No Need to Fight: A New Mechanism for Resolving Disputes

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Abstract

This paper studies a new mechanism that was developed for resolving disputes in a relatively amicable manner. Theoretical predictions for the mechanism are derived, and the mechanism is related to both the second-price auction and the provision point mechanism. Experimental results for the mechanism for subjects who have had learning opportunities largely follow theoretical predictions. For subjects who have not had learning opportunities, behavior follows the behavior seen in single-run provision point mechanism experiments. Discussion is provided comparing the use of the mechanism to what typically occurs with dispute resolution.

1. Introduction

Consider a standard question in economics – whether or not a country should have free trade for a given commodity. Suppose that we have a new commodity where the domestic producers of the commodity are entirely separate from the domestic consumers of the commodity. The commodity will also be produced internationally, and suppose that the world price will be lower than the domestic price. As such, following basic supply and demand, domestic consumers would prefer for there to be free trade for the commodity, and domestic producers would prefer for there not to be free trade for the commodity. We accordingly could imagine then a dispute between the two sides about what government policy will be in place with respect to international trade of the commodity.

It is commonly presented in economics courses and textbooks that there is a clear answer to this question – the policy should be for free trade. This answer is usually justified by the fact that economic surplus is higher with free trade. On occasion, a student will question the surplus maximization normative standard that underlies this answer. Surplus maximization then is often justified by noting the fact that an outcome with higher surplus is potentially Pareto improving over an outcome with lower surplus. That is to say, in principle, everyone could be made better off with the higher surplus outcome through the use of lump-sum transfers from those who gain with that outcome to those who lose with that outcome.

This justification of surplus maximization is problematic, however, because it is not the case that everyone is actually made better off; it is only possible in principle for this to happen. With it not being the case that everyone is made better off, this implies then that there are some people who win and some people who lose. An argument for increasing surplus would then need to argue that the gains to the winners should be valued more than the losses to the losers, and this would involve making interpersonal comparisons of happiness. In particular, it might involve the interpersonal assumption that one dollar of surplus to one person will result in happiness that is identical to what would be generated from one dollar of surplus to someone else.

Finally, we might justify the answer of free trade with the assumption that those lump-sum transfers from domestic consumers to domestic producers will be made so that in fact everyone is better off than they would have been without free trade, and free trade gives us a true Pareto improvement over the alternative. In principle, this may have a good deal of normative appeal, but in practice we would need to determine the willingnesses-to-pay of all the individuals involved, and these individuals would have incentives to overstate and understate these values. Moreover, if we are assuming that it is government who will implement the transfer scheme, public choice theory would suggest that it is difficult to envision a government that is incentivized to correctly do so (Buchanan and Tullock 1962).

We can note here as well what typically happens in the real world with such disputes – the sides battle with each other. We might imagine domestic producers and domestic consumers each using resources to try to influence politicians' votes or using resources to support campaigns of politicians whose views are aligned with theirs. This use of resources can be considered to be wasteful in that if each side devoted only, say, half as many resources as they had previously, the outcome would likely be the same – the side that devoted the most before still devotes the most now and accordingly still enjoys the corresponding boost to the probability of its preferred outcome – but resources are saved for other valuable uses. Similar waste can occur with other sorts of disputes – lawyer costs in a legal dispute, war between two countries involved in a land dispute, and time and effort and emotional costs for a couple in a dispute about housework.

What this paper will do is present a mechanism that can be used in these sorts of cases where two sides are involved in a dispute. The mechanism will involve actual transfers between the winning side and the losing side, where these transfers are intended to compensate the members of the losing side for losing their preferred outcome. Because the losing side will receive this compensation, it is intended that the mechanism will provide a relatively amicable method for resolving disputes, and accordingly it could be a good alternative to wasteful battling. The mechanism is built around the idea of individuals providing their true willingnesses-to-pay, so that then the surplus-maximizing outcome would the one chosen, and then, with the compensation payments, it would be a true Pareto improvement over the other outcome. The mechanism, however, will not fully follow this idea, but the way that it deviates from it would still perhaps keep it as being quite reasonable for resolving disputes, as will be discussed further in the paper.

Section 2 will explain the mechanism. Section 3 will discuss expectations for individual behavior under the mechanism. Section 4 will detail experimental results involving the mechanism. Conclusions are provided in Section 5.

2. Explanation of the Mechanism

As a benchmark, first of all, consider someone in a dispute who is told that a resolution to the dispute will result in the following:

> *(A) Either you will receive the outcome you prefer and pay less for it than it is worth to you, or you will not receive your preferred outcome but be fully compensated with a payment that is equal to how much you valued that outcome.*

Such a resolution would perhaps have a good amount of appeal to it for an individual. On one hand, if the individual loses the dispute, she would have little reason to be upset since she would receive something that would give her the same utility as winning the dispute would have. Moreover, then, she would have little reason to fight to avoid losing. On the other hand, though, if she wins the dispute, she will make a payment, but since this payment will be less than her value of winning, she will end up with positive net surplus over not having her preferred outcome.

For a simple illustration that involves only one person on each side, consider two brothers who are in elementary school who are in a dispute over who will get to sit in the front seat of the car for a family trip. It is possible to achieve (A) for each of them by simply having the brother who values the front seat more sit there and having that brother pay the other brother that other brother's value. For example, if David values the front seat at 40¢ and Steven values the front seat at 75¢, have Steven sit in the front seat and make a payment to David of 40¢. Hence (A) would be achieved for both of them.

This process can easily be extended to multiple people on each side. Sum up all the values for those who prefer free trade, and sum up all the values for those who prefer no free trade, and give the side with the higher total value its preferred outcome. Then collect from each member of the winning side a portion of that member's value, such that these collections will just be enough to pay each member of the losing side that member's value. Again, (A) would be achieved for all. Moreover, everyone is weakly better off than they would be with just having the outcome preferred by the losing side, resulting in a true Pareto improvement over that outcome.

Thus far, we have assumed knowledge of each individual's value, but individuals here would, in fact, have reason to misreport their values. If David knows that Steven is going to report 75¢, he would be better to report 50¢ than 40¢ for 10¢ more of compensation. If Steven knows that David is going to report 40¢, he would be better to report 45¢ than 75¢ to receive 45¢ of compensation rather than 35¢ of net surplus. However, would simply asking people for their values still perhaps make sense?

Note what would happen if someone is asked for his value. He can, in fact, ensure that he will achieve (A) by being truthful in reporting his value. If he chooses to report something different from his value, it would have to be the case (under standard assumptions) that he will be *better off*, at least in an *ex ante* sense, than he would be by achieving (A). Otherwise, he would have chosen to report his value instead.

As such, the mechanism is as follows: Each member of each side of the dispute is asked for a bid. If an individual wishes to achieve (A), she can do so by making her bid equal her value, but she can also bid something different from her value if that would make her even better off than with (A). The total bids from each side are determined as $\sum_j b_j$ and $\sum_k b_k$, and the side with the highest total gets its preferred outcome. Assume that this is the side indexed by *j*. Each member of the losing side will receive a compensation payment equal to the amount of his bid, and these payments will be financed by collections from each member i of the winning side equal to

$$\left(\sum_k b_k \Big/ \sum_j b_j \right) \cdot b_i \,.$$

It can be noted then that, for every individual involved, they will either achieve (A) or receive something that was *ex ante* preferred to (A).

