because it does not take into account that a high–grade project may crowd out several lower–grade projects which are inferior in pairwise comparisons, but lead to a superior allocation. Indeed, that selection is equivalent to preferring every single higher–grade to any number of lower–grade projects.

Therefore, as a first step towards achieving a better selection process, the selection committee has to learn how to think in terms of complete allocations, and apply the proposed selection rule:

[3] The development of an auction-like mechanism for awarding subsidies has been suggested by Blum et al. (2001).

Proposal 1 *Select projects based on a ranking of allocations, rather than based on a ranking of projects, as follows: 1) Determine all allocations that are feasible (can be funded with the given budget). 2) Rank all feasible allocations and select the projects that are part of the highest ranking feasible allocation.*

In practical application this procedure may be fairly complex if the grade system is very detailed and the number of feasible allocations is large. Moreover, committees may find it difficult to rank complete allocations or to classify projects on a fine grid. In these cases, the committee may be well advised to employ a less fine–tuned procedure that works with a small grade set, such as $\{A, B, C\}$ and a set of equivalence rules. Such a set of equivalence rules states how many lower–grade projects are equivalent to one higher–grade project. For example, for the grade set $\{A, B, C\}$ the equivalence rules $(e(b), e(c))$ state the number of grade–A projects that are equivalent to one grade–B, resp. grade–C, project. We also employ this practical device in our lab experiments which are described in section 4.

Formal statement of the allocation ranking problem We conclude this section with a precise statement of the allocation ranking problem. The notation introduced here will also be used to describe our auction mechanisms.

For this purpose, let $P := \{1, \dots, n\}$ be the finite set of short–listed projects, and $\mathcal{A}$ the set of subsets (i.e., the power set) of P. Therefore, $\mathcal{A}$ is the set of all conceivable allocations from which the committee has to select one, under some feasibility constraint.

Ideally, the selection committee has a complete preference ranking, "$\succsim$", of all allocations, such that for all $a, a' \in \mathcal{A}$ one has $a \succsim a'$ or $a' \succsim a$ that is reflexive and transitive. Such a preference ranking defined on a set of finite alternatives can be represented by an (ordinal) utility function, $U : \mathcal{A} \to \mathbb{R}$ such that $\forall a, a' \in \mathcal{A}$: $U(a) \geq U(a') \iff a \succsim a'$.

The promised subsidy for project i, if it is part of the allocation, is denoted by s_i.

The selected allocation, a^s, is the maximizer of $U(a)$ over all feasible allocations that can be funded from the given budget B:

$$a^s \in \arg\max_{a \in \mathcal{A}} \left\{ U(a) \mid \sum_{i \in a} s_i \leq B \right\}. \tag{1}$$

As mentioned before, committees often employ a grading scheme as a simplifying device. Together with an equivalence rule of grades this may lead to a pragmatic construction of a utility function, as follows.

Let $G := \{g_1, \dots, g_m\}$ be a set of grades, such as $G = \{A, B, C\}$ where $g_1 \succ g_2 \succ \dots \succ g_m$. Then, the first step is to grade all projects, which is summarized by $\Gamma : P \to G$. Using Γ, one then computes, for each allocation, its frequency distribution of grades, denoted by $\gamma : \mathcal{A} \to \mathbb{N}^m$.

Next, the committee chooses an equivalence rule $e : G \to \mathbb{R}^m$, where $e(g_j)$ states the number of grade–g_1 projects that are equivalent to one grade–g_j project. Of course, $1 = e(g_1) > e(g_2) > \ldots > e(g_m)$.

Combining the grading scheme and the equivalence rule, one finds the utility function

$$U(a) := \sum_{j=1}^{m} \gamma_j(a) e(g_j). \tag{2}$$

$U(a)$ has a nice interpretation: let a' be an allocation that contains $U(a)$ grade–g_1 projects and no other projects; then, the committee's preference order exhibits $a' \sim a$.

3. TWO AUCTION MECHANISMS

We now turn to the second deficiency of the current subsidization policy: the funding of projects at a predetermined percentage of the refundable project cost. Generally this leads to excessive funding of those who are selected, and thus tends to exclude other valuable projects.

