A compensation election for binary social choice

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We report experimental results examining the properties of a bidding mechanism, the "Compensation Election," which is designed to implement a simple binary choice between two options. We may think of the group decision problem as a choice between a new rule and the status quo. The rule and the status quo are each common outcomes that apply across all individuals, but the value or cost that they induce on each individual differs according to each individual's circumstances: some gain, some lose, and others are unaffected by a change to the new from the old. Rather than casting votes, each subject submits a bid reflecting his willingness to pay to induce the group to select one option and the amount he wishes to be paid if the alternative option is selected. The Compensation Election chooses the option that receives the highest sum of bids. We find that, although the Compensation Election allows subjects to strategically bid above their value (or even for the option they do not prefer), such behavior is not the norm. We also find that subjects' bids more truthfully reveal their values when there are more bidders in the election.

experimental economics | public goods | auctions | voting

Wicksell is credited with the insight that, in principle, if a proposal yields an outcome that is common to all members of a collective, and that outcome provides a preferred social state for the members of the collective, then there exists a compensation scheme whereby those who gain from the outcome can compensate those who lose and the outcome can command unanimous consent (1). This is Wicksell's "principle of unanimity and voluntary consent in taxation." For example, if there is a public proposition to alter a local property zoning restriction and the total capital gains accruing to its supporters exceed the total capital losses incurred by its detractors, then the value produced by altering the restriction is sufficient to compensate those who suffer a loss. With the compensation, all are made better off and the proposition is unanimously approved.

Prior Research

Incentive-compatible methods for solving public-good decision problems of this kind were provided as early as 1971 (2–4). Vickery had earlier specified a mechanism for solving the market monopoly problem but which also could be applied to a public good (5). These solutions were computational schemes for charging each decision maker the opportunity cost that his decision (bid) imposed on all others.

All these mechanisms were thought by Vickery and others to be too complex for practical application. But several laboratory and field experimental studies of simplified versions of these mechanisms suggest that practical solutions might be devised (6–8).

A small, more recent literature has developed around Varian's Compensation Mechanism (9), a procedure for inducing decision makers in small groups to make socially efficient decisions by requiring them to compensate those harmed by the decisions. The mechanism relies on the standard theoretical assumption that all participants know the values and costs of all other participants. By contrast, the mechanism considered in this article is designed for environments in which there is uncertainty about the preferences of other participants. Varian's Compensation Mechanism has been experimentally studied several times (10, 11), but it is the incomplete information condition that is of practical importance and that has been most studied in experimental market economies.

The Unanimity Principle was implemented in laboratory experiments with a procedure (the "Auction Election") similar to the one we use here in that value information was private and subjects tendered bids indicating how much they would pay (or need to be paid) to implement a given choice (12). In six experiments, five groups arrived at the socially efficient outcome.

In the experimental design we report here, two major changes are made in implementing the above Auction Election. First, each decision is dichotomous: A or B. We may think of it as the standard single issue voting proposition where A is the proposal and B is the status quo. Second, each election is a one-shot decision with no in-round feedback of information (although subjects participate in a large number of elections sequentially.) We will refer to this procedure as the Compensation Election.

Experimental Design and Research Questions

Environment. In the Compensation Election subjects make decisions that determine which of two mutually exclusive public goods will be chosen. Every subject $i \in I$ is assigned a private value for each good $k \in \{A, B\}$ in each round $j \in \{1, \ldots, 36\}$. For simplicity, subjects' values were normalized on their preferred good so that the value for their preferred good, c, is $v_{ij}^c \geq 0$, and their value for their less preferred good is $v_{ij}^{-c} = 0$ with $c \in \{A, B\}$. Thus, a subject always has a value of 0 for one good and a non-negative value for the other. Our design models a case in which $v_{ij}^k \sim N(\mu_k, \sigma_k^2)$.

