Adverse Selection in Conservation Auctions: Theoretical and Experimental Results

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Selected Paper prepared for presentation at the
Agricultural & Applied Economics Association 2010
AAEA,CAES, & WAEA Joint Annual Meeting, Denver, Colorado, July 25-27, 2010

Abstract

This paper evaluates land preservation and conservation programs by examining the performance of a discriminative auction that is often used to select parcels in the U.S. The paper hypothesizes that the auction is unlikely to be cost effective because an information asymmetry introduces adverse selection. Experiments are used to examine the extent of adverse selection and compare it to a baseline where no programs exist. Then, we examine the ability of two mechanisms to correct the incentive problem. The results show that adverse selection is likely to exist in conservation auctions (achieving just 60.7% of total possible social efficiency in the experiments) and that a mechanism can sort types so as to improve cost effectiveness with respect to the specific information asymmetry (90-92% of total social surplus). However, the mechanisms involve large transfers and the experiments show that a simple externality-correcting tax can achieve more cost effectiveness (99.4% of social efficiency) with lower transfers. This is an important result for policy because recent trends are focused on expanding fiscally costly auctions rather than taxes. The result also is surprising and important for researchers because there is little intuition as to why the tax resolves the selection problem.

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Owners of agricultural and natural lands make production decisions with implications beyond the nominal boundary of the pricing system. Erosion, nutrient loading, and groundwater depletion are representative of cost-shifting behavior, while benefit-conferring behavior arises from the provision of carbon sequestration and amenities such as scenic, open-space, and habitat. Over the past thirty years, institutions proliferated to offer these landowners incentives to abate cost shifting and to perpetuate benefit provision. For instance, the most recent U.S. Farm Bill (2008-2012) allocates $11.7 billion for conservation, while the E.U. plans to spend €35.4 billion between 2007 and 2013 on its "agri-environmental" programs.[1] In 2010 alone, the U.S. Department of Agriculture plans to spend $1.8 billion on rental payments under the Conservation Reserve Program (CRP) (USDA 2009). Beyond these expenditures, the U.S. federal government spends on average approximately $1 billion per year protecting endangered species (Langpap and Kerkvliet 2010), U.S. states and counties spent over $2 billion protection over 1 million acres with permanent agricultural conservation easements in 25 years (American Farmland Trust 2010), and 1,667 private U.S. land trusts protected 37 million acres through 2005 (Aldrich and Wyerman 2006). Governments outside the U.S. and E.U., governments also pursue conservation. Despite these large expenditures, conservation may be even more fiscally important in the future as policies are developed to pay farmers and natural landowners for carbon sequestration activities.

These programs transfer large quantities of tax dollars to landowners, and thus it is reasonable to ask: How well do these programs perform? We are particularly interested in the cost effectiveness of the auctions used to select parcels. The basic economics is simple. Institutions either create new conservation markets or alter prices within existing land markets to promote conservation ends. We know the inchoate efficiency arguments supporting such interventions: (1) they internalize externalities; (2) they bring the environment into the market

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[1] U.S. calculations based on data from Claassen R., Conservation Policy Briefing Room, Economic Research Service, U.S. Department of Agriculture. <http://www.ers.usda.gov/briefing/conservationpolicy/background.htm> accessed Feb. 2010. E.U. calculations based on data for Axis 2, Section 214, of the second pillar of the Common Agricultural Policy from: European Union Directorate-General for Agriculture and Rural Development, "Rural Development in the European Union: Statistical and Economic Information Report 2009." (EU, Brussels, 2009).

economy; and (3) auctions are used to select successful sellers because of funding constraints. Unfortunately, little evidence exists on whether these programs are efficient or whether they achieve social goals at the least cost. Previous work has identified a lack of coordination between the incentive created and the market failure (Duke and Lynch 2006), so it is unlikely that externalities are internalized correctly. The research presented here will show that these markets are unlikely to be cost effective because of incentive problems arising from information asymmetry.

This paper draws on the intuition in Akerlof (1970) to argue that conservation auctions are plagued by adverse selection and, in consequence, are not altering land-use patterns very much despite spending billions of dollars per year. In other words, these policies are transferring tens of billions of dollars from the government and nonprofits to landowners who were the most likely to deliver the conservation services in the absence of a policy. Among the drivers of this problem are the auction mechanisms used: (1) discriminative auctions that allow landowners to "name their price" and institutional constraints that force program managers to select the "cheapest"; and (2) the relatively small program budgets, which ensure that only a small subset of potential sellers will be selected. Although this story is straightforward, it has made little impact on the economic literature and there is no evidence we can find of an appreciable recognition of adverse selection in policy.

Wu and Babcock (1996) and Smith (1995) offered conceptual treatments of adverse selection in the conservation setting, comparing the status quo to second-best contracts offered by mechanism design. In the former papers, landowning sellers' private information about their reservation value drove the incentive problem, and Kirwan, Lubowski, and Roberts (2005) have offered empirical measures of these heterogeneous values using CRP auction data. Conservation auctions are often viewed as superior to fixed conservation payments because they "solve" some information problems—by paying heterogeneous owners by their individual offers—and as a way to conserve scarce government resources—by forcing owners to compete for limited budget expenditures. Auctions are used in many real-world settings, including the CRP, and some evidence suggests they outperform fixed price approaches (Horowitz, Lynch, and Stocking 2009) by supplying more acres of conservation.

Two key experimental studies exist. In Cason and Gangadharan (2004) the conservation buyer is posited to hold an information advantage—i.e., landowners do not know the environmental benefits of their land—and the lab results show that a discriminative auction outperforms a uniform-price auction. Schilizzi and Latacz-Lohmann (2007) use experiments to compare auctions to fixed price conservation, finding that the advantages of auctions erode as the conservation buyer and sellers interact over time.

In this paper, a model of conservation auctions is developed to describe the adverse selection phenomenon. The predicted adverse selection will then be replicated in the lab, and the efficiency of several different institutions will be compared to the status quo (discriminative auction, a price instrument, and a suite of screening contracts). We believe this is the first experimental examination of adverse selection in conservation auctions and is the first to compare the performance of discriminative auctions to a price instrument and to second-best contracts. The experimental results show that adverse selection can be replicated in the lab, suggesting it is indeed a problem in real-world discriminative auction settings. The results also show that the second-best contract outperform the discriminative auction under a full range of assumptions about the deadweight loss of government expenditures. Furthermore, the price instrument is found to outperform contracts.

1 The Model

Consider a market in which N individuals own land that is currently undeveloped and provides a positive social externality S in its undeveloped state. For structure, we focus on the case of a program to purchase permanent conservation easements, though the model should adapt to other conservation auctions. Each parcel has a private development value $\sigma_i D$ in a competitive commercial real estate market where D is a common development parameter, and σ_i is a site specific development parameter. The value of σ_i is private information to the owner and can be ascertained by a developer prior to purchase, but is not easily observed by the government. The value $\sigma_i D$ represents the price the owner can obtain by selling the parcel to a developer. In its undeveloped state the property provides the current owner a positive land return f which is common to all parcels, as well as a private utility with a dollar value of $\sqrt{zv_i}$ where

z is a utility parameter common to all owners and v_i is an owner specific utility parameter. We assume that it is possible for the government to change the owner's private utility through changes in z which impose the same cost on the government regardless of the parcel, but which will have different marginal effects on the landowner's private utility value depending upon v_i. In particular, because $d^2\sqrt{zv_i}/dv_i dz = 1/\left(4\sqrt{zv_i}\right) > 0$ and $d^3\sqrt{zv_i}/dv_i dz^2 < 0$, the impact of a change in z on marginal utility is greater for a landowner with a higher private value v_i but is decreasing in z. Each parcel is characterized by a parameter pair $\{\sigma_i, v_i\}$. The government knows the set of $\{\sigma_i, v_i\}$ pairs, but is unable to determine the particular parcel to which a specific $\{\sigma_i, v_i\}$ pair is assigned -- each landowner's $\{\sigma_i, v_i\}$ is private information.