3. Expectations for Individual Behavior

We can note that there are similarities between the mechanism presented in this paper and the second-price auction. In the second-price auction, proposed by Vickrey (1961), the highest bidder wins the auctioned item and pays the second-highest bid for it. Similarly, with the mechanism, the side with the highest total bids wins and pays the second-highest total, which is just the total from the other side. The theoretical predictions for behavior in the second-price auction are straightforward. Assuming that bidders have known private values, each bidder's dominant strategy, regardless of his attitude toward risk, is to bid exactly his value (Kagel 1995).

Experimental results from the second-price auction, however, are less straightforward. In particular, experimental subjects tend to bid above their values. For example, Kagel, et al. (1987) find overbidding that results in winning payments that are on average 11% higher than what these payments would be if the subjects did bid their values. Moreover, they find no evidence that overbidding diminishes as subjects gain more experience. Overbidding that continues even with experience is also found by Kagel and Levin (1993), and they report that only 30% of bids are essentially equal to values, with 62% of bids being above values. Harstad (2000) finds that experience with other auctions, such as the theoretically equivalent English auction, results in a significant reduction in overbidding but does not eliminate it. Overbidding is also significantly reduced but not eliminated by giving subjects one day to "introspect" before participating in additional rounds (Aseff 2004).

These theoretical and experimental results for the second-price auction provide some insights and benchmarks for how individuals will behave under the mechanism, but we can also note a key difference between the mechanism and the second-price auction that results in additional behavioral incentives. This difference is that, under the mechanism, the losing side will receive compensation, and this creates two ways for behavior to differ from what occurs in a second-price auction. Both ways were suggested in the example above about sitting in the front car seat. If an individual suspects that she will lose, she would have reason to increase her bid to try to receive a larger compensation payment. If an individual suspects that he will win, he could have reason to decrease his bid, to try to lose instead, if that compensation payment would result in more surplus for him than winning would.

To consider individual behavior under the mechanism more thoroughly, we can first theoretically examine the case of there being one person on each side as a normal-form game. Let the individuals involved in the dispute be player 1 and player 2, and let their values from winning be v_1 and v_2, respectively. Without loss of generality, assume that $v_1 \leq v_2$. The players' strategies will be their bids b_1 and b_2. To avoid losing meaningful equilibria, we will make the realistic assumption that money is discrete and that the smallest unit is ε (i.e. a penny, a molecule of salt, etc.).

Figure 1 illustrates the game. Player 1's strategies are the discrete quantities along the vertical axis, and player 2's strategies are the discrete quantities along the horizontal axis. The dashed forty-five degree line indicates outcomes where their bids are the same. The tie-breaking rule will be that each player wins with probability ½. For any outcome in region A, b_1 is greater than b_2, so 1 will win and pay 2 b_2. Similarly, 2 wins for outcomes in region B.

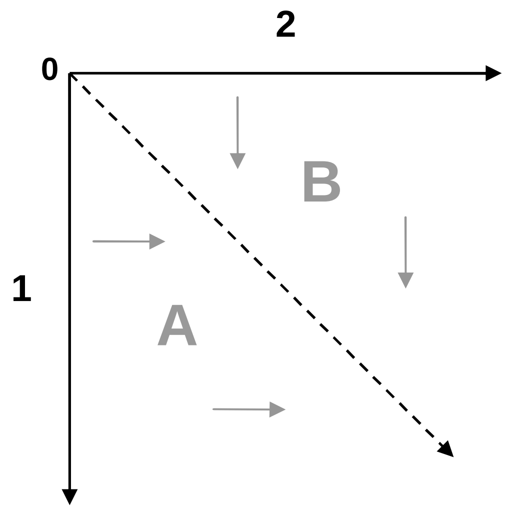

Figure 1: The Two-Player Game

Solving for the Nash equilibria, any outcome that is not on the diagonal or adjacent to the diagonal can immediately be ruled out. In such cases, the loser's bid is more than ε below the winner's bid. As such, she could necessarily do better by increasing her bid by ε. The grey arrows in Figure 1 indicate such movements. For example, if we are at an outcome in region B where b_1 = \$20 and b_2 = \$30, 1 could increase his compensation by 1¢ by changing his strategy to \$20.01.

Consider now the outcome *(b, b)* and other outcomes close to it, for any monetary quantity *b*. These outcomes are illustrated in Figure 2. Given that the bids are the same at outcome *(b, b)*, the tie-breaking rule will apply, and 1 have a 50% chance of winning and receiving v_1 while paying compensation *b* and a 50% of losing and receiving compensation *b*. Hence 1's expected payoff is $\frac{1}{2}(v_1 - b) + \frac{1}{2}b$, or, ${}^{v_1}\!/_2$. Similarly, 2 will receive ${}^{v_2}\!/_2$ at outcome *(b, b)*. Since this result holds for all *b*, all outcomes on the diagonal will have payoffs ${}^{v_1}\!/_2, {}^{v_2}\!/_2$. These outcomes are shaded in Figure 2. Below the diagonal, we are in region A, so 1 will receive v_1 minus 2's bid and 2 will receive her bid. Above the diagonal, we are in region B, so1 will receive his bid and 2 will receive v_2 minus 1's bid.

The arrows in Figure 2 follow the grey arrows in Figure 1. That is, below the diagonal, 2 would always be better to move one outcome to the right until the outcome is adjacent to the diagonal, and, above the diagonal, 1 would always be better to move down one outcome until the outcome is adjacent to the diagonal. The short line segments between cells in Figure 2 indicate cases where the player receives the same payoff from each of the two outcomes. In particular, any vertical moves by 1 below the diagonal will result in the exact same payoff for him, and any horizontal moves by 2 above the diagonal will result in the exact same payoff for her. This is because, regardless of these moves, the player would still win and still make the same compensation payment to the other player.

		2			
		b-ε	**b**	**b+ε**	**b+2ε**
	b-ε	$v_1/2$, $v_2/2$	b-ε, v_2-b+ε	b-ε, v_2-b+ε	b-ε, v_2-b+ε
	b	v_1-b+ε, b-ε	$v_1/2$, $v_2/2$	b, v_2-b	b, v_2-b
1	**b+ε**	v_1-b+ε, b-ε	v_1-b, b	$v_1/2$, $v_2/2$	b+ε, v_2-b-ε
	b+2ε	v_1-b+ε, b-ε	v_1-b, b	v_1-b-ε, b+ε	$v_1/2$, $v_2/2$

Figure 2: Outcomes Close to *(b, b)*

Consider an outcome adjacent to the diagonal that is immediately above the diagonal. Without loss of generality, consider *(b, b+ε)*. Is this outcome a Nash equilibrium? For 1, any move up will make him worse off and any move below *(b+2ε, b+ε)* will leave him with the same payoff that *(b+2ε, b+ε)* would. Hence, he will have no reason to change his strategy as long as $b \geq {}^{v_1}\!/_2$ and $b \geq v_1 - b - \varepsilon$. For 2, any move right will give her no increase in her payoff and any move to the left of *(b, b-ε)* will leave her worse off than she would be at *(b, b-ε)*. Hence, she will have no reason to change her strategy as long as $v_2 - b \geq {}^{v_2}\!/_2$ and $v_2 - b \geq b - \varepsilon$. All four of these inequalities are satisfied if and only if ${}^{v_1}\!/_2 \leq b \leq {}^{v_2}\!/_2$. That is, as long as the individual with the lower value makes a bid that is weakly between half of his value and half of the other individual's value and the other individual bids *ε* more than that, they will be at a Nash equilibrium.