In our experimental environment, a subject's value for his preferred good is determined by the net value $v_{ij}^N \equiv v_{ij}^A - v_{ij}^B$, which is distributed $N(\mu_N \equiv \mu_A - \mu_B, \sigma_N^2 \equiv \sigma_A^2 + \sigma_B^2)$. A subject's value for his preferred good is given by $v_{ij}^c = |v_{ij}^N|$. Informally, a subject's preferred good is A if $v_{ij}^A > v_{ij}^B$ and B if $v_{ij}^A < v_{ij}^B$.

Our design consists of two treatment variables: the size of the cohort, I, and the distribution out of which the v_{ij}^N are drawn. Cohorts in the large and small treatments consisted of 18 subjects and 6 subjects, respectively. Each cohort participated in 36 elections. An election could be one of three election types: Even, Close, or Landslide. Each of the 3 types occurred 6 times in the first 18 elections and 6 times in the next 18 elections, and the ordering of the elections was randomized within these blocks.

Election types are differentiated by the distributions of v_{ij}^N, which are common knowledge. Specifically, although the variance of v_{ij}^N is held constant throughout all elections, the mean is varied from election type to election type. Because we are studying small samples but wish to study behavior in cases in which the asymptotic properties of the distribution hold (as in a large-scale public decision or election), the draws we use in our

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experiments are not independent random draws. Although the distribution of v_{ij}^N is described to subjects as a random process, we select samples whose values satisfy three criteria: (*i*) value draws are symmetric about the mean, (*ii*) the sample mean is equal to the theoretical mean, and (*iii*) the sample variance is equal to the theoretical variance of the population. Thus, the samples mirror the population, so that the Even, Close, and Landslide election types described below are precisely reflected in the samples of 6 or 18.[¶] To maximize comparability between periods, we use the same set of values across cases of an election although we rotate their assignments to subjects each period.

In all election types, $v_{ij}^N \sim N(\mu_t, \sigma_t^2)$, where $t \in \{E, C, L\}$ indicates the type of election: Even, Close, and Landslide. Subject values were selected so that $\mu_E = 0$, $\mu_C = 11$, $\mu_L = 51$, and $\sigma_E^2 = \sigma_C^2 = \sigma_L^2 = 33{,}373.67$. All of these parameters of the environment were common knowledge to subjects each round as they made their decisions. However, because few subjects were likely to have sufficient statistical sophistication to make informed use of the parameter σ_t^2, this information was displayed in the form of quartile estimates of the population of values of each good given the underlying σ_t^2.

The environment we study is inspired by Downs' classic treatment of two-candidate political elections (13), although it serves as a good model of any binary public good. The normality of the distribution of net values ensures that a large mass of participants on average will be relatively close to indifferent between the alternatives. In Downsian theory, this indifference is endogenous, stemming from equilibrium policy platforms. Our Even election is in line with the Downsian prediction of candidate location. That is, under majority rule, preferences are such that on average the Even election would be split 50%–50%. Close and Landslide elections were parameterized according to the outcomes that the preferences, on average, would induce under majority rule. Specifically, Close elections would, on average and in our samples, induce 48%–52% splits and Landslide elections would induce 40%–60% splits, both in favor of good B. In this article, we will refer to good A as the expected majority rule "loser" and good B as the corresponding "winner" in Close and Landslide elections.

Institution. Experimental cohorts made their social choice between goods A and B by using a Compensation Election. In the Compensation Election, each subject *i* in period *j* submits a bid, b_{ij}^k, for one and only one good *k*. The mechanism chooses good *k* if $\Sigma b_{ij}^k > \Sigma b_{ij}^{-k}$.