Typically, the selection committee cannot know the amount of funding needed to induce the applicant to carry out his project. They only know that this unknown amount is not greater than s_i, the amount of subsidy that would be granted according to the current rules[4] (otherwise the applicant had not applied). This suggests that one can reduce funding without losing valuable projects. It requires the design of a mechanism that induces applicants to compete by lowering their request for funding.

We propose two such mechanisms: one sealed–bid and one open descending–bid mechanism. Both mechanisms are auction–like in the sense that applicants compete with their requests for funding which can be viewed as their bids and the mechanism selects the best allocation that can be funded with the given budget.

To carry out their project as stated in the application, the applicant requires a certain amount of subsidization, which is denoted by z_i. The fact that z_i is private information motivates the use of the auction mechanisms. An auctioneer knowing z_i could directly implement the optimal allocation, namely

$$a^o \in \arg\max_{a \in \mathcal{A}} \left\{ U(a) \mid \sum_{i \in a} z_i \leq B \right\}, \tag{3}$$

by funding each applicant in the allocation exactly at the required level to implement his project.

Each applicant now submits a bid b_i according to one of the following two mechanisms.

[4] As we mentioned before, this amount is usually a fixed percentage of the refundable project cost.

3.1. *Sealed–Bid Mechanism*

The sealed–bid mechanism is characterized by the following allocation and pricing rules:

1. Each applicant $i \in P$ makes a sealed bid $b_i \in [0, s_i]$, without knowing the bids made by others. Bids are requests for funding.
2. On the basis of the given bids $b = (b_1, \ldots, b_n)$, the mechanism
   (a) selects the allocation, a^*, that solves the maximization problem[5]

$$a^* \in \arg\max_{a \in \mathcal{A}} \left\{ U(a) \mid \sum_{i \in a} b_i \leq B \right\}. \tag{4}$$

   (b) pays a subsidy equal to b_i if $i \in a^*$ and equal to zero otherwise.

3.2. *Open Descending-Bid Mechanism*

The second mechanism is an open descending–bid auction which consists of several "rounds."

1. Each applicant i faces his own price clock that starts at s_i. Subsequently, the reading of the price clock declines at rate Δ in each round.
2. The final bid b_i of applicant i is the price where he stops his price clock. After stopping the price clock, applicants are not allowed to lower their bid any further. Applicants can see others' price clocks at any time and can always observe if other applicants have stopped in an earlier round.
3. On the basis of the given bids $b = (b_1, \ldots, b_n)$, the mechanism selects the allocation as in the sealed–bid mechanism.

PROPOSAL 2 *Use either the sealed–bid or the open descending–bid mechanism. This induces competition for funding.*

3.3. *Maximum Bid Restriction*

It is advisable to structure the auction in such a way that its outcome can never be inferior to the outcome that would be reached if one would apply Proposal 1 only, without an auction.

This can be achieved by setting individual maximum bids equal to the subsidy rates s_i that would be granted according to the current subsidy rules. Therefore, we propose

[5] If a^* is not unique, it selects the allocation that minimizes $\sum_{i \in a^*} b_i$; if the result is still not unique, it selects at random.

PROPOSAL 3 *If one uses one of the auction mechanisms, set each applicant's maximum bid equal to the subsidy rate that would be granted according to the current subsidy rules, which before were denoted by s_i.*

In policy advice one should always try to make proposals that can only bring about an improvement relative to the *status quo* practice. To achieve this is the only purpose of Proposal 3.

Notice that we already incorporated this proposal in the two auction mechanisms proposed before.

We close this section with an illustration by example.

3.4. *An Example of an Open Descending–Bid Auction*

The following simple example illustrates the working of the proposed open, descending–bid mechanism (see Table 1). The example assumes a budget of 70 and bidding decrement of 5. There are five applicants (1 to 5). Their projects are substitutes and have the utilities stated in column 2. The associated minimum subsidies (z_i) are stated in column 3, and the subsidies s_i that would be granted if no auction were used are stated in column 4. Bold numbers denote which applicants are part of the best allocation given their current subsidy requests (resp. bids). If no auction were used, the allocation would be $\{1, 2\}$, with total utility 100.