Now consider outcome *(b, b)*, on the diagonal. 1 will have no reason to move to a cell above *(b, b)* as long as ${}^{v_1}\!/_2 \geq b - \varepsilon$, and he will have no reason to move to a cell below *(b, b)* as long as ${}^{v_1}\!/_2 \geq v_1 - b$. Hence, 1 has no reason to change his strategy when ${}^{v_1}\!/_2 \leq b \leq {}^{v_1}\!/_2 + \varepsilon$. Similarly, 2 will have no reason to move to a cell to the left of *(b, b)* as long as ${}^{v_2}\!/_2 \geq b - \varepsilon$, and she will have no reason to move to a cell to the right of *(b, b)* as long as $v_2/2 \geq v_2 - b$. Hence, 2 has no reason to change her strategy when $v_2/2 \leq b \leq v_2/2 + \varepsilon$. Since $v_1 \leq v_2$, a Nash equilibrium will occur if and only if $v_2/2 \leq b \leq v_1/2 + \varepsilon$. Note that this can only occur if v_1 and v_2 are quite close to each other. In particular, it must be the case that $v_2 - v_1 \leq 2\varepsilon$. Then, in such cases where the higher value is no more than 2ε above the lower value, up to two Nash equilibria can occur with both individuals making the same bid, where the bid in those equilibria must satisfy being weakly greater than half of the higher value and being weakly less than half of the lower value plus ε.

Lastly is the case of an outcome adjacent to the diagonal that is immediately below the diagonal. Without loss of generality, consider $(b+\varepsilon, b)$. 1 has no reason to change his strategy when $v_1 - b \geq v_1/2$ and $v_1 - b \geq b - \varepsilon$. 2 has no reason to change her strategy when $b \geq v_2/2$ and $b \geq v_2 - b - \varepsilon$. Nash equilibria will then occur if and only if $v_2/2 \leq b \leq v_1/2$. Note that this requires $v_2 \leq v_1$. By assumption we have that $v_1 \leq v_2$. Hence, Nash equilibria will require $v_1 = v_2$ with b equaling $v_1/2$ (as well as equaling $v_2/2$). Accordingly then, when the individuals' values are equal, an additional Nash equilibrium will occur with one individual bidding half of the values and the other individual bidding ε more than that.

There are a few aspects of these results to highlight. The first is that, of the three cases, only the first one will always apply. The equilibria from the second and third cases will only occur when the values are equal or quite close to equal. Second, the outcome will generally be efficient. That is, we generally will not have a situation where the individual with the strictly lower value is the winner. In the first case, the winner will always have a weakly higher value. It is only when the values are within 2ε of each other, but not equal, and we are at an equilibrium from the second case and the tie-breaking rule results in the individual with the lower value winning that we will fail to have an efficient outcome.

Third, there is a tendency for individuals to bid below their values. In the second and third cases, the individuals bid within ε of half of their values. In the first case, the individual with the higher value will bid no more than half her value plus ε, and she could bid substantially less than this depending on the other individual's value. The individual with the lower value in the first case could bid as low as half his value, but he could also possibly bid above his value if the other individual's value is more than double his. Fourth, it should be noted that all of the results will continue to hold even when b in Figure 2 is zero.

We have now two theoretical predictions for when there is just one person on each side. The first is for ending up at an efficient outcome, and the second is for individuals to tend to bid below their values. Recall that there were two ways that were discussed previously for how behavior could differ from what occurs in the second-price auction, one which would result in bids being increased and the other which would result in bids being decreased. The second theoretical prediction suggests that the way which would result in decreased bids is the stronger effect. That is, attempting to ensure losing to receive compensation is, on average, more important than trying to receive a larger compensation payment.

It should be noted however that with uncertainty about others' bids, the game-theoretic analysis we have carried out might be limited in its ability to fully predict individual behavior. Moreover, when there is more than one individual on each side, there is an additional way that behavior could differ from second-price auction behavior. This additional way derives from the fact that when a side wins, the payment that a member of that side will make will vary with the size of his bid. Accordingly then, an individual who suspects that his side will win could have reason to decrease his bid to try to decrease the payment that he would make. This is a standard free-riding problem where one might prefer for his side to win but he would also prefer that the compensation payments to the other side be made by members of his side other than himself.

Given uncertainty and multiple individuals on each side, the mechanism presented in this paper has similarities to the provision point mechanism. The discussion of the provision point mechanism here will assume a money-back guarantee and a proportional rebate following Rondeau, et al. (1999). With the provision point mechanism, a fixed amount of money is needed (the provision point) to fund some sort of public good. Voluntary contributions are accepted from individuals for the purpose of funding the good. If the contributions fail to provide the fixed amount of money, nothing is funded and all contributions are given back. On the other hand, if the provision point is met, the public good is funded with the fixed amount of money, and any excess funds are rebated to the contributors proportionally.

With the mechanism presented in this paper, for a given side, the sum of the bids from the other side can be thought of as a provision point. In addition, the bids from the members of the given side can be thought of as their contributions. If their bids/contributions fail to meet the provision point, that is, they lose, then they do not receive their outcome, and they do not make any payments. If their bids/contributions do meet the provision point, that is, they win, then they do receive their outcome, and they effectively receive proportional rebates of any funds that exceed the fixed amount by each only having to pay a portion of his or her bid. As such, there are close parallels between the provision point mechanism and the current mechanism. In addition, with the provision point mechanism, individuals face uncertainty about what others will contribute, and this uncertainty can affect their contribution decisions. The uncertainty with the current mechanism about others' bids has a similar effect on individuals' bid decisions.

Theoretical results for the provision point mechanism are presented in Marks and Croson (1998) and follow the results of Bagnoli and Lipman (1989). As long as there are sufficient benefits from the provision of the public good, Nash equilibria will exist where the sum of the individual contributions just meets the provision point and hence just funds the provision of the good. These results would suggest one side just outbidding the other side in the current mechanism, which we also saw in the theoretical results for the case of one individual on each side. Note that there also generally exist equilibria with the provision point mechanism where the provision point is not met and the good is not provided. The condition required for these equilibria is that it is in no individual's interest, based on the benefits that she will receive from the good, to unilaterally increase her contribution to make the total contributions reach the provision point.

Experimental results for the provision point mechanism provide evidence for how individuals will behave in the presence of uncertainty. Marks and Croson (1998) ran experiments with groups of five, where each individual had the same value for the public good being provided. The provision point mechanism was repeated 25 times for each group. Contributions averaged 49.8% of values, essentially averaging to just the provision point and fitting with the Nash prediction.

Rondeau, et al. (1999) ran experiments intended to match field conditions. These experiments were run with larger groups of around 50 subjects, and the provision point mechanism was carried out only once for each group. Subjects' values were heterogeneous, and each subject's value was unknown to the other subjects. Contributions in these experiments averaged to being close to subjects' values, with the average percentage of value contributed being 103.2%, 110.0%, 110.5%, and 132.2% across the experiments. None of these percentages are different from 100% at the 5% significance level. These experiments included cases where the provision point was unknown to the subjects at the time that they were making their contribution decisions. These cases match the uncertainty that occurs with the current mechanism with respect to not knowing the sum of the bids from the other side.