In the special case of a tie ($\Sigma b_{ij}^k = \Sigma b_{ij}^{-k}$) good *k* is chosen with 50% probability. Denoting the election's winner *w* and the subject's bid-upon good *k*, the profit π to subject *i* in period *j* is:

$$\pi_{ij} = \begin{Bmatrix} v_{ij}^{\mathrm{k}} - b_{ij}^k \text{ if } w = k \\ v_{ij}^{-k} + b_{ij}^k \text{ if } w \neq k \end{Bmatrix}. \quad [1]$$

As long as $0 \leq b_{ij}^c \leq v_{ij}^c$, which we will refer to as a "preference bid," a subject is guaranteed non-negative earnings. However, there are two "off-preference" bidding strategies that offer the possibility of profits above v_{ij}^c (i.e., "supernormal profits") but expose subjects to the risk of loss and even bankruptcy. First, a subject could submit a bid $b_{ij}^c > v_{ij}^c$, which would result in supernormal profits if w ≠ c. Second, a subject could submit a bid $b_{ij}^{-c} > 0$ and earn supernormal profits in the event that $w = c$. (This result is formally equivalent to submitting a bid $b_{ij}^c < 0$.) Throughout this article, we will refer to bidding on one's less preferred good, $-c$, as "counterbidding" and bidding greater than one's value as "over-bidding." Notice that an over-bid will lead to bankruptcy if $w = c$ and $|v_{ij}^c - b_{ij}^c| > \Sigma_{g=1}^{j-1}\pi_{ig} + \varepsilon_i$, where ε_i is subject *i*'s initial endowment.[‖] A counterbid will lead to bankruptcy if $w \neq c$ and $|b_{ij}^{-c}| > \Sigma_{g=1}^{j-1}\pi_{ig} + \varepsilon_i$[**].

To guard against bankruptcy, the final feature of the Compensation Election in our experimental protocol is that bidding is constrained by the subject's total wealth,[††] consisting of his initial endowment plus all prior earnings:

$$\sum_{g=1}^{j-1} \pi_{ig} + 500 + (v_{ij}^k - b_{ij}^k) \geq 0. \quad [2]$$

We note that there exists no equilibrium model for predicting behavior in this bidding mechanism, except in the special case in which there are only two bidders. This condition holds because an ordering on the values induces no corresponding ordering on the bids, as in standard private or common value auction environments (14). Any sum of bids for A that are greater than the sum of bids for B yields an outcome in favor of A, whatever might be the sums of the values associated with the bids. However, the absence of a theoretical equilibrium does not rule out the possibility of empirical regularities in individual and aggregate bidding behavior.

Research Questions. Whereas our interest in the Compensation Election is based on the fact that it enables minorities to protect their assets from confiscation by majorities, our main empirical motivation for this study is to understand bidding behavior under the mechanism. Because theory cannot provide a benchmark equilibrium, it is difficult to assess the incentives for individual bidders to reveal their preferences through their bids without such empirical study.

We pose four main experimental questions.

Question 1. What does the empirical bid function look like? Are bids positively related to value? Are they linear in value?

Question 2. To what degree do bidders engage in pathological bidding strategies? How frequent are counterbidding and overbidding relative to preference bidding?

Question 3. Is bidding impacted by the election type or cohort size?

Question 4. Do subjects bid differently when they are in the minority than when they are in the majority? If minorities have a tendency to bid more of their value than members of the majority, the mechanism may systematically choose inefficient goods, especially in environments like ours in which majority decisions have a tendency to be efficient.

A fifth question, posed in previous studies on the Auction Election, is whether the mechanism has any tendency to improve upon outcomes observed under majority rule. Unfortunately, our design is ill-suited to studying this question for the Compensation Election. The distribution of values we use in our design is such that the majority rule outcome will tend to coincide with the efficient outcome. We study three unique sets of value draws and in none of these is there a clear case in which we can predict that majority rule would systematically end in an inefficient outcome. We therefore leave this question for future research.

¶Additionally, a string of outliers might make it appear to subjects as though we were manipulating the outcome. Thus, in constraining the sample draws in this way, we also avoid the appearance of deception among subjects.