Applicant	Utility	z_i	s_i	Round 1	Round 2	Round 3
1	53	20	**40**	35	30	**25**
2	47	20	**30**	**25**	**20**	**20**
3	38	20	30	**25**	**20**	20
4	37	10	25	**20**	**15**	**10**
5	35	15	25	20	**15**	**15**
a			{1,2}	{2,3,4}	{2,3,4,5}	{1,2,4,5}
$U(a)$			100	122	157	172

Table 1: Example of an Open Auction

This example assumes that all applicants stop their price clocks at round three. The auction ends with allocation $a^* = \{1, 2, 4, 5\}$. The example illustrates how an applicant, in the course of an auction, can be crowded out at some round and return to the allocation in a later round. The last row of the table states the total utility of the respective allocations. The optimal allocation is $\{1, 2, 3, 4\}$, and the maximum feasible utility is 175.

4. EXPERIMENTS

In order to test the two auction mechanisms we set up a series of computerized lab experiments.[6] There, subjects were assigned to play the role

[6] For instructions and screenshots see Giebe et al. (2005).

of a firm that applies for an R&D subsidy. They either participated in the sealed–bid or in the open descending–bid mechanism. In the experiment, we used a simple grading scheme for projects as proposed above, with only two grades.

4.1. *Experimental Design*

In the experiment, we formed groups of six subjects participating in one of the two mechanisms. Prior to the auction, each subject i was given the following private information $(z_i, \pi_i, s_i, g(i))$:

1. the minimum subsidy needed to execute one's project, z_i;
2. the private profit earned in addition to the subsidy if one's project is executed, π_i;
3. the maximum (resp. starting) bid, s_i;
4. the grade of one's project, $g(i)$, either A or B.

The smallest monetary unit was 1 ECU (experimental currency unit).

Each subject was informed that (z_i, π_i, s_i) were independently drawn from uniform distributions with supports $z_i \in \{0, 1, \ldots, 5\}$, $\pi_i \in \{0, 1, \ldots, 10\}$, $s_i \in \{5, 6, \ldots, 10\}$, and that there would be three grade–A and three grade–B projects, assigned to subjects with equal probability.

The following information was given to all subjects:

1. the budget $B = 20$,
2. the preference ranking over possible allocations:

$$\begin{array}{rrr} \{A,A,A,B,B,B\} \succ & \{A,A,A,B,B\} \succ & \{A,A,B,B,B\} \succ \\ \{A,A,A,B\} \succ & \{A,A,B,B\} \succ & \{A,B,B,B\} \succ \\ \{A,A,A\} \succ & \{A,A,B\} \succ & \{A,B,B\} \succ \\ \{B,B,B\} \succ & \{A,A\} \succ & \{A,B\} \succ \\ \{B,B\} \succ & \{A\} \succ & \{B\}. \end{array} \tag{5}$$

In the sealed–bid auction subjects were asked to enter their requested subsidy, b_i, referred to as "bid" in a computer screen window. After all bids were submitted, the software computed the best feasible allocation, based on the above preference ranking, according to the rules described in section 4. Those subjects who were part of the allocation received a credit equal to $b_i + \pi_i$ ECU; all others received no credit.

The open descending–bid auction was set up as a clock auction. There, each subject had its own price clock, starting at the maximum bid s_i and decreasing at the fixed rate of one ECU per round. In each round, we first asked the grade–A subjects to make simultaneous bids; then, all grade–B subjects observed the bids of all A subjects, and made their own simultaneous bids. There, a bid means that one either freezes the current reading of one's price clock or accepts a reduction by one ECU. This procedure continued until all subjects had stopped their price clock.

A subject who stopped its price clock in one round was not able to "unfreeze" it later. In each round, the active grade–A subjects could see the current reading of the price clocks of all subjects and who had already stopped its price clock in which previous round and at which price. Similarly, the active grade–B subjects could see the current reading of the price clocks of all subjects, which subjects had stopped in previous rounds, and, in addition, which grade–A subjects stopped in the current round.

When all subjects had stopped their price clock, the final bids b were the levels at which the individual price clocks had been stopped; the auction ended, and the software computed the best feasible allocation by the same rule as in the sealed–bid auction. Those subjects who were part of the allocation earned a credit of $b_i + \pi_i$ ECU; all others received no credit.