The laboratory experiments involving the provision point mechanism in Poe, et al. (2002) and used as part of a meta-analysis in Rondeau, et al. (2005) followed the conditions of Rondeau, et al. (1999). Across these experiments, the median percentage of value contributed varied from 60.0% to 100.0%. Spencer, et al. (2009) also followed the conditions of Rondeau, et al. (1999) and found contributions to average 106% of values. In addition, based on an econometric analysis, they suggest the provision point mechanism as defined for the current discussion to be empirically demand revealing at the individual level.

Although free-riding might be expected with the provision point mechanism given that it is used to fund public goods, we see it being not much of an issue in all but the first study discussed above. A key element to these results is the uncertainty that individuals face when making their decisions. In the first study, on the other hand, there is more information from the beginning with respect to what others' values are. Moreover, given that the mechanism is repeated, subjects gain additional information on others' contribution behavior. With the added information in these experiments, free-riding became a more pronounced issue as subjects engaged in what is essentially Nash behavior. Also to be noted with the first study is the relatively small group size. Rondeau, et al. (1999) found significantly smaller contributions in smaller groups, and Isaac, et al. (1994) found the same result in standard voluntary contributions public good experiments, without a provision point.

Given the similarities between the provision point mechanism and the mechanism presented in this paper, these experimental results can lead us to three predictions for the current mechanism. The first is for free-riding to not occur, on average, when individuals only participate in a single run of the mechanism and face other uncertainty. The second is for free-riding to become an issue when individuals participate in the mechanism repeatedly. And the third is for free-riding to be a worse issue in smaller groups.

It can be noted that the current mechanism does differ from the provision point mechanism in that an individual will receive compensation if his side's "provision point" is not met. This difference results, again, in the initial two ways for behavior to differ from second-price auction behavior. As such, theoretical results beyond those for the provision point mechanism, that will incorporate these two ways, are required for full theoretical predictions of behavior under the current mechanism.

Consider an individual who is deciding on a bid b to submit. Given uncertainty about others' bids, let her beliefs about the sum of the bids from other members of her side (x) be given by the cumulative distribution function $F(x)$, and let her beliefs about the sum of the bids from members of the other side (y) be given by the cumulative distribution function $G(y)$. Let the corresponding probability density functions be $f(x)$ and $g(y)$. Assume that the individual is an expected utility maximizer with Bernoulli utility function $u(\cdot)$ and initial wealth w.

When her side loses, the individual will be compensated with the amount of her bid and will receive $u(w+b)$. When her side wins, she will gain her value v. She will also pay a portion of her bid where that portion is equal to the total bids from the other side divided by the total bids from her side. Hence, when her side wins, given x and y, she will receive $u\left(w+v-\frac{y}{x+b}b\right)$. Noting that her side wins when $x + b > y$, we can find the individual's expected utility for any bid b. We could then attempt to solve for when her expected utility will be maximized by solving the following for b:

$$\frac{\partial}{\partial b}\left(\int_0^{\infty}\int_0^{x+b} f(x)g(y)u\left(w+v-\frac{y}{x+b}b\right)dydx+\int_0^{\infty}\int_{x+b}^{\infty} f(x)g(y)u(w+b)dydx\right)=0\,.$$

Unfortunately, and as might be expected, even with specifying explicit functions for $f(\cdot)$, $g(\cdot)$, and $u(\cdot)$, this expression cannot generally be solved for b. A key issue that arises comes from the $\frac{y}{x+b}$ term. With $x + b$ being in the denominator, when the antiderivative is taken with respect to x, we end up with terms involving the natural logarithm of a function of b. After differentiating with respect to b, such terms cannot be combined with terms that involve other functions of b to isolate and solve for b.

For this paper, we will solve two special cases that were discovered where the logarithmic terms do not show up, in order to provide some intuition for optimal bidding behavior under the mechanism. In the experimental section, we will also numerically calculate results for optimal behavior for the parameters that were used in the experiment. Additional theoretical work on optimal bidding behavior under the mechanism is left for future research.

First, consider the case where $u(a) = a$, x is uniformly distributed over $[j, k]$, and y is uniformly distributed over $[0, m]$. Note that the minimum value for y being zero is necessary for a solution for b here. The expression in this case then becomes

$$\frac{\partial}{\partial b}\left(\int_j^{k}\int_0^{x+b} \frac{1}{k-j}\frac{1}{m}\left(w+v-\frac{y}{x+b}b\right)dydx+\int_j^{k}\int_{x+b}^{m} \frac{1}{k-j}\frac{1}{m}(w+b)dydx\right)=0\,.$$

Taking the first integrals results in a cancelling of the $x + b$ term in the denominator. Then, taking the second integrals and differentiating yields

$$\frac{1}{k-j}\frac{1}{m}\left(vk - vj - \frac{k^2}{4} - bk + \frac{j^2}{4} + bj + mk - \frac{k^2}{2} - 2bk - mj + \frac{j^2}{2} + 2bj\right) = 0 .$$

Solving for b results in

$$b^* = \tfrac{1}{3}v + \tfrac{1}{3}m - \tfrac{1}{4}j - \tfrac{1}{4}k .$$

For the second case, let the individual be the only member of her side. j and k then are each zero. Let y now be uniformly distributed over $[l, m]$, and continue to let $u(a) = a$. The individual's probability of winning is now simply the probability that y is less than b (and greater than l) which equals $\frac{b-l}{m-l}$. Similarly, her probability of losing is $\frac{m-b}{m-l}$. When she wins, what she will expect to pay is just the expected value of the total bids from the other side, conditional on her winning. This expected value is just the midpoint between her bid and the minimum value for y, which equals $\frac{b+l}{2}$. Her expected utility then will be

$$\frac{b-l}{m-l}\left(w + v - \frac{b+l}{2}\right) + \frac{m-b}{m-l}(w+b).$$

Differentiating with respect to b and setting the expression equal to zero and then solving for b results in

$$b^* = \tfrac{1}{3}v + \tfrac{1}{3}m .$$

It should be noted here that these results only provide interior solutions. For example, in the first case, with an exceptionally large v, the individual should bid just high enough to ensure that her side wins. That is, she should bid $m - j$. Bidding higher than this will make her worse off since it cannot increase her probability of winning and it will increase the payment that she will have to make. However, our expression for b^* will indicate a bid higher than this amount. Similarly, in the second case, our expression for b^* could indicate a bid lower than l, but, in such a case, the individual would be better to make her bid be equal to l. She still would be assured of losing by bidding this amount, but she would receive more compensation. As such, our primary use for these results will lie in predicting the responses of interior bids to marginal changes in the different variables.

We can see that the expressions for b^* are quite similar between the two cases, in that the first case is just the second case with two additional terms. As such, we will first consider the second case, and then we will consider the additional two terms in the first case. For the second case then, with an increase in her value from winning, the individual will increase her bid, which will serve to increase her likelihood of receiving that increased value. Interestingly, though, the increase in her bid will be only a third of the increase in her value. This is because losing and receiving full compensation is a relatively good outcome for the individual. So, with a higher value, she has some increased preference for winning, but that increase is tempered by her preference for the outcome of losing. We do then as well gain a testable prediction for the mechanism from this result, which is simply for the change in bid divided by a corresponding change in value to equal ⅓.