‖In our experiments, $\varepsilon_i = 500\ \forall i \in I$.

**These are not hypothetical cases. In nearly all our pilot experiments that did not use a bidding constraint, at least one subject suffered a net loss. Often a subject who attempted to use one of the off-preference bidding strategies lost a moderate sum in an early round and attempted to earn this money back in subsequent rounds by submitting ever riskier bids. In sessions where there were two such subjects who valued opposite goods, they tended to reinforce risky behavior in one another.

††Such a constraint would undoubtedly be used in any field application of the Compensation Election and could be accomplished by means of bonded bids.

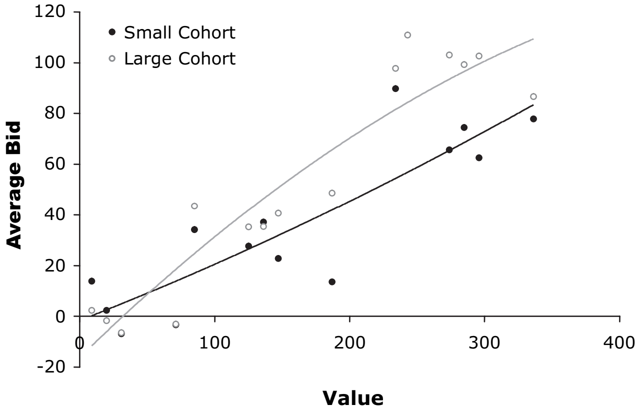

Fig. 1. Average bid by value and cohort size. The lines are quadratic fits to the data under each cohort size. ●, Small cohort; ○, large cohort.

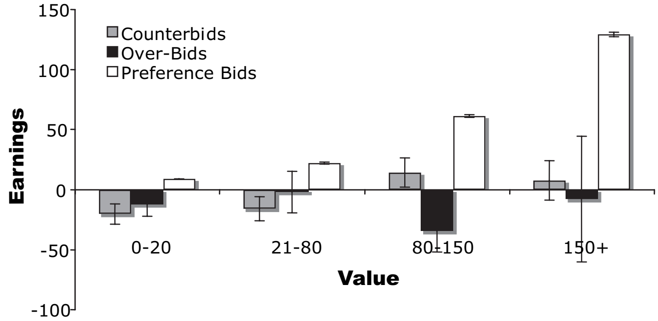

Fig. 2. Average earnings by bid type over several ranges of values with standard error bars. Stippled bars, counter bids; black bars, over-bids; white bars, preference bids.

Results

In the results reported below, we make use of data only from the last 18 rounds (the last half) of each experimental session. Our results, therefore, reflect the behavior of subjects experienced in bidding under the Compensation Election.

Our research questions concern the characteristics of the empirical bid function: the observed relationship between subjects' bids and their values. We use two techniques to study this mapping. First, Fig. 1 shows average bids at each value induced in the experiment for large cohorts and for small cohorts. Fig. 1 also includes a quadratic fit for each of these treatments to allow for curvature in our visual assessment of the bid function.

Second, to statistically pose the questions raised in *Research Questions*, we estimate the bid function using a random effects feasible generalized least squares regression model reported in Table 1. The model estimates the linear relationship between subjects' bids and their values. The regressors include (*i*) the intercepts made up of the interactions between treatment indicator variables for cohort size and election type, shown in the first six rows of Table 1, and (*ii*) slope terms estimated for cohort size and election type dummy variables interacted with the subjects' values, listed in the next six rows in Table 1. The result is separate estimates of intercepts and the marginal effect of values on bids for each treatment. We also include each of these treatment indictor variables interacted with an additional indicator variable, taking a value of 1 for observations in which the bidder prefers the losing or socially disfavored outcome. These interactions allow us to look for the type of off-preference bidding effect discussed in Research *Question 4*. Our model includes a subject-specific random (intercept) term. Although we allow for heteroskedasticity across subjects, we impose homoskedasticity within subjects.