4.2. *Experimental Procedure*

The experiments were conducted in November 2003 at the Department of Economics, Humboldt University at Berlin. The subjects were 96 student volunteers. They were recruited by advertisements in lectures and by mail shots. Most of them were undergraduate economics or business students.

The treatments were computerized using the experimental software "z-tree" developed by Fischbacher (1999).

We conducted eight sessions. Four sessions were dedicated to the sealed–bid auction, and another four sessions to the open descending–bid auction. In each session there were twelve distinct subjects.

Instructions and Trial Auction After being seated at a computer terminal, subjects were given written instructions including a detailed example.

In the instructions we referred to an allocation as a "combination," to a subsidy as a "grant," and to an applicant as a "bidder" in order to keep the terminology as neutral as possible without making it unduly difficult to understand the mechanism. We made clear that all decisions would be taken anonymously and that identities would not be revealed.

Two control questions checked whether the instructions were understood by all subjects. These control questions were computerized, with feedback for incorrect answers. Then, a "trial auction" was played which did not count for earnings.

Assignment of Subjects to Payoff–Relevant Auctions A session consisted of two parallel sequences of five auctions, each played by six subjects. After each auction subjects were randomly and anonymously reassigned to one of the two groups playing the next auction.

After each auction subjects were privately informed about their earnings. In order to reduce path dependencies, subjects were not told which allocation was selected.

At the end of the session subjects got a summary account of their earnings, and earnings were paid, including a show–up fee.

Payoffs A typical sealed–bid session took 40 and an open descending–bid session 90 minutes. Each subject's earnings in ECU were converted into € at the rate 9 ECU = €1; in addition, subjects earned a show–up fee of €4 in a sealed–bid and €10 in a descending–bid session.

In sealed–bid sessions earnings were between €5.90 and €11, with an average of €8.40, and in the open descending–bid sessions between €11.70 and €17.40, with an average of €14.40.

5. RESULTS

Altogether, 96 subjects participated in 8 sessions with a total of 78 payoff–relevant auctions.[7] The trial auctions are not considered in our analysis. As groups were rematched in every auction, subjects were able to learn from each other's behavior. Because of this, the results within a session are not independent. Hence, each treatment consists of 4 independent observations, one per session.

Since the set of independent observations is relatively small, we perform a mainly descriptive data analysis.

Of course, each auction resulted in one of the allocations stated in equation (5). These allocations are ranked by assigning a number $r \in \{1, \dots, 15\}$, where $r = 1$ stands for $\{A, A, A, B, B, B\}$, $r = 2$ for $\{A, A, A, B, B, B\}$, etc. For convenience of notation we refer to the rank of the implemented allocation as r^*, that of the optimal allocation as r^o, and that of the allocation that would be implemented if all bids were equal to the maximum bids as r^s.

As it happened, the optimal allocation was $\{A, A, A, B, B, B\}$ in 70 of the 78 auctions and $\{A, A, A, B, B\}$ in the remaining eight auctions.

Table 2 indicates which allocations were implemented in the experiments.

The further presentation and interpretation of the experimental results is ordered by the following hypothesis:

[7]Actually, 80 auctions took place. However, due to a network problem, the data of 2 of the open descending–bid auctions were lost. Subjects were only informed after the experiment. They received a lump–sum payment of €2 for the third auction where the problem occurred. We therefore think that the data from the remaining auctions can be analyzed.

Allocations (ordered by rank r)	Sealed–Bid Frequency	%	Open Descending–Bid Frequency	%
$1: \{A, A, A, B, B, B\}$	3	7.5	6	15.8
$2: \{A, A, A, B, B\}$	22	55	20	52.7
$3: \{A, A, B, B, B\}$	6	15	3	7.9
$4: \{A, A, A, B\}$	8	20	9	23.7
$5: \{A, A, B, B\}$	1	2.5	0	0

Table 2: Frequency Distribution of Implemented Allocations

1. *The auction improves the allocation:* We explore to what extent the allocation improves relative to the allocation that would be reached if one adopted our Proposal 1 but not also Proposals 2 and 3.

2. *The auction is almost efficient:* We explore how close the observed allocations are to optimal allocations.

3. *"Handicapped" bidders play more aggressively:* We explore whether and if so to what extent grade–B bidders bid lower.