In the absence of any program to purchase development rights, a landowner will retain the property in its undeveloped state if $f + \sqrt{zv_i} \geq \sigma_i D$ and will sell to a developer if $\sigma_i D > f + \sqrt{zv_i}$. The equation

$$\sigma_i = \frac{f + \sqrt{zv_i}}{D} \equiv \underline{\sigma}_i \tag{1}$$

defines a boundary such that in the absence of any program to purchase development rights in order to preserve undeveloped land, any property characterized by a $\{\sigma_i, v_i\}$ that lies above this boundary will be sold to a developer, and any parcel below the boundary will be preserved. It is clear that a market with no preservation program is not optimal because of the social externality S. In particular, it is socially optimal for a parcel to be preserved if $\sqrt{zv_i} + f + S \geq \sigma_i D$ and to be developed if $\sigma_i D > \sqrt{zv_i} + f + S$. This implies a second boundary

$$\sigma_i = \frac{f + S + \sqrt{zv_i}}{D} \equiv \overline{\sigma}_i \tag{2}$$

such that it is socially optimal for any parcel characterized by a pair $\{\sigma_i, v_i\}$ that lies above this boundary to be developed and for any parcel that lies below this boundary to be preserved. These boundary conditions, presented in Figure 1, can be used to classify each parcel into one of three categories. We define type 1 parcels (or land owners) as those satisfying $\sigma_i < \underline{\sigma}_i$, type 2 parcels as those satisfying $\underline{\sigma}_i \le \sigma_i \le \overline{\sigma}_i$, and type 3 parcels as those satisfying $\sigma_i > \overline{\sigma}_i$. It is socially optimal for type 1 and type 2 parcels to be preserved and for type 3 parcels to be developed. However, in the absence of a preservation program, the socially optimal outcome will only occur for type 1 and type 3 parcels. The type 2 parcels, for which $S + f > \sigma_i D - \sqrt{zv_i} > f$, will be sold to a developer despite the fact that preservation of these parcels is socially optimal. These parcels are a primary target of land preservation programs which purchase development rights from landowners.

1.1 Allocation using an auction mechanism with a budget constraint

In this subsection we consider the use of an auction mechanism to purchase development rights from landowners when the state has a limited budget for the program. Under the auction mechanism the government announces the amount E allocated to the auction and invites the N landowners to participate. Each participant submits a bid b_i that he is willing to accept in return for transferring development rights to his land to the state. If the bid is accepted, then the state gains control of the development rights. If it is not accepted, then the owner retains his private value. Assume that in the absence of an auction program there are n_1 type 1 parcels, n_2 type 2 parcels, and $n_3 = N - n_1 - n_2$ type 3 parcels.[2]

For any expenditure E announced by the government, any landowner for whom the price $\sigma_i D$ offered by a developer is less than the price that the state pays in the auction will prefer to sell development rights to the state. This is true regardless of whether or not the owner is willing to sell to a developer. Owners for whom $\sigma_i D \le f + \sqrt{zv_i}$ (the type 1 owners) are willing to sell to the state at any price. Owners for whom $\sigma_i D > f + \sqrt{zv_i}$ (those above the boundary defined by equation (2) will only sell to the state instead of a developer at a bid b_i such that

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[2]If we suppose that v is distributed over some interval $[0, \bar{v}]$ and that σ is distributed over some interval $[\underline{\sigma}, \overline{\sigma}]$ and let $g(v,\sigma)$ be the joint probability density function for the random variables v and σ, then $n_1 = N\int_0^{\bar{v}}\int_{\underline{\sigma}}^{(f+\sqrt{zv})/D} g(v,\sigma)\,d\sigma\,dv$, $n_2 = N\int_0^{\bar{v}}\int_{\underline{\sigma}}^{(f+S+\sqrt{zv})/D} g(v,\sigma)\,d\sigma\,dv - n_1$, and $n_3 = N - n_1 - n_2$.

$b_i + f + \sqrt{zv_i} \geq \sigma_i D$ or $b_i \geq \sigma_i D - f - \sqrt{zv_i}$. Define $\underline{b}_i$ as the lowest bid that would induce owner i to sell development rights to the state. Note that if $\sigma_i D < f + \sqrt{zv_i}$, so the price offered by the developer is less than the owners utility from preserving the parcel, then the owner is willing to transfer rights to the state at any bid greater than 0. Thus, $\underline{b}_i = \max\{0, \sigma_i D - f - \sqrt{zv_i}\}$.

Note that in equilibrium all winning bidders must submit the same equilibrium bid $\tilde{b}$, and this bid must satisfy $\tilde{b}n_w = E$, where n_w is the number of winning bidders. The claim that all successful bidders must submit the same bid $\tilde{b}$ follows from the fact that if two owners with bids b_i and b_j, where $b_i > b_j$, are both successful in the auction, then bidder j could have submitted a higher bid and still been successful, so b_j was not an equilibrium bid. The claim that $\tilde{b}n_w = E$ follows from the fact that if $\tilde{b}n_w < E$, then any one of the winning bidders would still have won with a bid of $\tilde{b} + \varepsilon$ for some small $\varepsilon > 0$. In addition, the type 1 owners all will be successful bidders in any equilibrium. Because the type 1 owners are willing to sell development rights to the state at any equilibrium bid $b > 0$, they will always submit the equilibrium bid $\tilde{b}$.

Given the known owner types, we can order the bidders according to the minimum amount $\underline{b}_i$ each would accept in in the auction where $\underline{b}_i = 0$ for the n_1 type 1 bidders. Ordering owners from the lowest to highest minimum acceptable bids, we have

$$0 = \underline{b}_1 = \underline{b}_2 = \cdots = b_{n_1} < \underline{b}_{n_1+1} \leq \underline{b}_{n_1+2} \leq \cdots \leq \underline{b}_{n_1+n_2} < \underline{b}_{n_1+n_2+1} \leq \cdots \leq \underline{b}_N.$$

Proposition 1

1. If $E < (n_1 + 1)\underline{b}_{n_1+1}$, then the equilibrium bid $\tilde{b} = E/n_1$, and only the n_1 type 1 owners who would not have developed their parcel in the absence of a program will sell their development rights to the state.

2. If $(n_1+1)\underline{b}_{n_1+1} \le E < (n_1+1+k)\underline{b}_{n_1+1+k}$, where k is an integer satisfying $n_2 \ge k \ge 1$, then $\tilde{b} = E/(n_1+k)$ and the first k of the type 2 bidders as well as all of the n_1 type 1 bidders sell their development rights to the state.

3. If $(n_1+n_2+1)\underline{b}_{n_1+n_2+1} \le E < (n_1+n_2+1+k)\underline{b}_{n_1+n_2+1+k}$, where k is an integer satisfying $n_3 \ge k \ge 1$, then $\tilde{b} = E/(n_1+n_2+k)$ and the first k of the type 3 owners and all of the type 1 and type 2 owners sell their development rights to the state.

4. If $E \ge N\underline{b}_N$, then the equilibrium bid is $\tilde{b} = E/N$, and all owners sell development rights to the state.

Proposition 1 illustrates the adverse selection problem inherent in the use of an auction to purchase development rights. In any auction equilibrium, the n_1 owners who would not develop their property in the absence of an auction are always included in the set of successful bidders. These owners drive up the minimum expenditure required by the government to preserve properties that would not be preserved in the absence of a government program. Furthermore, any increase in the budget amount E will increase the winning bid received by these owners -- the increase in E will not necessarily lead to an increase in the number of parcels preserved. An example of this is provided in the discussion of the experimental design in section 2 below.

1.2 Screening Mechanism

In this section we consider the use of a screening mechanism as a means of improving upon the auction mechanism in the government effort to preserve undeveloped land. It is well known that screening mechanisms are ideally suited for addressing adverse selection problems (see Riley (2001) for a survey of the literature). We consider screening contracts of the form $\{p,t\}$ where $p \in \mathbb{R}$ is a direct payment to the owner (or payment from the owner to the state if $p < 0$), and $t \in -z,\infty)$ is an adjustment to z which impacts the owners preservation value. In particular, if an owner agrees to transfer development rights to the state in return for a contract $\{p,t\}$, then the owner's utility is $u_i = f + p + \sqrt{(z+t)v_i}$.