Because counterbids are equivalent to negative bids on preferred goods, we code them as such in the data used to generate both Fig. 1 and our statistical results.

Result 1. There is a direct positive relationship between bids and values in all treatments and the bid function is roughly linear. The first bolded section of Table 1 contains slope term estimates for the bid function for all treatments. In all treatments, bids increase in value, and the coefficient is statistically significantly greater than zero. Fig. 1 shows the mean bids at each value under each cohort size with quadratic curves fit to the data. These quadratic fits show little curvature under either cohort size.

Table 1. Results from mixed effects model estimating the bid function

Treatment condition	Coefficient	SE	*z*	*P* value
Large × Even	−1.2818	2.9346	−0.44	0.662
Small × Even	−0.4190	4.5396	−0.09	0.926
Large × Close	−4.9018	4.3538	−1.13	0.26
Small × Close	−8.1903	6.7350	−1.22	0.224
Large × Landslide	−5.6806	3.5306	−1.61	0.108
Small × Landslide	−10.0253	5.4615	−1.84	0.066
Large × Close × Value	**0.4521**	**0.0227**	**19.9**	**0.000**
Small × Close × Value	**0.3784**	**0.0351**	**10.77**	**0.000**
Large × Even × Value	**0.4646**	**0.0160**	**28.92**	**0.000**
Small × Even × Value	**0.3451**	**0.0248**	**13.89**	**0.000**
Large × Landslide × Value	**0.4296**	**0.0180**	**23.87**	**0.000**
Small × Landslide × Value	**0.3152**	**0.0278**	**11.32**	**0.000**
Loser × Large × Close	3.6997	5.8799	0.63	0.529
Loser × Small × Close	8.2610	9.0957	0.91	0.364
Loser × Large × Landslide	9.8330	7.9780	1.23	0.218
Loser × Small × Landslide	11.4155	12.3093	0.93	0.354
Loser × Large × Close × Value	**0.0098**	**0.0321**	**0.31**	**0.759**
Loser × Small × Close × Value	**−0.0150**	**0.0496**	**−0.3**	**0.762**
Loser × Large × Landslide × Value	**0.0375**	**0.0448**	**0.84**	**0.403**
Loser × Small × Landslide × Value	**0.0726**	**0.0685**	**1.06**	**0.289**

Large and Small, indicator variables indicating the cohort size; Close, Even, and Landslide, indicator variables for the election type.

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Result 2. The empirical bid function does not admit important off-preference bid behavior and subjects exhibit a strong tendency to submit preference bids. The first unbolded section of Table 1 shows intercept terms for each treatment. These intercept estimates are all insignificantly different from zero. Because, by *Result 1*, bids are increasing in value, the bid function does not, on average, feature negative bids at any value. Because counterbids are negative bids, the empirical bid function shows insignificant counterbidding.

The first bolded section of Table 1 contains estimates of the slope terms in the bid function. These slope terms are all significantly smaller than one, meaning subjects do not, on average, over-bid. Because there is neither counterbidding nor over-bidding in the empirical bid function, we may conclude that off-preference bidding is atypical behavior in our data.

Furthermore, we note that this bidding behavior is individually rationally sustainable, given the aggregate outcomes that obtain in our data. Off-preference bidding yields lower expected returns than preference bidding.

Fig. 2 shows the average earnings resulting from counterbids, over-bids, and preference bids over several value ranges. At low values, off-preference bidding results in negative expected returns, whereas preference bidding guarantees positive returns. Moreover, preference bids provide significantly higher returns at all levels of value.

Result 3. Bidding is affected by cohort size, but unaffected by the election type. In particular, subjects tend to bid a significantly larger proportion of their value in large cohorts than in small cohorts.