4. *Higher private profits give rise to more aggressive bidding:* We explore whether and if so to what extent bidders with a higher private profit submit lower bids.

5. *More experience gives rise to more aggressive bidding:* We explore whether bidders bid lower in later auctions in the sequence after gaining some experience.

Improvement due to the auction Figure 1 indicates that competition is effective. Bids are, on average, substantially below the maximum bids. Approximately 33% of all bids are even equal to the respective minimum bids. Average bids are slightly lower in the open descending–bid mechanism.[8] Therefore, both mechanisms induce a remarkable intensity of competition.

We measure the improvement due to the auction by computing the average difference between the rank r^s and that of the implemented allocation, r^*, i.e., $|r^* - r^s|$. In the sealed–bid mechanism that measure is equal to 5.78 and in the open descending–bid mechanism equal to 5.89.[9] On average the auction increases the number of subsidized projects, relative to the allocation a^s, by 2.04. This indicates that adding the auction brings about a remarkable improvement.

Efficiency We call the outcome first–best if an auction implements the allocation a^o, i.e., if $r^* = r^o$. Similarly, we call it second–best or higher if $r^* = r^o + 1$ resp. $r^* > r^o + 1$.

[8]Wilcoxon Rank–Sum tests using the difference in average bids in the two mechanisms ($n = 8$) confirm our result on the 10%-significance level.

[9]The average difference between r^* and the rank of the *status quo* allocation, i.e., the