It is helpful to compare our setting with a standard screening model in which an employer is interested in sorting workers by ability level in a way that excludes the lowest skilled workers, and then pays all higher skilled workers a wage that is increasing in the workers skill level, and avoids outcomes in which lower skilled workers opt for a contract intended for higher skilled workers. The standard assumption that the marginal cost of education is decreasing in the worker's innate ability level generates a single crossing property which ensures that observable education levels serve to screen workers by ability level. An important feature of these models is the fact that the firm wishes to include all workers whose skill level exceeds some minimum. In our model, the owner's private preservation parameter v_i is analogous to the negative of skill level in the classic job market screening context, and changes to the parameter z by an amount t are analogous to the negative of education. As noted earlier, we also assume that the state can impact the owner's private preservation value by altering the parameter z. Because reductions in z are more costly and increases in z are more beneficial to an owner owners with a higher v_i, the individual utility functions satisfy a single crossing property so that contracts offering $\{p,t\}$ pairs can be used to screen different owners. The complication in our land allocation setting when compared with the standard job market screening model is that the state wishes to exclude owners with very low reservation values (low v_i and σ_i) as well as those with very high reservation values Thus, for two owners with identical preservation values, v_i, (analogously, identical skill levels), it is possible that it is optimal for the state to include one and exclude the other from participation in the program.

For a given owner i the reservation utility level from not accepting a contract offered by the state is

$$\underline{U} = \max\left\{f + \sqrt{zv_i}, \sigma_i D\right\} \tag{3}$$

Ideally, the contracts would offer both the type 1 and type 3 owners a utility less than $\underline{U}$ while attracting type 2 owners to preserve their property instead of selling to a developer. Let B

denote the set of owners who choose to sell to a developer, let C denote the set of owners who accept one of the contracts in return for transferring development rights to the state, and let R denote the set of owners who refuse both the developer's offer and the state contract. The state's objective is to choose a set of m different contracts $\{p,t\} = \left\{\{p_1,t_1\},\ldots,\{p_m,t_m\}\right\}$ which maximizes total welfare $W,$ where

$$W \equiv \sum_{i\in B}\sigma_i D + \sum_{i\in C}\left(f + S + p_j^i + \sqrt{\left(z+t_j^i\right)v_i} - c\left(p_j^i,t_j^i\right)\right) + \sum_{i\in R}\left(f + S + \sqrt{zv_i}\right)$$

subject to

$$\begin{array}{lll} i \in B & if & \sigma_i D > \max\left\{f + p_j^i + \sqrt{\left(z+t_j^i\right)v_i}, f + \sqrt{zv_i}\right\} \\ i \in C & if & f + p_j^i + \sqrt{\left(z+t_j^i\right)v_i} \geq \max\left\{\sigma_i D, f + \sqrt{zv_i}\right\} \\ i \in R & if & f + \sqrt{zv_i} > \max\left\{\sigma_i D, f + p_j^i + \sqrt{\left(z+t_j^i\right)v_i}\right\} \end{array}$$

where $\{p_j^i,t_j^i\} \in \{p,t\}$ is the contract choice that maximizes owner i's payoff given he accepts a contract, and $c\left(p_j^i,t_j^i\right)$ is the cost to the government of implementing the contract $\{p_j^i,t_j^i\}$. It is clear that a screening mechanism at least weakly dominates an auction because the government can always adopt the contract set $\{p,t\} = \left\{\{\tilde{b},0\}\right\}$ which simply offers to purchase development rights from any landowner willing to sell to the state at the equilibrium bid $\tilde{b}$ for the auction. Such contracts would result in the same outcome achieved by the auction. Thus we have

Proposition 2 *The use of screening contracts dominates the use of an auction as a mechanism for purchasing development rights in order to preserve undeveloped parcels.*

While it is easy to see that screening contracts at least weakly dominate the auction, it is not obvious that they strictly dominate the auction. However, by using differences in each owner's private land preferences $\sqrt{zv_i}$ the government may be able to improve upon the auction mechanism with contracts that separate different land owners. The fact that the marginal benefit of the contract parameter t is increasing in the owner's private preservation value v_i implies that for a given σ_i, a single crossing property holds for owners with different v_i values. An owner's indifference curve from accepting a contract is defined by the set of contracts $\{\hat{p},\hat{t}\}$ satisfying $f+\hat{p}+\sqrt{(z+\hat{t})v_i}=K$ where K is an arbitrary constant. Restating the indifference curve in $\{p,t\}$ space, we have

$$\hat{p}=K-f-\sqrt{(z+\hat{t})v_i}.$$

Thus, the slope of an indifference curve is increasing in v_i. This implies that for a given σ_i, standard results in the screening literature apply, and owners can be sorted by contracts. However, the screening contracts are still subject to an adverse selection problem because it is possible that owners with the same v_i parameter will have different development parameters σ_i. The adverse selection problem arises because type 1 owners, who have lower σ_i values than type 2 owners with the same v_i parameter, participate in the program even though no program is needed to induce them to preserve their property. This presents a problem for screening contracts because any contract preferred over selling to a developer by a type 2 owner with a given v_i also will be preferred over not participating in the program by a type 1 owner with the same v_i. Thus, the screening contracts cannot be used to exclude type 1 owners from participating. However, because owner preferences satisfy the single crossing property with respect to t, screening contracts can be used to separate owners with different v_i parameters.

Incentive compatibility constraints require that type 1 owners do not participate, type 2 owners participate, and type 3 owners sell to a developer. Using the boundaries derived in the previous subsection these constraints can be stated as

$$
\begin{aligned}
f + \sqrt{zv_i} &> f + p_j^{i^*} + \sqrt{\left(z + t_j^{i^*}\right)v_i} && \text{if} \quad \sigma_i D \le f + \sqrt{zv_i} \\
f + p_j^{i^*} + \sqrt{\left(z + t_j^{i^*}\right)v_i} &> \sigma_i D && \text{if} \quad f + S + \sqrt{zv_i} > \sigma_i D > f + \sqrt{zv_i} \\
\sigma_i D &> f + p_j^{i^*} + \sqrt{\left(z + t_j^{i^*}\right)v_i} && \text{if} \quad \sigma_i D > f + S + \sqrt{zv_i}.
\end{aligned}
$$

In general contracts satisfying these constraints for at least some owners can be established, generating an outcome that is less subject to adverse selection than the auction.

1.3 A Simple Taxation Mechanism

The adverse selection problem associated with mechanisms through which development rights are purchased arises because they shift the lower boundary defined by equation ( ) upwards and are therefore attractive to both type 1 and type 2 owners. As an alternative to purchasing development rights, a policy which reduces the sellers return $\sigma_i D$ to $\tilde{\sigma}_i D$ such that

$$\tilde{\sigma}_i D \le f + \sqrt{zv_i} \text{ if } \sigma_i D \le f + S + \sqrt{zv_i}, \text{ and}$$

$$\tilde{\sigma}_i D > f + \sqrt{zv_i} \text{ if } \sigma_i D > f + S + \sqrt{zv_i}.$$

also would ensure efficient allocation of each parcel. These equations imply that

$$\tilde{\sigma}_i D \le f + \sqrt{zv_i} \text{ if } \sigma_i D - S \le f + \sqrt{zv_i}, \text{ and}$$

$$\tilde{\sigma}_i D > f + \sqrt{zv_i} \text{ if } \sigma_i D - S > f + \sqrt{zv_i}.$$

This is satisfied by any policy such that $\tilde{\sigma}_i D = \sigma_i D - S$ or $\tilde{\sigma}_i = \sigma_i - S/D$. Because this policy is independent of the owner's private preservation value v_i, any policy which reduces the private development value σ_i of the owner by the amount S/D will result in the efficient development and preservation outcomes for all parcels.

A simple tax can be implemented to achieve this result. In particular, let t_i be the tax rate imposed on the sale price if owner i 's parcel is sold to a developer. The owner's return from sale is $\sigma_i D(1-t_i)$. Setting the tax rate so that this return equals the sellers return $\tilde{\sigma}_i D$ achieved under the optimal policy yields

$$\sigma_i D(1-t_i) = \tilde{\sigma}_i D$$

$$= (\sigma_i - S/D)D.$$

Solving for the optimal tax policy yields $t_i^* = S/\sigma_i D$. Noting that $\sigma_i D$ is the price the developer is willing to pay for the parcel, it follows that the optimal total tax $t_i^* \sigma_i D$ for any parcel i is S. A flat tax of S imposed on the sale of any parcel to a developer results in only those parcels for which the value of the parcel in development exceeds the total social value from preservation being sold to a developer. Such a flat tax will successfully screen owners by causing each owner to fully internalize the social cost of selling to a developer. Of course, this is just the well-known Pigouvian tax.