We conduct pair-wise Wald tests comparing intercepts and slope terms across treatments. Intercepts are statistically indistinguishable across treatments. Slope terms are also statistically indistinguishable across election types. However, slope terms under large cohorts are significantly larger than slope terms in small cohorts in Even ($P = 0.001$) and Landslide elections ($P = 0.0006$) and marginally larger under Close elections ($P = 0.0784$). Table 1 shows that the estimated slope term in a large cohort is 0.12 points higher than in a small cohort in Even elections, 0.11 points higher in Landslide elections, and 0.08 higher in Close elections.

Result 4. Bids by those not preferring the socially preferred good are indistinguishable from bids by those preferring the efficient good. The second unbolded and bolded portions of Table 1 contain intercept and slope terms for the bid function interacted with an indicator variable that takes a value of 1 only if the bidder prefers the minority good.[‡‡] These terms measure the marginal effect on bidding behavior of those not preferring the socially preferred good. The coefficients on these terms are insignificantly different from zero in every case.

Discussion

We experimentally tested a bidding mechanism for referendum decision making that allows participants to protect their assets from confiscation by a majority rule winning coalition. Overall, the empirical bid function in the Compensation Election is qualitatively similar to the bid function under many commonly studied private auctions. Empirically, there is a direct relationship between values and bids, no tendency for bidders to bid over their value, a tendency for bidders to bid on the good they prefer, and a tendency for bidders to bid less than their value (i.e., to shade). This latter property is theoretically less than optimal in public goods provision, but we note that majority rule suffers from precisely the same defect and can potentially be more inefficient. Moreover, despite its pervasive popularity, majority rule voting often violates democratic principles of freedom and fair play in confiscating minority asset value to the benefit of a majority.

Our experiments were designed to evaluate subject bidding behavior under the compensation features of our mechanism. Therefore, our parameter choices were not suited for systematic efficiency comparisons of the Compensation Election with the majority rule mechanism. Future research could return to this issue, and to the important question of how robust our findings are for much larger collectives than 18 people. Our findings that 18-subject cohorts shade bids to a lesser degree than their 6-subject counterparts are suggestive, but far from conclusive.

In closing we note that there are many variations on the mechanism suggested by applied problems in historical practice. For example, the mechanism can be studied for application to classic "holdout" problems in acquiring right-of-way for railroads, power lines or pipelines, and land assemblages for private or public projects (airports, arenas, shopping malls, etc.) in which any sequential acquisition and information-release procedure can invite one or a few holdout owners who seek to capture a disproportionate share of the surplus. Eminent domain as a solution to this problem has itself led to spectacular and unpopular abuses. An advantage of the bidding mechanism we propose is that all decisions are made simultaneously; all parties are confronted by the same uncertainty regarding the bids of their counterparts; and, where more than one site or right-of-way path is feasible, the efficiency of the common outcome decision can benefit from contestability among the alternatives.

Materials and Methods

Experiments were conducted in the Interdisciplinary Center for Economic Science laboratory at George Mason University. We recruited 108 undergraduate subjects through an online recruiting system. Ten sessions were conducted. At 4 of these sessions, 18 subjects participated, and, in 6 of them, 6 subjects participated. Recruited subjects had no experience in the experiment and were not allowed to participate in more than one of the experiments reported here. However, all recruited subjects had previous experience with the double auction institution and were thus familiar with laboratory procedures. Sessions were held between September 2003 and October 2004, and each lasted ≈2 h.

In a typical session, subjects waited in a reception room until a sufficient number had arrived. Twelve to 18 subjects were taken into a laboratory room and seated at computers behind partitions so that they could not see each other's screens. A strict no-talking rule was enforced as soon as subjects entered the laboratory. At each session, subjects were given identical computerized instructions that gave detailed information on the environment and rules of the institution and gave subjects experience with the interface. Subjects earned, on average, $33.22 in small-cohort sessions and $32.78 in large-cohort sessions.

‡‡Because there are no minority goods in the Even election, there are no such interaction terms for Even election treatments.

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