Turning now to the term involving *m*, when the individual believes that bids from the other side will be higher, she will increase her bid. This serves to moderate the decrease in her probability of winning and to take advantage of higher compensation that she can receive from losing. Considering the first case now, the only difference from the second case is the addition of the two terms, which capture her free-riding behavior. In the second case, with there being no one else on her side, free-riding is not an issue, and, accordingly, these terms did not appear. These terms can be rewritten as $-\frac{1}{2}\frac{j+k}{2}$, that is, negative one half multiplied by her belief about the expected total bids from her side. When she believes that bids from her side will be higher, she will decrease her bid because her bid is less necessary for her side winning and the payment that she will have to make when her side does win will then be smaller. In addition, with a lower probability of losing, there is less reason to try to receive increased compensation, and, accordingly, less reason for her to submit relatively high bids. The predictions that come from these latter terms are less straightforward for testing since actual beliefs are unobserved. Still, qualitatively, they lead to the predictions that when an individual believes that other side is bidding more, he will bid more, and when he believes that his side is bidding more, he will bid less.

4. Experimental Results

4.1 Design

One experimental session that consisted of carrying out the mechanism 67 times was conducted with 18 subjects. All subjects were Hamilton College students, and they were recruited by emailing former students from introductory microeconomics courses and emailing a list of economics majors. Seven of the subjects were majors. The subjects were randomly divided into two sides which were called “Group A” and “Group B.”

Each run through the mechanism was considered one period. The first period was a practice period with no financial consequences that was intended to help subjects gain familiarity with the mechanism and the computer software. The experiment then consisted of two treatments. The first treatment lasted for 36 periods, and it involved there being 9 subjects in Group A and 9 subjects in Group B. The second treatment lasted for the remaining 30 periods, and it involved there being 6 subjects in Group A and 12 subjects in Group B. Subjects stayed with their group throughout the session except for the three subjects randomly chosen to switch from Group A to Group B at the beginning of the second treatment. The additional periods for the first treatment were provided both to give subjects additional learning opportunities while they were still becoming familiar with the mechanism and with the software and to try to avoid any end-of-experiment effects at the end of the second treatment.

Each period, each subject was given a value that he would receive if his side won. Each value was randomly selected from the whole numbers between \$6 and \$14, inclusive, and a value had an equal probability of being each of these nine numbers. Each subject then submitted a bid, which could be any non-negative dollar amount to two decimal places. With the subjects' bids, the mechanism was then carried out. That is, the total bids from each side were determined, each member of the losing side received her bid, and each member of the winning side received his value minus a payment that was calculated as is described above.

All subject interactions occurred using a computer software program that was written specifically for the experiment. The interface told subjects the group they were in, the current period, and their value for that period. The interface also provided subjects with a history of what had occurred in all previous periods. This history included, for each period, the subject's value, the subject's bid, the total bids from Group A, the total bids from Group B, and the subject's earnings. Lastly, the interface allowed subjects to submit a bid for the current period. The interface is shown in Figure 3.

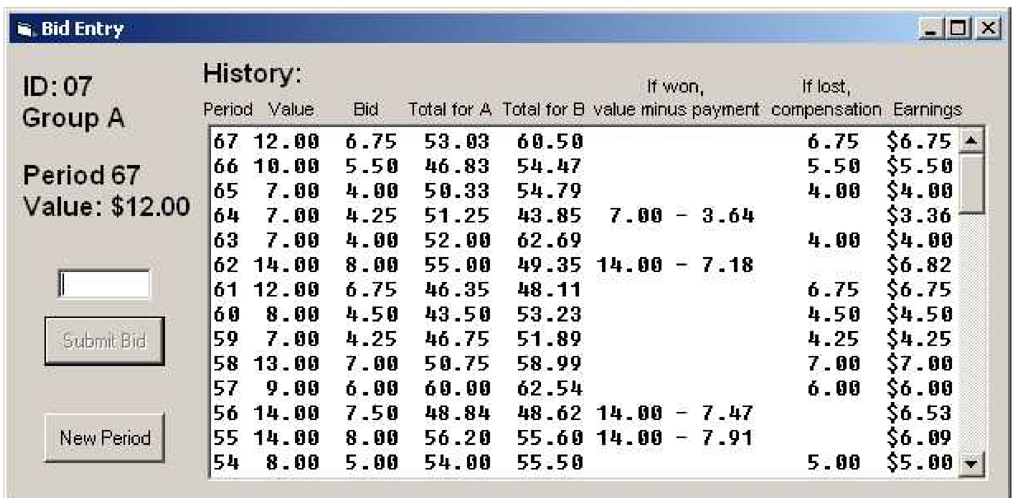

Figure 3: Subject Software Interface

When subjects arrived at the experiment, they were each assigned an ID number and given instructions to read. The instructions explained the mechanism and explained that there were the same number of individuals on each side. The instructions stated that there would be a second part to the experiment, but they did not provide any details about what would happen in that part. They also did not state how many periods there would be, only stating that there would be "many periods." The instructions told subjects that their dollar payment from the experiment would consist of a $4 show-up fee plus their earnings from one randomly selected period plus their earnings from a second randomly selected period.

After reading the instructions, subjects had the opportunity to ask questions. Then, the computer software was explained. Next, subjects completed the one practice period using the software and had the opportunity to ask questions about the software. Once there were no more questions, the official periods began. There was no talking between subjects while the experiment was being run. After all subjects had completed the 36th official period, it was explained that they would now be switching to the second part of the experiment. Subjects were told that the second part would be identical to the first part except that three randomly selected individuals from Group A would be switched to Group B, making the sides uneven. After all subjects had completed the

30th period of uneven sides, they were told that that was the end of the experiment. For the two randomly selected periods that subjects' payments would be based on, two rolls of a six-side die determined a period from the first treatment, and the die was similarly used to determine a period from the second treatment. Subjects were given their payments in cash before they left.

4.2 Learning

The experiment undoubtedly involved learning on the part of the subjects, and prior to the experiment, it was anticipated that early periods in each treatment would have particularly noisy data due to subject learning and could justifiably be removed from the data analysis. Upon examining the data, however, little was found that could provide a clear justification for the removal of any selection of early periods. There was some noise to the data throughout the experiment as different subjects occasionally experimented with different strategies, even in later periods, and the variance in bidding behavior in early periods was generally not markedly different from what was seen throughout all other periods.

The one exception, however, is the first two periods of the first treatment. Running single period regressions, the standard deviation of the error term was substantially greater for each of these two periods than for any other period of the treatment. Also, when period was included as a variable in regressions involving all periods of the treatment, it had a significant negative effect on bids, with a p-value less than 0.001, but this effect largely disappeared when the first two periods were removed from the regressions. Moreover, with a dummy variable for the first two periods included, it was found that there is a significant difference between bids in these periods and bids in other periods of the treatment, with the p-value being less than 0.001 and bids being $2.36 higher in the former.