In the market for development rights, government programs which pay landowners to preserve their land, effectively assigning the social surplus to the owner and paying the owner for providing that surplus to society are subject to an adverse selection problem in which the state pays some landowners for services that would have been provided even in the absence of the government program. With a fixed government budget allocated to make payments to owners for this surplus, the resulting outcome is not economically efficient. The inefficiency is greatest under the auction mechanism, and can be mitigated, but not eliminated using screening contracts. However, if rights to the social surplus are assigned to the state, and owners (or developers) are penalized for destruction of social surplus, then the socially efficient outcome can be achieved through a tax in the amount of the social surplus destroyed.[3]

[3]Note that if the government faces no budget constraint, then the assignment of rights to the social surplus is irrelevant á la Coase. The auction with a budget of $E = (n_1 + n_2)S$ results in an equilibrium bid of $\tilde{b} = S$. Under

2 Experimental Design

2.1 Experiment Parameters

To test the predictions of the theoretical models, we conduct economic experiments using parameters that reflect possible land, development and private preservation values with twelve landowners distributed symmetrically over (σ, v) space. We use three different development values, $\sigma_i \in (.25,.5,.75)$, and four different private preservation values $v_i \in (0,1,2,3)$, which results in twelve different owner types presented in Table 1.

We assign a land use value of $f = \$300$ and a development value of $D = \$20{,}000$ to all properties. This implies that in our experiment, the developer will make an offer of $\$5000$ to owners 1-4, of $\$10{,}000$ to owners 5-7, and of $\$15{,}000$ to owners 9-12. The social surplus of each parcel is set at $S = \$10{,}000$, and the parameter $z = 400{,}000$. This implies that owner land preservation utility values, $\sqrt{zv_i}$ range from 0 to $\$3464$, with an average of $\$2073$, and that an owner's overall utility $U_i = f + \sqrt{zv_i}$ from his parcel ranges from 3000 to 6464.

Below one may see the socially optimal allocation of each parcel as well as the expected allocation in the absence of any program to purchase development rights. The outcome is denoted P if the property is preserved and D if the property is developed.

Parcel Allocation	1	2	3	4	5	6	7	8	9	10	11	12
No Program	D	P	P	P	D	D	P	P	D	D	D	D
Socially Optimal	P	P	P	P	P	P	P	P	D	P	P	P

The typical development value for an acre of agricultural land varies widely depending upon property characteristics. However, the average capitalized value is in the $7,000 range.

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such a program, any owner for whom $f + S + \sqrt{zv_i} \geq \sigma_i D$ will sell development rights to the government while those for whom $\sigma_i D > f + S + \sqrt{zv_i}$ will sell to a developer. This is the socially optimal allocation.

The typical capitalized revenue from agricultural use is \$3,000. In the experiment we consider a market in which the parameters of each of the twelve owners are known, but the mechanism designer is unable to observe the parameters of any specific landowner. The preference and development parameters are held constant across all rounds.

2.2 The Auction Mechanism

Under the auction mechanism, each owner must choose between one of three alternatives. They can keep their property, which yields a utility of $U_i = f + \sqrt{zv_i}$, sell to a developer at a price of $\sigma_i D$, or submit a bid b_i in the auction which yields a utility of $U_i = f + b_i + \sqrt{zv_i}$ if the bid is accepted, and a utility of $U_i = f + \sqrt{zv_i}$ if the bid is rejected. As demonstrated in Section 1.1, the equilibrium bid and successful biders are determined by the budget E. To select this budget, we determined the dollar amount that would generate the largest marginal contribution to total welfare. In order for the auction to preserve land that would otherwise be developed, a budget of at least $E = 4050$ is needed. This is obtained by subtracting the utility $f + \sqrt{zv_i}$ obtained by not developing parcel i from the development offer $\sigma_i D$ to determine the minimum bid each owner would be willing to accept in return for transferring development rights to the state. This value is negative for owners 2-4, 7 and 8 (five of the twelve owners). The surplus generated by inducing a type 2 (or 3) owner to sell development rights to the state instead of a developer is equal to the difference between the surplus $f + S + \sqrt{zv_i}$ generated by preserving the land and the development value $\sigma_i D$. The surplus gained from participation by a type 1 owner is 0. The minimum bid and auction surplus values are presented below. Owner types are ordered by minimum bid.

Subject	2	3	4	7	8	6	12	1	11	10	5	9
$\underline{b}_i$	0	0	0	0	0	675	1046	2000	3056	5675	7000	12000
Auction Surplus	-	-	-	-	0	9325	8954	8000	6944	4325	3000	-2000

Using the analysis from Section 1.1 we can determine the expenditure E needed to include each owner as a successful bidder in the equilibrium of the auction. A minimal expenditure is needed to induce owners 2-4 and 6-7 to participate because they are willing to sell development rights to the state at any bid greater than 0. To induce the next owner (of parcel 6) to participate, a minimum bid of $\$675$ must be paid to six bidders (owners 2-4, 7, 8 and 6) which implies a total expenditure of $E = \$4050$. Including the next owner (of parcel 12) requires an expenditure of $E = 7 * \$1046 = \$7322$. An increase in the expenditure of $\$3272$ generates an additional surplus of $\$8954$. Including the next owner (of parcel 1) requires an expenditure of $E = 8 * \$2000 = \$16,000$ or an increase of $\$16,000 - \$7322 = \$867$ and generates an increase in surplus of $\$8000$. Adding owner 1 to the set of successful bidders in equilibrium requires an increase in the auction expenditure which exceeds the benefit. Therefore, in our experiment, we limit our auction budget to an amount such that only seven owners (2-4, 6-8, and 12) are successful bidders in the predicted equilibrium. For reasons discussed above, we set an auction budget of $8535 in the experiment.

2.3 The Screening Mechanism

The screening mechanism allows for separating owners using contracts that take advantage of differences in each owner's marginal rate of substitution between a fixed payment p_i and a change t_i to the property that enhances or reduces the private preservation utility parameter z. The inability to separate owners with the same v_i discussed in Section 1.2 prevents the complete separation of owners using screening contracts. In the screening treatment of our experiment we offer the subjects a choice between three contracts. The first contract $C_1 = \{2050, -300000\}$ offers a fixed payment of 2050 to any owner who is willing to accept a reduction in z of 30. The reduction in z can be interpreted as allowing public access to the owners land which significantly reduces the private preservation utility for subjects 5-12 (those with $v_i > 0$), but has not impact on the utility of subjects 1-4 who place no value of preservation of the land. We assume the cost $c(2050, -300000) = \$2050$ requiring the owner to allow public access imposes no incremental cost on the state. The second contract $C_2 = \{700, 0\}$ offers a payment of $\$700$ with no change in the owner's private preservation value. The cost $c(700, 0) = \$700$. Finally, under the third contract $C_3 = \{-2000, 260000\}$ the government significantly improves the owner's private preservation value in return for a payment of $2000 from the owner. Because the third contract entails increasing the owner's total utility through the private utility parameter $\sqrt{(z+t_j)v_i}$, the cost of this contract is not a straightforward fixed payment. We (somewhat arbitrarily) assume that the cost of this contract is equal to 1.1 times the change in total utility achieved by this contract for a subject with $v_i = 300$. The $v_i = 300$ subjects all should prefer this contract over selling to a developer or not participating in the program. The implies a cost of

$c(-2000, 260000) = 1.1\left(-2000 + \sqrt{(400000 + 260000)\cdot 300} - \sqrt{400000\ 300}\right) = \$1228.5$ The predicted choices of each subject and the associated cost to the government are presented below (i.e., a summary of screening contracts). C_i implies the subject chooses contract C_i, $i = 1,2,3$, and D implies the subject sells to a developer.

Screening Allocation	1	2	3	4	5	6	7	8	9	10	11	12
Outcome	C_1	C_2	C_2	C_3	D	C_2	C_2	C_3	D	D	D	C_3
Government Cost	2050	700	700	1228.5	0	700	700	1228.5	0	0	0	1228.5

The total expected cost of the screening mechanism to the government is $8535.50. Under these contracts the theory predicts that eight of the 12 parcels will be preserved, whereas only 7 of the 12 parcels are preserved under the auction mechanism. The equilibrium with 7 of the 12 parcels being preserved with the auction mechanism also could have been achieved with a lower budget, of $7322. Thus, the predicted outcome under the screening mechanism provides an increase in surplus of $8000 (the surplus from preserving instead of developing parcel 1) at an additional cost of $1213.5. Because the minimum expenditure required to preserve the seven parcels that generate an increase in surplus which exceeds the increase in the auction budget required to secure that surplus is less than $8535.5, we set the auction budget equal to the expected cost of the screening mechanism, $8535.5, in order to increase the chance that additional parcels will be preserved under the auction if subjects do not adopt equilibrium strategies. Because we expect that the screening mechanism will perform better than the auction, this choice of auction budget biases the experiment against our predicted outcome.