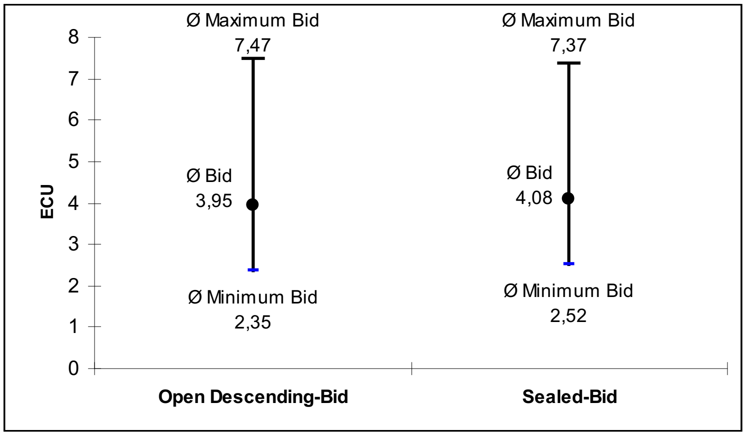

Figure 1: Average Bids

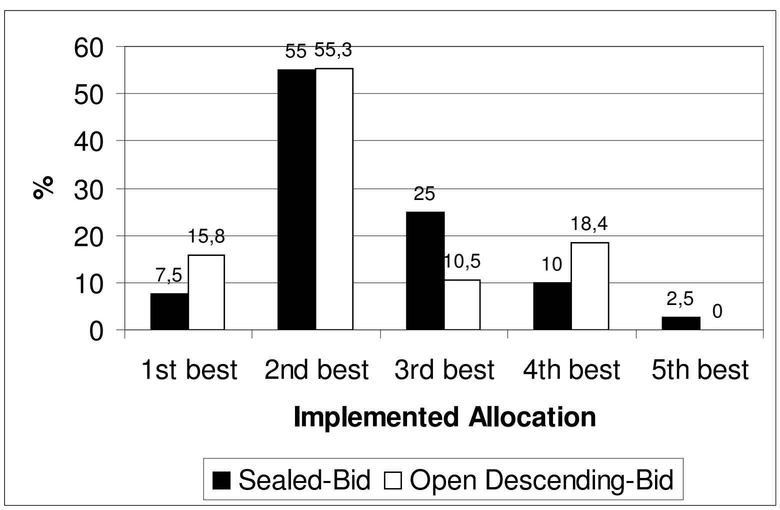

Figure 2: Efficiency Results

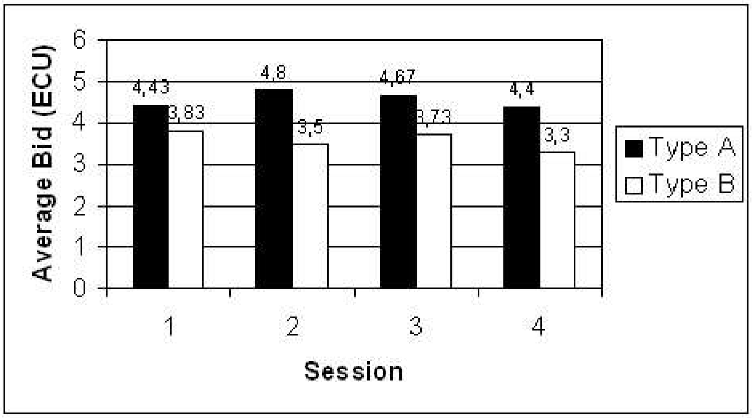

Figure 3: Average Bids in the Sealed–Bid Mechanism

We measure the deviation from the first–best by computing the average difference between the ranks of the optimal and the implemented allocations, $r^* - r^o$. In the sealed–bid mechanism that measure is equal to 1.45 and in the open descending–bid mechanism 1.31. This indicates that the auctions implement allocations that are close to the efficient ones.

Figure 2 summarizes the efficiency properties of both mechanisms. Without the auction, the implemented allocation would have been, on average, 8th–best.[10] Thus, the deviation from efficiency is considerably smaller than the deviation from the allocations that would be reached without the auction.

"Handicapped Bidders" Figures 3 and 4 show that grade–A applicants bid higher on average. This applies to all eight sessions. Specifically, in the sealed–bid auction, grade–A bidders bid 27% higher on average and in the open descending–bid auction 12% higher.[11]

Private Profits Intuitively, higher private profits should induce lower bids because those bidders should care more about getting the minimum funding needed to get their project off the ground, rather than about collecting unnecessarily high subsidies.

The coefficients for the correlation between private profit and the bid are $\rho_{\pi,b} = -0.1$ for the sealed–bid mechanism and $\rho_{\pi,b} = -0.15$ for the open descending–bid mechanism. The negative sign does indeed confirm this conjecture. However, the observed correlation is rather weak.

allocation that would be reached without using any of our proposals, is 7.4 on average.

[10] If one had used the established procedure, and not followed any of our proposals, the implemented allocation would have been, on average, 10th– best.

[11] Wilcoxon Signed–Rank Tests (n=4) confirm these results for both mechanisms on a 5%–significance level.