Data analysis was accordingly carried out with these first two periods removed, but it was found that the results were essentially the same as they were without these periods removed. As such, and to avoid any semblance of data mining, no periods were removed from the first treatment for any of the results presented in this paper. For the second treatment, period had no statistically significant effect on bids for either Group A or Group B, and the standard deviation of the error term from single period regressions stayed roughly constant throughout the second treatment. As such, no periods were removed from the second treatment for any of the results presented in this paper either.

There is good reason to believe that learning was an important part of the experiment and that subjects did make better individual decisions over time. Evidence can be found by looking at the decisions of different individual subjects across time. However, without a clear case for removing any selection of periods that would significantly alter the results, all periods have been left in the analysis, again, partially to ensure that there does not appear to have been any data mining involved in the selection of periods for removal.

4.3 Group Results

In the game-theoretic results for the case of one player on each side without uncertainty, we arrived at a prediction for ending up at an efficient outcome. We can extend this prediction to the current experiment. Also, with the provision point mechanism, demand revelation was suggested from experiments that involved the mechanism being carried out just once, and Marks and Croson (1998) found subjects' contributions to average to essentially just the provision point in their experiments. Both of these imply a tendency for efficient public goods to be funded. Given the similarities between the provision point mechanism and the mechanism presented in this paper, we then could suspect that the mechanism presented here and implemented in the current experiment also has a tendency for arriving at an efficient outcome.

Of the 66 times that the mechanism was carried out following the practice period, 43 times the side with the higher total value won and the efficient outcome was achieved. This equals 65.2% of the time, and the null hypothesis of both sides being equally likely to win under the mechanism can be rejected with a p-value equal to 0.009. Moreover, there was not too much difference between the two treatments. In the first treatment, the side with the higher total value won 61.1% of the time, and in the second treatment, the side with the higher total value won 70.0% of the time.

4.4 First Period Results

The first official period of the current experiment is similar to a single run of the mechanism due to the fact that subjects had not had opportunities for learning. As such, examining subject behavior in this period can provide some assessment of our prediction for free-riding to not occur, on average, with a single run of the mechanism. Across the first treatment, the mean percentage of value that was bid was 71.1%, but in this first period of this treatment the mean percentage of value that was bid was 99.8%, with a standard deviation of 56.5%. Moreover, the median and the mode were both at 100% of value being bid.

We see then good evidence for free-riding not occurring, on average, with a single run of the mechanism. Moreover, given the drop in the percentage of value that was bid for later periods of the treatment, we also have evidence for our prediction for free-riding to become an issue when individuals participate in the mechanism repeatedly. The first period results fit closely with the results from the provision point mechanism being carried out just once, where, although some subjects' contributions were clearly above their values and other subjects' contributions were clearly below their values, contributions were on average approximately 100% of values.

Results related to a single run of the mechanism may be the most useful results for understanding what would happen with its implementation in real-world settings. Similar to the argument made in Rondeau, et al. (1999), if the mechanism presented in this paper were used to resolve a real-world dispute, it would, most likely, be carried out just once, and, accordingly, experimental results related to a single run of the mechanism would seem best for predicting what would happen in such situations. This paper from here, though, will explore results where subjects have had learning opportunities. The intent of this is to try to understand what Nash behavior would be under the mechanism, which may be interesting for its own sake and may be useful for predicting real-world behavior when the stakes are high enough for individuals to make especially careful bidding decisions. Future research may wish to further explore individual behavior in single-run environments.

4.5 Numerical Predictions

Given the difficulties with solving for optimal individual behavior in the most general case involving uncertainty, numerical results were calculated for optimal behavior under the parameters of the experiment. That is, in the numerical simulations that were run, each individual's value had an equal probability of being each of the whole numbers between \$6 and \$14. Moreover, in the first simulations, there were nine players on each side, and in the second simulations, there were six players on one side and twelve players on the other side.

The simulations solved for strategies, where a strategy simply specified what the player would bid for each of the nine values. To solve for a player's strategy, an assumption was made regarding the strategies of all other players. For example, it could have been assumed that all players bid one half of their values. Then, given all the possible combinations of values for the other players and given the probabilities of each of those combinations occurring and given what the total bids would be from each side, excluding the current player, from the bidding strategy assumption for each combination and given a value for the player, the simulations calculated what the expected payoff would be for the player from different possible bids.

For example, with eight other players on the player's side and nine players on the other side, with probability $(1/9)^{17}$ all other players have values equal to \$6 and, given the bidding strategy assumption, the total bids from each side can be calculated. Similarly, with probability $9 \cdot (1/9)^{17}$ all other players on the player's side have values equal to \$6, one player on the other side has a value equal to \$7, and all other players on the other side have values equal to \$6, and total bids from each side can also be calculated. With all of the different possible bid-totals and the probabilities of each of those occurring, a simulation would calculate the player's expected payoff for a given value and bid. Optimal strategies were found by finding, for each value, what bid would provide the highest expected payoff for the player.

In running the simulations, it was found that optimal strategies increased in value and were at least approximately linear. To keep the number of strategies to be tested in the simulations manageable, assumptions of non-linear strategies for the other players were avoided. Accordingly, a strategy in the simulations can then be fully represented by two numbers where the first number indicates the bid at a value of \$6 and the second indicates the bid at a value of \$14. Notation such as [5,7] will henceforth be used to represent strategies, where \$5 is the bid at \$6, \$7 is the bid at \$14, and the bids at the other values are determined linearly between \$5 and \$7.

The first simulations followed the parameters of first treatment of the experiment with nine subjects on each side, and they effectively solved for symmetric Nash equilibria. That is, with all other players playing a given strategy, is it optimal for the player to also play that strategy? An answer of "yes" would indicate that if all players were playing that strategy, no one would have reason to switch to a different strategy, and they would be at a Nash equilibrium. To avoid finding a potentially infinite number of equilibria, the simulations only tested strategies with whole number bids for \$6 and \$14. Two equilibria were found: all players playing [4,6] and all players playing [5,7].

The second simulations followed the parameters of second treatment of the experiment with six subjects on one side and twelve on the other, and they were more complicated than the first simulations. The equilibria that they solved for specified two strategies, one for Group A and the other for Group B, and they sought to find pairs of strategies such that no member of Group A would have reason to switch from her group's strategy while no member of Group B would have reason to switch from his group's strategy.

The simulations first tested whole number strategies, but no equilibria were found. Given feasibility issues with solving for the four numbers to specify the two strategies, where each strategy needed to be both consistent with itself and consistent with the other strategy, a procedure based on approximation was used. The strategies that a player could choose in response to what all others are doing were limited to whole number strategies. In addition, after specifying a strategy for one side, when searching for strategies for the other side, the bid at $14 was set to be $2 greater than the bid at $6. $2 was chosen for this range because optimal strategies that had been found had ranges that generally were close to $2.

The full procedure was then as follows. First, a whole number strategy was specified for one side. The reason for being limited to whole numbers strategies here is, again, to avoid finding a potentially infinite number of equilibria. Then, strategies for the other side were searched through, including non-whole number strategies, to find which of them would give players on the first side no reason to switch from their group's initial, specified strategy. Lastly, of all the strategies for the second side that met this criterion, was it the case for any of them that players on the second side would stick with a strategy that was approximately the same as that strategy? If so, then the strategy for the first side together with this strategy for the second side were considered an equilibrium.