2.3 The Tax Mechanism

Under the tax mechanism, a tax of $\tau = S = \$10,000$ is imposed on any subject that sells to a developer. This results in a final utility of $\sigma_i D - \$10,000$ if the owner sells to a developer. Owners who do not sell to a developer receive the preservation utility $u_i = f + \sqrt{zv_i}$. The predicted outcome from this policy is that subject 9 sells to a developer and all other subjects retain their land.

3 Experimental Design

A summary of the behavior and other parameters for the 12 types in the five treatments (described below) are presented in table 1. A total of 120 subjects were recruited from undergraduate economics and business classes to participate in this experiment. All of the sessions were conducted in an experimental economics laboratory in a large university in the northeast of the United States. Subjects were assigned to a computer station by random. Each computer station was equipped with privacy screens to ensure confidentiality of subject decisions and outcomes. The choices were made using Excel spreadsheets programmed with Visual Basic for Applications. Each experimental session lasted approximately one hour and a half and subjects earned approximately $20.

At the start of each session, subjects received written instructions (see Appendix) and listened to an oral description of the experiment protocols that was accompanied by a PowerPoint presentation. Subjects were welcome to ask questions of the administrators, but were told not to talk with other participants of the experiment.

Each experiment session consisted of twelve subjects. As discussed previously, in each round, there were 12 different sets of induced values (or seller) types. Each treatment had 12 rounds, which meant that each subject participated in each treatment as each seller type. To control for potential order effects, the seller type in each round was randomly selected so that subjects did not know which type they would be in the subsequent rounds, nor were there any duplicates of types. Additionally, the five treatments were presented in a Latin squares design to control for potential order effects. The experiment consisted of 65 rounds where the first five rounds served as training on the baseline treatment. The subsequent sixty rounds consisted of the five treatments. This design created 7,200 individual-level observations (120 subjects x 60 subjects) and 600 group-level observations (10 sessions x 60 rounds).

All of the treatments had subjects have a set of induced values based on their ownership of one parcel of land. The induced benefits represented the stream of benefits that would accrue to this seller type. Transaction costs were considered part of the stream of benefits represented by the set of induced values and therefore were not treated separately. Therefore, the decision in one round had no impact on their values or choices in subsequent round. In other words, each round represented the beginning and the end of the world for this decision, which kept the data from each round independent (except, of course, for the learning that took place over time within individuals and in Part B where there was an auction that where the outcomes were affected slightly by group behavior). The five treatments are summarized as follows:

3.1 Baseline

Buyers:	Set-Price Buyer (Developers)	
Seller Choice:	i)	Accept set-price offer
	ii)	Retain parcel, earn ownership return

In the *Baseline* treatment, subjects in each seller type were shown a set-price from a buyer, referred to as the "Set-Price Buyer". This set-price can be thought of as a posted price offered by a developer for the landowner to sell their land. The administrator served as the set-price buyer and the posted prices were pre-set to test the theory described above. The seller has the choice of accepting this set-price or retraining their parcel of land and earning the induced ownership return.

After each subject had made their decision, the administrator computer would record this information and then provide subjects with their next set of induced values. The subjects also learned of the number of parcel purchased by the Set-Price Buyer and the lowest, highest, and average prices paid. This information was displayed on the subject's spreadsheet. These procedures continued until all 12 rounds of this treatment were completed.

3.2 Public Auction

Buyers: Set-Price Buyers & Auction Buyer (public conservation buyer)

Auction Rules: Discriminative auction

Seller Choice:
- i) Accept Set-Price offer
- ii) Try to sell to Auction buyer
  - a. Sell & receive auction payment
  - b. Don't sell, retain parcel
- iii) Retain parcel, earn ownership return

In the *Public Auction* treatment, subjects again received a set of induced values for their parcel and received a posted price from the Set-Price Buyer. As in the *Baseline* treatment, the subjects had the choice to accept the Set-Price offer or to retain their parcel. However, in this treatment, the subject could also try to sell their parcel by submitting an offer to sell to the "Auction Buyer". The Auction Buyer could be though of as a government conservation agency.

Subjects were aware that the Auction Buyer had a budget of $8,535 to purchase as many parcels as possible. Similar, to the auctions used government conservation agencies, such as the Delaware Agricultural Lands Preservation Foundation, a discriminative auction was used where the offers to sell were ranked from lowest to highest, based on offer price, and then the Auction buyer would buy the lowest priced-parcel and continue up the list of offers until the budget was exhausted. Subjects that sold their parcels to the Auction buyer received their offer price and those that did not successfully sell to the Auction buyer just received their ownership return since they still retained the parcel. Whatever funds remained in the budget for the Auction buyer after the round did *not* carry forward into the next round. As described previously, each round was considered the beginning and end of the world.

After each subject had made their decision, the administrator computer would record this information and then inform the subjects who submitted their offers to the Auction Buyer whether they had successfully sold their unit. After each round, subjects learned of the number of parcel purchased by the Set-Price Buyer and the lowest, highest, and average prices paid. They also learned the number of offers submitted to the Auction Buyer, the number of parcels purchase, and the lowest, highest, and average accepted offer purchased. This information was displayed on the subject's spreadsheet.

3.3 Impact Fee

Buyers:	Set-Price Buyer
Public Rules:	Fee added to the point of sale
Seller Choice:	i) Accept set-price offer and pay fee
	ii) Retain parcel, earn ownership return

The *Impact Fee* (or flat tax) treatment operated identically to the *Baseline* treatment, except that now when a subject accepted the set-price they had to also pay the fee (similar to an impact fee in real estate settings). As described above, the set-price was set equivalent to the social surplus lost from developing the parcel.

Like with the *Baseline* treatment, after each subject had made their decision, the administrator computer would record this information and then provide subjects with their next set of induced values. The subjects also learned of the number of parcel purchased by the Set-Price Buyer and the lowest, highest, and average prices paid.

3.4 Screening Mechanism I – Development Value Unknown

Buyers:	Set-Price Buyer & Contract Buyer
Public Rules:	Four different contracts with different effects on the Land Income and Personal Value
Seller Choice:	i) Accept developer offer
	ii) Accept one of four contracts
	iii) Retain parcel, earn ownership return

The *Screen Mechanism I* treatment built upon the *Baseline* treatment, except that the subjects also faced up to four different contracts that had various affects on their set of induced values as described above. Therefore, the choices faced by subjects was to sell to the Set-Price Buyer (no impact fee was included in this treatment), retain their parcel and received the ownership return, or to accept the contract and the resulting payoff vector.

After each subject had made their decision, the administrator computer would record this information and then provide subjects with their next set of induced values. The subjects also learned of the number of parcel purchased by the Set-Price Buyer and the lowest, highest, and average prices paid. The screens also displayed the number of contracts that were accepted by subjects.

3.5 Screening Mechanism II – Development Value Known

Buyers:	Set-Price Buyer & Contract Buyer
Public Rules:	Four different contracts with different effects on the Land Income and Personal Value based on development value.
Seller Choice:	i) Accept developer offer
	ii) Accept one of four contracts
	iii) Retain parcel, earn ownership return

The *Screen Mechanism II* treatment operated identically to the *Screen Mechanism I* treatment, except that the contracts were now different based on the assumption that the government would be able to observe the development value of the parcels and therefore make more specific contracts to improve social efficiency.

4 Results

The driving hypothesis is that the discriminative conservation auction is unlikely to be cost effective because an information asymmetry introduces adverse selection. The data from experiments testing this theory illustrate that this hypothesis is likely to be correct. This can been seen by inspecting the five panels in figure 1 and the summary results shown in table 1.