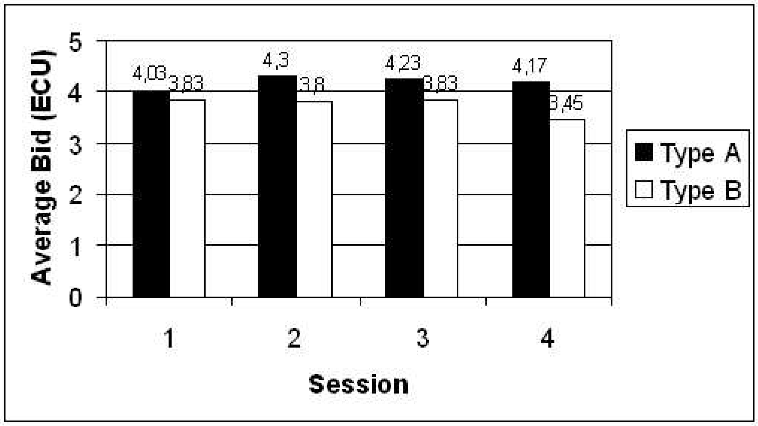

Figure 4: Average Bids in the Open Descending–Bid Auction

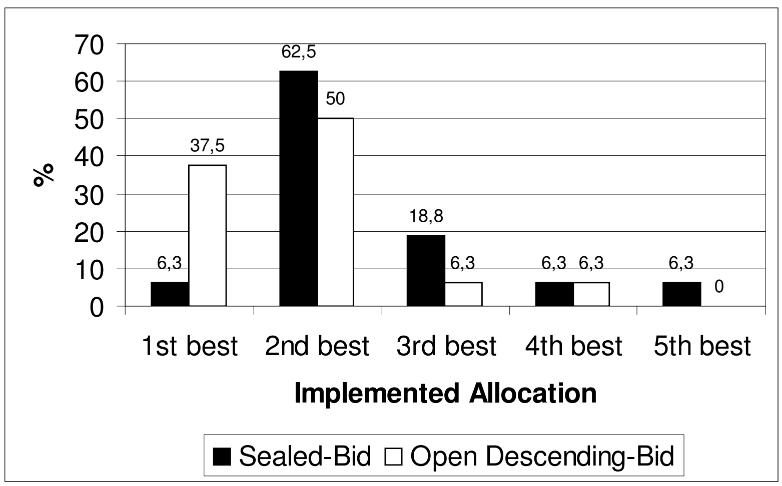

Figure 5: Efficiency in Late Auctions

Experienced Bidders In the sealed–bid mechanism, average bids remain fairly stable during a session. However, in the open descending–bid mechanism the average bid in the first auction of each sequence is 15.7% higher than in the final one.

Figure 5 states the outcomes of the fourth and fifth auction of each sequence, i.e., after bidders have acquired some experience. It indicates that experience induces more competitive bidding, resulting in a higher degree of efficiency. However, this improvement due to experience is more pronounced in the open descending–bid mechanism.[12]

Not surprisingly, players lower their bids after they lose an auction. This

[12] A Wilcoxon Signed–Rank test on the 5%–significance level ($n = 4$) confirms our result: For the open descending–bid mechanism, bids during the first two auctions of each sequence are significantly higher than in the final two. For the sealed–bid mechanism, the hypothesis of significantly higher bids in the first two auctions of each sequence is rejected.

learning effect is particulary strong in the sealed–bid auction. In fact, after losing an auction bids are on average reduced by 33.7% in the sealed–bid auction and by 16.7% in the open auction. And 73.7% of all losers respond in this way in the sealed–bid and 62.5% in the open auction.

6. SUMMARY AND DISCUSSION

The present paper analyzes the allocation of subsidies to fund socially valuable projects that are not feasible without subsidy. Applications range from R&D subsidies to the funding of charitable projects and of academic fellowships. Typically, these allocation decisions are based on a ranking of individual projects, and subsidies are awarded successively to the best projects until the budget is exhausted. Thereby, the awarded subsidies are often a lump–sum payment or a fixed share of the estimated project cost.

We identify two sources of inefficiency of the commonly used funding procedures and propose better mechanisms that may remedy them. The highlights of our proposals can be summarized by two recommendations:

- Select projects on the basis of a ranking of complete allocations rather than on a ranking of individual projects.
- Induce applicants to reveal information about their true need for funding and use that information. This can be done by employing some form of an auction in which applicants bid for subsidies.

We test two specific mechanisms in a controlled lab experiment. In these experiments, players are given private information about the minimum funding they need to carry out their project. Based on this private information they are then asked to compete for funding in an auction–like environment.

In our experiments, both mechanisms perform quite well. In most cases, adding the auction improves the allocation from rank 8 to 2. This improvement becomes stronger as bidders gain experience. This suggests that considerable gains can be realized by applying our proposals. Thereby, the highest efficiency gains are realized by adopting an open descending–bid mechanism.

The results of our experiments suggest that adopting our proposals may give rise to substantial improvements. However, we must stress that we evaluate the impact of our proposed mechanisms assuming a given set of projects. This ignores that the proposed change in selection rules may affect the proposed projects. If applicants anticipate that they compete not only in terms of project quality but also in terms of the requested amount of funding, they may propose different projects that are better targeted to the preferences of the selection committee. This may be an additional source of welfare improvements.

Our observations are based on only 32 "late" auctions, 16 per treatment. A more extensive series of experiments would be required to check the robustness of these results.

Moreover, it must be stressed that we assumed here all projects to be substitutes. If one deals with a subsidy program that concerns complementary projects, one must design different mechanisms.

Finally, we would also like to point out that bureaucrats are probably reluctant to apply our proposals. The currently used procedures give them considerably more discretion. No one can be expected to give up such power on his own initiative. Therefore, the policymaker must be reminded to exercise his power to make rules, and not to delegate it to those whose job it is to execute rules. This obvious principle is, however, frequently violated in the public sector.

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