Since the players were restricted to whole number strategies, "approximately the same" meant that each of the two numbers of the strategy that players would switch to was less than one away from the corresponding number of the group's initial strategy. With such strategies being approximately the same, there should exist a strategy, that is similar to these strategies, that the players would exactly stick with and that would still result in players from the first side sticking with their strategy. Because of the feasibility limitations, however, what will be reported here is simply the approximate equilibria. With Group A being the first side, five equilibria were found: {[5,7],[2.1,4.1]}, {[6,8],[2.6,4.6]}, {[7,9],[3.15,5.15]}, {[8,9],[3.4,5.4]}, and {[9,10],[3.93,5.93]}. With Group B being the first side, one equilibrium was found: {[6.7,8.7],[3,5]}. In all cases, Group A's strategy is listed first.

We gain from these numerical simulations predictions for behavior in the experiment. The first prediction is for bids to increase with values and for these bid increases to be less than their corresponding value increases. The same prediction was provided by earlier theoretical results. Across the simulations that were run, usually the difference in the optimal bid between a $6 value and a $14 value was $2, although sometimes it was $1 and on occasion it was $3. On average, though, we can predict for bid increases to be about ¼ of their corresponding value increases, which is not too different from our earlier theoretical prediction of ⅓.

The next predictions are for what bids will be at specific values under different conditions. For the first treatment, the prediction would be for the bid at $6 to be around $4 or $5 and for the bid at $14 to be around $6 or $7. For Group A in the second treatment, the prediction would be for the bid at $6 to be in the range of $5 to $9 and for the bid at $14 to be in the range of $7 to $10. For Group B in the second treatment, the prediction would be for the bid at $6 to be around $3 and for the bid at $14 to be around $5. Qualitatively, we can lastly predict from these simulation results that bids from Group A in the second treatment will be higher than bids in the first treatment and that bids from Group B in the second treatment will be lower than bids in the first treatment.

4.6 Individual Results

As a first, simple look at individual behavior, we can examine what the mean bid is for the different conditions across the different values. Figure 4 illustrates these mean bids. The black line represents the first treatment, when the sides were balanced, the light gray line represents Group A in the second treatment, and the dark gray line represents Group B in the second treatment.

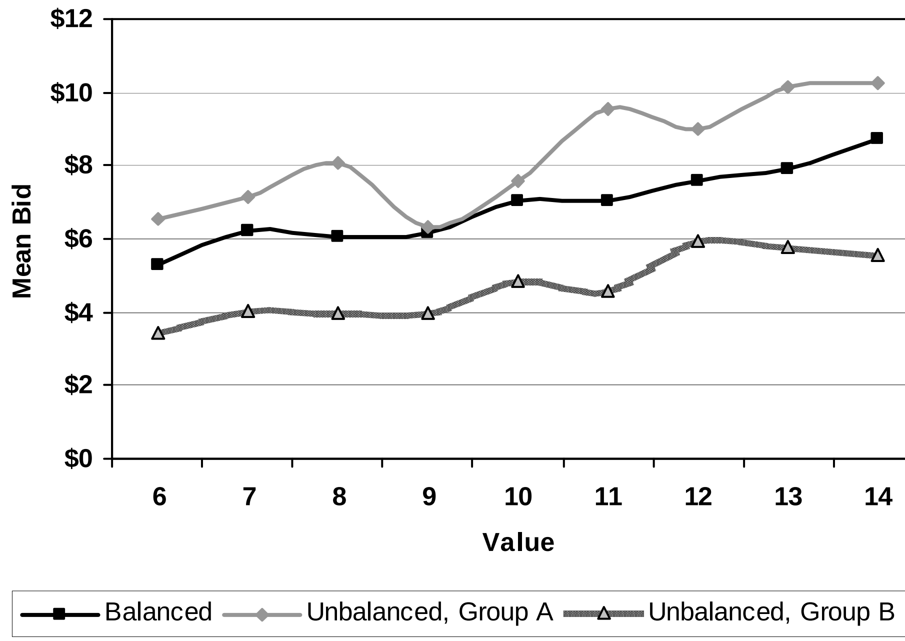

Figure 4: Mean Bid by Condition and Value

The different conditions vary in the number of observations that they contain, as the subjects in the balanced condition were split into the two groups for the second treatment and there were more subjects in Group B than in Group A. The number of observations is related to how noisy each relationship appears to be. For the Group A relationship, the number of observations for each value ranges from 14 to 28. For the Group B relationship, the number of observations for each value ranges from 33 to 46. For the relationship when the sides were balanced, which appears the closest to linear, the number of observations for each value ranges from 63 to 80.

This would suggest that the bumpiness seen, particularly in the Group A relationship, would diminish with more observations.

As predicted, bids did tend to increase with values. Also following predictions, Group A mean bids were always higher than mean bids in the balanced condition, and Group B mean bids were always lower than mean bids in the balanced condition. There was a tendency for mean bids to be around the high end of the quantitative predictions of the simulations. For the balanced condition, at $6, the mean bid was $5.30 while the prediction was for around $4 or $5, and at $14, the mean bid was $8.71 while the prediction was for around $6 or $7. For the Group A condition, at $6, the mean bid was $6.52 while the prediction was for $5 to $9, and at $14, the mean bid was $10.28 while the prediction was for $7 to $10. For the Group B condition, at $6, the mean bid was $3.46 while the prediction was for around $3, and at $14, the mean bid was $5.54 while the prediction was for around $5. These results are perhaps similar to the tendency for high bids in the second-price auction.

We will next turn to regression results for understanding individual behavior. The focus remains on understanding how subjects' bids depend on their values and on the condition they are in. An ordinary least squares regression was run where bid was regressed on value, a dummy variable indicating whether the bid was made in the Group A condition, a dummy variable indicating whether the bid was made in the Group B condition, and demographic characteristics. The demographic characteristics include a dummy variable indicating gender and a dummy variable indicating whether the subject was an economics major. A fixed effects regression was also run that excluded the demographic characteristics but included dummy variables for each subject. The coefficients estimated by the regressions can be found in Table 1.

We see that the coefficients from the OLS regression are quite similar to those from the fixed effects regression, with the fixed effects regression providing lower standard errors and accordingly more precise estimates. Value is found to have a significant effect on bid, and the coefficient is significantly less than one, following predictions. The theoretical prediction was for this coefficient to be ⅓, and ⅓ is within the 95% confidence interval of both estimates. However, the estimates are significantly greater than the prediction provided by the simulations of a coefficient of about ¼.

In the Group A condition, relative to the balanced condition, the other side would be expected to bid more, given its larger numbers, and one's own side would be expected to bid less, given its smaller numbers. From the theoretical predictions, both of these imply that one's optimal bid will be higher. Moreover, the simulations predicted higher bids in the Group A condition as well. Following these predictions, bids were found to be about $1.37 higher in this condition. In the Group B condition, relative to the balanced condition, the other side would be expected to bid less, and one's own side would be expected to bid more. These would both imply lower individual bids from the theoretical predictions, and the simulations also predicted lower bids in this condition. Following these predictions, bids in the Group B condition were found to be about $2.14 lower.