Figure 1(first panel) reflects treatment A. When subjects were confronted only with a developer buyer, the data replicate what is known as a problem of overdevelopment. The circle sizes reflect the number of participants accepting the developer's offer by type. Many of the types that were vulnerable to the developer's offer (Types 1, 5, 6, 11, and 12, despite the social efficiency of their remaining in farming. Yet, the subjects reflecting adverse selection do not tend to accept the developer's offer (Types 2, 3, 4, 7, and 8). As can be seen in Table 2, treatment A results in the lowest average social surplus $16,366. The subsequent analysis will used this treatment as the baseline to see how alternative mechanism compare to the situation where no government program exists to deal with the externality.

The second panel shows treatment B, which replicates the current discriminative conservation auction. Adverse selection is rampant, with subjects who would remain in farming without a program now winning the auction (and thus getting government payments despite their intention to remain in farming). Moreover, many of the subjects vulnerable to the developer's offer still accept it. Hence, the net effect of the program is not much different than a world without a program. This provides experimental evidence for the adverse selection hypothesis. Relative to the baseline treatment A, social surplus does increase to $17,614 (Table 2), which is statistically significant at the 0.01 level (Table 3)

The third panel shows treatment C, the tax program. The results are stark. Almost every subject made a decision in-line with social efficiency. In this case, Type 9 subjects develop 97.5% of the time compared to the other 11 subject types which developed only 1.4% of the time (Table 1). This yielded the highest level of social surplus – an average of $19,623, which is statistically higher than the baseline at the 0.01 level (Table 3). The surplus in this treatment is also statistically higher than any of the other treatments.

The mechanisms in treatments D and E—panels four and five in figure 1—show that the contracts can successfully sort subjects by types. The average social surplus in treatment D was $18,307 while in treatment E it was $18,881 (Table 2). Both of these results are better than the baseline (Table 3). Also, the ability to write better contracts by knowing the development value

(*D*) helps the government write contracts that yield more surplus as the social surplus increase in treatment E compared to treatment D is statistically significant at the 0.01 level. However, even the best contact mechanism fails to produce the socially optimal results of the tax program. Moreover, the treatments involve government expenditures and private penalties.

Figure 2, considers the impact of these programs at varying level of government waste, w. The horizontal axis extends from w=0 (no government waste) to w=1, such that an intermediate value, such as w=0.2 implies that $1.20 needs to be raised via taxes to deliver $1.00 in government expenditure. Inspection of this figure shows that the baseline treatment A is invariant with changes to w as no program exists. However, increases in government waste decrease the social surplus of the auction (treatment B) and the conservation contracts (treatments D & E). This figure also illustrates the superiority of the impact fee (treatment C), as like treatment A, the social surplus derived from this treatment is not related directly to government waste.

Interestingly, if the concept of the 'double-dividend' is applied to this case of government expenditures and associated taxes, we can see that the efficiency of impact fee (treatment C) actually delivers increasingly higher levels of social surplus with increases in w. In contrast, the contracts where the values of *D* is unknown yields increasingly lower levels of social surplus with increases in w.

In sum, the results show that adverse selection is likely to exist in conservation auctions and that a mechanism can sort types so as to improve cost effectiveness with respect to the specific information asymmetry. However, the mechanisms involve large transfers and the experiments show that a simple externality-correcting tax can achieve more cost effectiveness with lower transfers. This is an important result for policy because recent trends are focused on expanding fiscally costly auctions rather than taxes. The result also is surprising and important for researchers because there is little intuition as to why the tax resolves the selection problem.

5 Conclusions

This research demonstrates both theoretically and empirically—using experimental economics techniques—that conservation auctions are plagued by adverse selection and, in consequence, are not positively altering land-use patterns very much despite spending billions of dollars. In other words, these policies are transferring billions of dollars from the government and nonprofits to landowners who were the most likely to deliver the conservation services in the absence of a policy. Among the drivers of this problem are the auction mechanisms used, which allow landowners to "name their price" and force program managers to select the "cheapest," and the relatively small program budgets, which ensure that only a small subset of potential sellers will be selected. Although this story is straightforward, it has made little impact on the economic literature and there is no appreciable recognition of adverse selection in policy.

A model of conservation auctions is developed to describe the adverse selection phenomenon. The model then develops several versions of a mechanism to mitigate the incentive problem optimally. Economic experiments test the contract mechanism relative to the commonly used discriminative auction and the status quo of no intervention. Experiments involving 120 student subjects conducted in 2009 closely follow the theoretical predictions by testing five different treatments (See figure 1). Of particular interest is the finding that conservation auctions are highly influenced by adverse selection. In contrast, various conservation contracts can correctly sort the landowner types to achieve a higher level of efficiency, all of these policies involve government expenditures and are inferior to the implementation of an impact fee on development, which not only solves the externality problem underlying this question, but also solves the adverse selection problem as well. These results thus suggest changes to conservation markets, which will improve their cost-effectiveness.

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Table 1. Individual choices by treatment.

			Treatment A (Baseline)			Treatment B (Auction)			Treatment C (Impact Fee)		
Type	Sigma	V (100s)	Set Price	Preserved	Retained	Set Price	Preserved	Retained	Set Price	Preserved	Retained
9	0.75	0	97.5%	0.0%	2.5%	97.5%	0.8%	1.7%	97.5%	0.0%	2.5%
10	0.75	1	99.2%	0.0%	0.8%	93.3%	1.7%	5.0%	2.5%	0.0%	97.5%
11	0.75	2	99.2%	0.0%	0.8%	93.3%	3.3%	3.4%	2.5%	0.0%	97.5%
12	0.75	3	98.3%	0.0%	1.7%	42.5%	43.3%	14.2%	2.5%	0.0%	97.5%
5	0.5	0	96.7%	0.0%	3.3%	95.0%	3.3%	1.7%	2.5%	0.0%	97.5%
6	0.5	1	96.7%	0.0%	3.3%	17.5%	72.5%	10.0%	0.8%	0.0%	99.2%
7	0.5	2	1.7%	0.0%	98.3%	0.0%	78.3%	21.7%	0.8%	0.0%	99.2%
8	0.5	3	0.0%	0.0%	100.0%	0.0%	82.5%	17.5%	0.0%	0.0%	100.0%
1	0.25	0	96.7%	0.0%	3.3%	79.2%	10.0%	10.8%	3.3%	0.0%	96.7%
2	0.25	1	1.7%	0.0%	98.3%	0.8%	81.7%	17.5%	0.8%	0.0%	99.2%
3	0.25	2	0.0%	0.0%	100.0%	0.0%	80.0%	20.0%	0.0%	0.0%	100.0%
4	0.25	3	0.8%	0.0%	99.2%	0.0%	77.5%	22.5%	0.0%	0.0%	100.0%

			Treatment D (Contracts - *D* Unknown)						Treatment E (Contracts - *D* Unknown)				
Type	Sigma	V (100s)	Set Price	Preserved	Contract1	Contract2	Contract3	Retained	Set Price	Preserved	Contract4	Contract5	Retained
9	0.75	0	97.5%	2.5%	2.5%	0.0%	0.0%	0.0%	98.3%	0.0%	0.0%	0.0%	1.7%
10	0.75	1	95.8%	4.2%	0.8%	2.5%	0.8%	0.0%	98.3%	1.7%	1.7%	0.0%	0.0%
11	0.75	2	92.5%	7.5%	0.8%	6.7%	0.0%	0.0%	5.8%	93.3%	93.3%	0.0%	0.8%
12	0.75	3	7.5%	91.7%	0.0%	1.7%	90.0%	0.8%	0.8%	99.2%	99.2%	0.0%	0.0%
5	0.5	0	97.5%	2.5%	2.5%	0.0%	0.0%	0.0%	97.5%	2.5%	2.5%	0.0%	0.0%
6	0.5	1	6.7%	92.5%	0.0%	91.7%	0.8%	0.8%	5.0%	92.5%	91.7%	0.8%	2.5%
7	0.5	2	0.8%	95.0%	0.0%	92.5%	2.5%	4.2%	0.8%	95.0%	92.5%	2.5%	3.3%
8	0.5	3	0.8%	98.3%	1.7%	0.8%	95.8%	0.8%	0.8%	90.0%	5.8%	84.2%	1.7%
1	0.25	0	8.3%	90.8%	90.8%	0.0%	0.0%	0.8%	1.7%	98.3%	98.3%	0.0%	0.0%
2	0.25	1	0.8%	95.8%	0.8%	95.0%	0.0%	3.3%	0.8%	1.7%	1.7%	0.0%	97.5%
3	0.25	2	0.0%	96.7%	0.8%	95.0%	0.8%	3.3%	0.8%	1.7%	1.7%	0.0%	97.5%
4	0.25	3	0.0%	99.2%	0.8%	4.2%	94.2%	0.8%	0.8%	1.7%	1.7%	0.0%	97.5%

Table 2. Social Surplus by Treatment by Type.

Treatment		1	2	3	4	5	6	7	8	9	10	11	12	Average
A	**Baseline**	$ 5,267	$ 19,086	$ 21,944	$ 23,796	$ 10,100	$ 10,311	$ 21,745	$ 23,954	$ 14,950	$ 15,036	$ 15,058	$ 15,149	$ 16,366
B	**Auction**	$ 6,667	$ 19,205	$ 21,944	$ 23,954	$ 10,150	$ 17,693	$ 21,944	$ 23,954	$ 14,950	$ 15,288	$ 15,463	$ 20,149	$ 17,614
C	**Impact Fee**	$ 12,733	$ 19,205	$ 21,944	$ 23,954	$ 12,925	$ 19,247	$ 21,845	$ 23,954	$ 14,950	$ 19,216	$ 21,771	$ 23,731	$ 19,623
D	**Contracts (*D* unknown)**	$ 12,333	$ 19,179	$ 21,905	$ 23,613	$ 10,075	$ 18,701	$ 21,838	$ 23,448	$ 14,950	$ 15,152	$ 15,484	$ 23,002	$ 18,307
E	**Contracts (*D* known)**	$ 12,867	$ 19,152	$ 21,729	$ 23,705	$ 10,075	$ 18,484	$ 21,310	$ 23,797	$ 14,967	$ 15,072	$ 21,539	$ 23,880	$ 18,881
	Average	$ 9,973	$ 19,166	$ 21,893	$ 23,805	$ 10,665	$ 16,887	$ 21,737	$ 23,822	$ 14,953	$ 15,953	$ 17,863	$ 21,182	$ 18,158

Table 3. Panel Data Analysis of Social Surplus

	Coefficient	P-value
Constant	13,161.53	0.000
Treat_B	1,247.11	0.000
Treat_C	3,256.59	0.000
Treat_D	1,940.34	0.000
Treat_E	2,515.00	0.000
Type_1	-4,980.00	0.000
Type_2	4,212.17	0.000
Type_3	6,939.91	0.000
Type_4	8,851.33	0.000
Type_5	-4,288.33	0.000
Type_6	1,933.82	0.000
Type_7	6,783.26	0.000
Type_8	8,868.35	0.000
Type_10	999.71	0.000
Type_11	2,909.51	0.000
Type_12	6,228.83	0.000