Variable	OLS	Individual Fixed Effects
Value	0.364 (0.033) *p<0.001*	0.372 (0.024) *p<0.001*
Unbalanced, Group A	1.362 (0.250) *p<0.001*	1.374 (0.215) *p<0.001*
Unbalanced, Group B	-2.140 (0.193) *p<0.001*	-2.146 (0.152) *p<0.001*
Male	0.702 (0.229) *p=0.002*	
Econ Major	0.982 (0.189) *p<0.001*	
Constant	2.310 (0.404) *p<0.001*	

Dependent variable is bid.
Standard errors are in parentheses.

Table 1: Regression Coefficients

From the OLS regression, the fourteen men bid about 70¢ more on average than the four women did. Also, the seven economics majors bid about 98¢ more on average than the eleven non-majors did. Not too much can be inferred from these differences given the small numbers of individuals in each group. However, a possible explanation for the difference between majors and non-majors is that majors are more likely to be exposed to topics like the second price auction that suggest bidding one's full value, and exposure to such topics could bias individuals in the direction of following those suggestions, even when in situations that are only similar. This bias would then result in bids that are closer to values, and, since bids were generally below values, it would accordingly result in bids that are higher than they would be otherwise.

As it turned out, 80.8% of bids were in fact below values, and the mean bid-to-value ratio was 0.662. These results follow the game-theoretic prediction from the case of one player on each side without uncertainty for individuals to tend to bid less than their values. However, for low values in the Group A condition, mean bids were greater than values. In these cases, the individual's side is likely to lose, and hence there is less incentive to underbid for free-riding purposes and also seemingly less incentive to underbid for purposes of trying to increase the odds of receiving compensation. On the other hand, given low values, there are incentives to overbid, to try to receive a more substantial compensation payment. Regressions were run that included interactions between each dummy variable and value, but none of the coefficients estimated for the interaction terms were significantly different from zero at conventional significance levels.

5. Conclusions

The mechanism presented in this paper provides a way to resolve disputes such that each person involved in the dispute could guarantee himself either the outcome he prefers at a cost less than his value for it or a full compensation payment for not having that preferred outcome. We saw that in the first period, subjects on average bid their value, which would provide that guarantee. This first period was similar to a single run of the mechanism, which is most likely how the mechanism would be carried out in practice. Moreover, these first period results fit closely with results from single runs of the provision point mechanism.

Across later periods, subject bids tended to follow theoretical predictions and also the predictions from numerical simulations. In particular, these bids were generally less than values. In addition, subjects followed predictions by bidding higher when the other side was expected to bid higher, by bidding lower when one's own side was expected to bid higher, and by increasing their bids in response to increases in value, with the bid increase being less than the value increase. With subjects choosing to bid something different from their value, this bid would make them, under standard assumptions, *ex ante* even better off than they would be with the guarantee.

We saw that the mechanism usually resulted in the efficient outcome being achieved. It did not always result in the efficient outcome, though. Still, even if the efficient outcome is not assured with the mechanism, its use for resolving disputes might nonetheless be highly desirable. As noted, on the individual level, each person can make herself be at least as well off as she would be with the guarantee. Moreover, on the group level, the mechanism provides an alternative to what typically happens with disputes – costly, wasteful batting between the two sides. Such battling is harmful to efficiency, and the mechanism can accordingly result in efficiency gains simply by avoiding these costs of typical dispute resolution, even in those cases where it fails to result in the efficient outcome. These efficiency gains ultimately stem from the fact that the losing side is able to be fully compensated for their loss, and, as such, a situation is created where, simply put, there is no need to fight.

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Experiment Instructions

You are about to participate in an experiment. The experiment will consist of many periods. In each period you will be able to submit a bid that either will result in a payment for you or will provide funding for an outcome that will be beneficial to you. Through your actions in the experiment, you will be able to earn real money.

Each participant in the experiment will be in one of two groups: Group A or Group B. There will be the same number of participants in each group. You will find out which group you are in once the experiment begins. Each group has an **outcome** that it would like to have happen. In each period, only one outcome will happen – either Group A will get its outcome or Group B will get its outcome but not both at the same time.

If your group's outcome happens in a given period, you will receive your **value** for that period. Your value will vary across the periods in the experiment, and each period it will be randomly chosen from the following:

\$6 \$7 \$8 \$9 \$10 \$11 \$12 \$13 \$14

Your value has an equal probability (11.1%) of being each of these in each period. The other participants will have their values for each period determined in the exact same way, and each of them will also similarly receive his or her value for a given period if his or her group's outcome happens in that period.

To determine which outcome will happen in a period, each participant will be able to submit a **bid**. After all bids are submitted, we will add up all the bids from Group A and add up all the bids from Group B, and whichever group has the greatest total bids will be the one to have its outcome happen for that period.

The members of this winning group will, however, make **payments** to the members of the losing group. Each member of the losing group will receive **compensation** which will be *equal to* the amount of his or her bid. The total payments from the members of the winning group will be just enough to fund the total compensation. More specifically, a winning group member's payment will be a portion of his or her bid as determined by the following:

$$Payment = \frac{Total\ bids\ \ from\ losers}{Total\ bids\ \ from\ winners} \cdot Bid$$

Note that since the total bids from the losers must be less than the total bids from the winners, *a winner's payment cannot be greater than his or her bid*.

An Illustrative Example

The following example will illustrate compensation, payments, and earnings for a given period.

Please note, the example bids and values are fictitious and are for illustration purposes only. They have no relevance to the experiment that you will be participating in.

Group A Bids	Group B Bids
01: \$200	04: \$320
02: \$240	05: \$360
03: \$280	06: \$400

Group A's total bids are \$720 and Group B's total bids are \$1080, so Group B will win and its outcome will happen for this period.

Since Group A does not win, the earnings for each Group A member will just be the compensation he or she receives. Recall that compensation equals the amount of that participant's bid, so 01 will earn \$200, 02 will earn \$240, and 03 will earn \$280.

Since Group B wins, the earnings for each Group B member will be his or her value minus his or her payment. Suppose that the value for 04 for this period is \$800, the value for 05 for this period is \$200, and the value for 06 for this period is \$500. Note that $(\$720/\$1080) = \frac{2}{3}$. Then, using the payment formula from the previous page, we can determine each participant's earnings.

$$
\begin{aligned}
&04\colon\ \$800 - \tfrac{2}{3}(\$320) = \$586.67 \\
&05\colon\ \$200 - \tfrac{2}{3}(\$360) = -\$40.00 \\
&06\colon\ \$500 - \tfrac{2}{3}(\$400) = \$233.33
\end{aligned}
$$

Structure of the Experiment

After completing many periods following what is described above, we will move to the second part of the experiment. Then we will determine which two periods of the experiment will be *implemented*.

Only two periods of the experiment will, in fact, matter for how much actual money you will make. More specifically, at the end of the experiment, we will randomly pick two of the periods, and the actual money that you will make in this experiment will be based precisely on what your earnings were in *those two periods*. At that point then, what happened in all other periods will not matter.

Because the actual money that you make will be determined as such, you are strongly advised to be quite careful with each of your decisions. This is because each decision that you make could end up being one of the two decisions that will be carried out.

Note that in addition to receiving your earnings from those two periods, you will also automatically receive a $4 show-up fee simply for participating today.

Final Details

There is to be no talking once the experiment has started. If you have a question, please raise your hand.

I will quickly review these instructions, explain the computer software we will use, and ask for any questions. We will then complete one practice period before beginning officially.