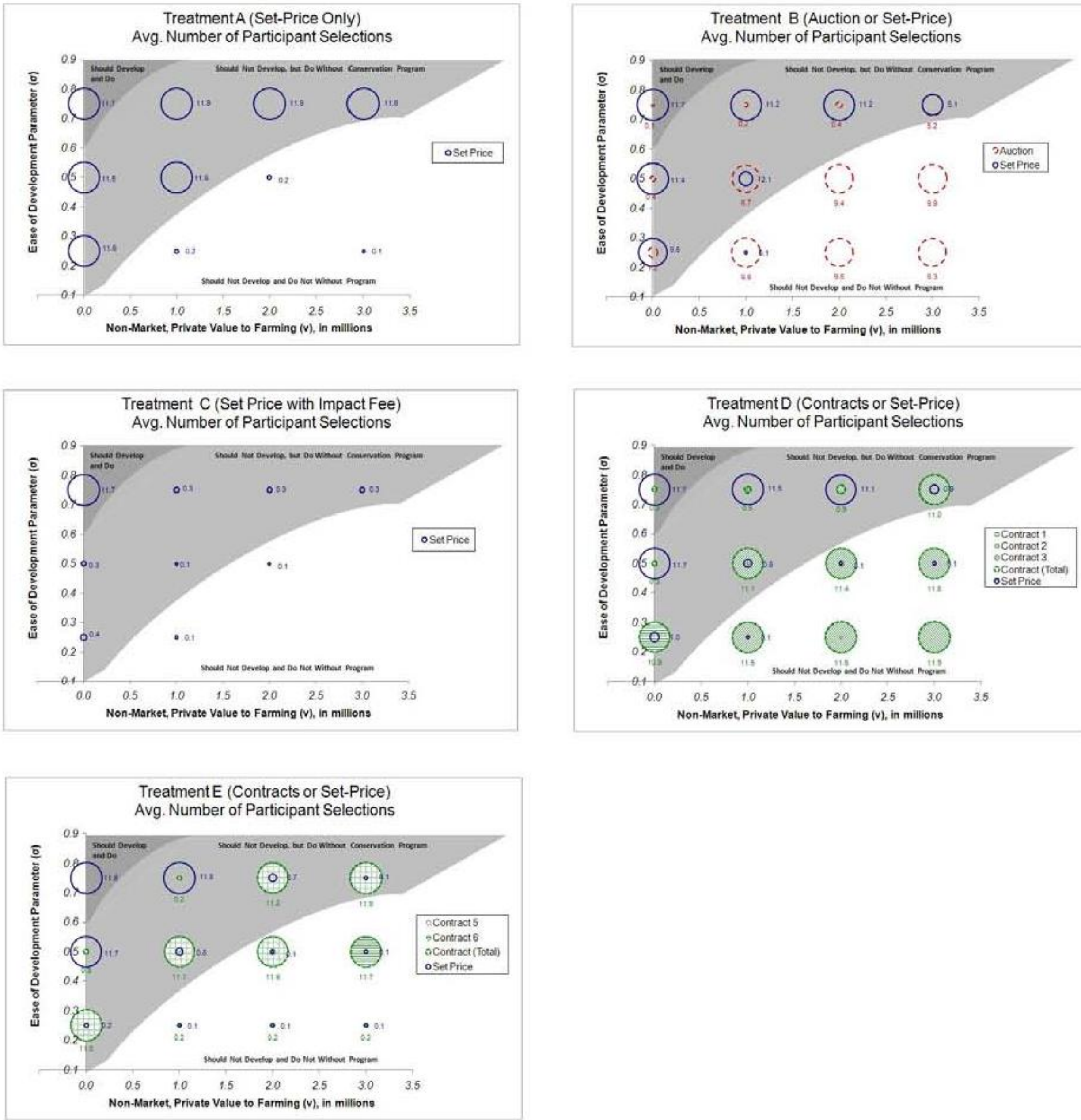


Figure 1: Experimental Results by Type

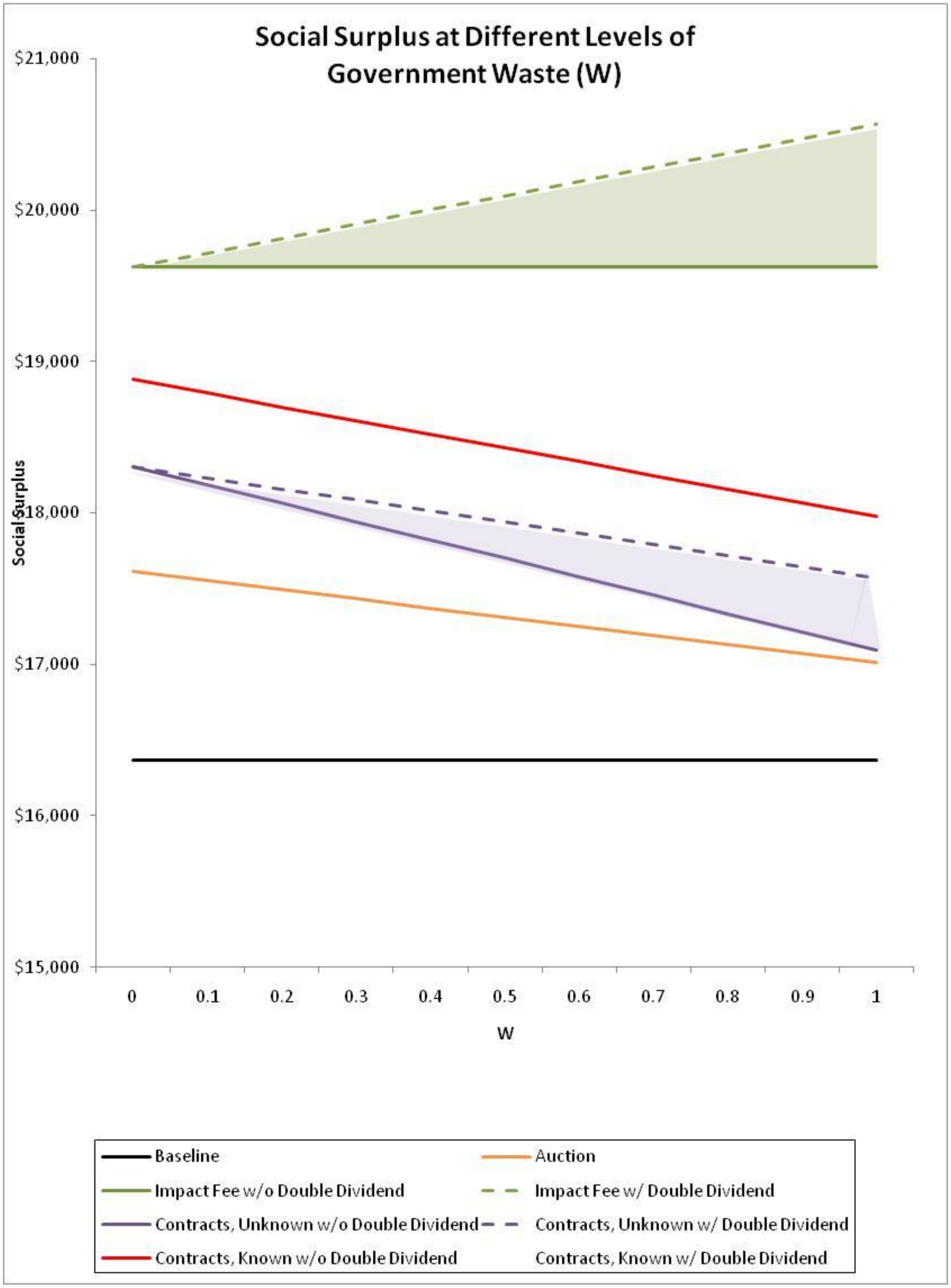


Figure 2: Social Surplus at Different Levels of Government Waste

Appendix: Experiment Instructions

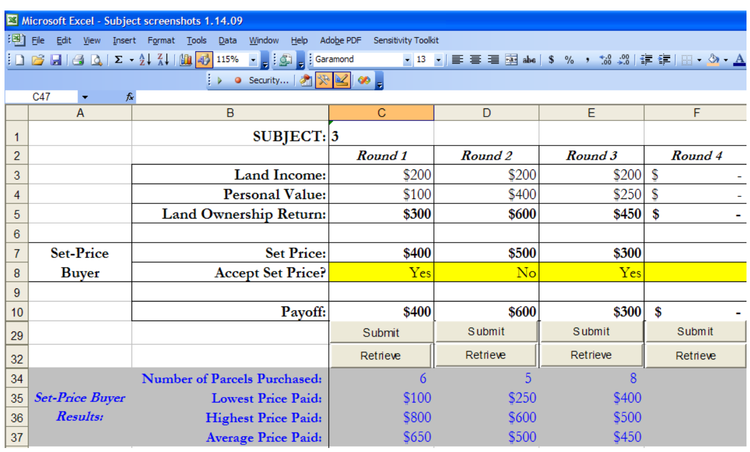
Instructions -- Set-Price Buyer

Welcome to this experiment in the economics of decision making. During the experiment, you will have opportunities to earn money. Any money earned is yours to keep. Therefore, please read these instructions carefully. Please do not communicate with other participants during the experiment.

In this experiment, you will assume the role of an **owner** of one **parcel** of land, and you will make decisions about whether or not to **sell** your parcel. You will make one decision per **round**. The session administrator will assume the role of a **Set-Price Buyer** and all buying decisions will be made according the rules described here.

Below is a hypothetical example of a computer screen you might see in the experiment—all numbers displayed are hypothetical and in no way correspond to numbers you will see in the actual experiment. In this example, three rounds have been completed and the fourth round is about to begin. Your parcel is assigned a **Land Ownership Return**, which is derived from two components: **Land Income** and **Personal Value**.

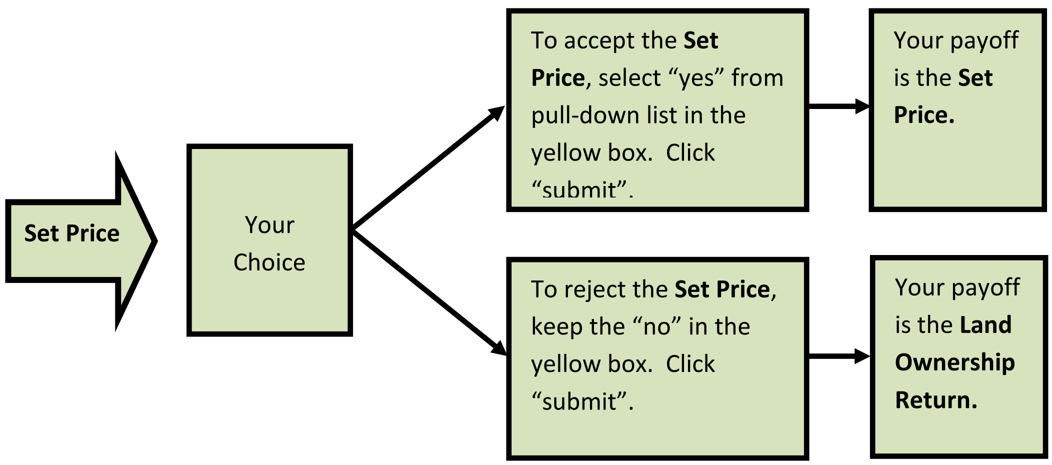
- **Land Income** indicates the monetary value to you of growing products on your parcel or from renting your parcel to another party.
- **Personal Value** is a monetary measure of any additional enjoyment you receive from owning or managing this parcel of land.
- **Land Ownership Return** equals **Land Income** and **Personal Value** added together. This is the total amount of money you earn if you do not sell your parcel.



	A	B	C	D	E	F
1		SUBJECT:	3			
2			*Round 1*	*Round 2*	*Round 3*	*Round 4*
3		Land Income:	$200	$200	$200	$ -
4		Personal Value:	$100	$400	$250	$ -
5		Land Ownership Return:	**$300**	**$600**	**$450**	**$ -**
6						
7	Set-Price	Set Price:	**$400**	**$500**	**$300**	
8	Buyer	Accept Set Price?	Yes	No	Yes	
9						
10		Payoff:	**$400**	**$600**	**$300**	**$ -**
29			Submit	Submit	Submit	Submit
32			Retrieve	Retrieve	Retrieve	Retrieve
34		Number of Parcels Purchased:	6	5	8	
35	*Set-Price Buyer*	Lowest Price Paid:	$100	$250	$400	
36	*Results:*	Highest Price Paid:	$800	$600	$500	
37		Average Price Paid:	$650	$500	$450	

In the example above, the Land Ownership Return is $200 in the first round, $200 in the second round and $200 in the third round. Your ownership return will not necessarily be the same as that of other sellers and will change throughout the experiment. Decisions made in any given round will <u>not</u> affect your values in subsequent rounds (though your total cash earnings from the experiment will be cumulative).

In each round, the buyer will offer a **Set Price** to purchase your parcel and you must decide if you want to accept it (see figure below). The Set-Price Buyer's price may or may not change in each round.



Payoffs in Each Round

After everyone has submitted their confidential choice, the administrator records which sellers sold their parcels and then pays each player. There are two possible **payoff** scenarios:

i) Sellers who accept the Set-Price Buyer's price will receive the Set Price. For example in Round 1, the seller would have earned $400.

ii) Sellers who do not accept the Set-Price Buyer's price will receive their ownership return for the parcel. For example in Round 2, the seller earned a profit of $600.

Market Information

As seen at the bottom of the sample screen, after each round you will receive market information, summarizing the choices of other people in this experiment session. This information will be revealed on your spreadsheet when you click on the "Retrieve" button upon the instruction of the administrator. The market information includes the number of subjects selling for the Set Price. It also includes the lowest, highest, and average Set Prices accepted.

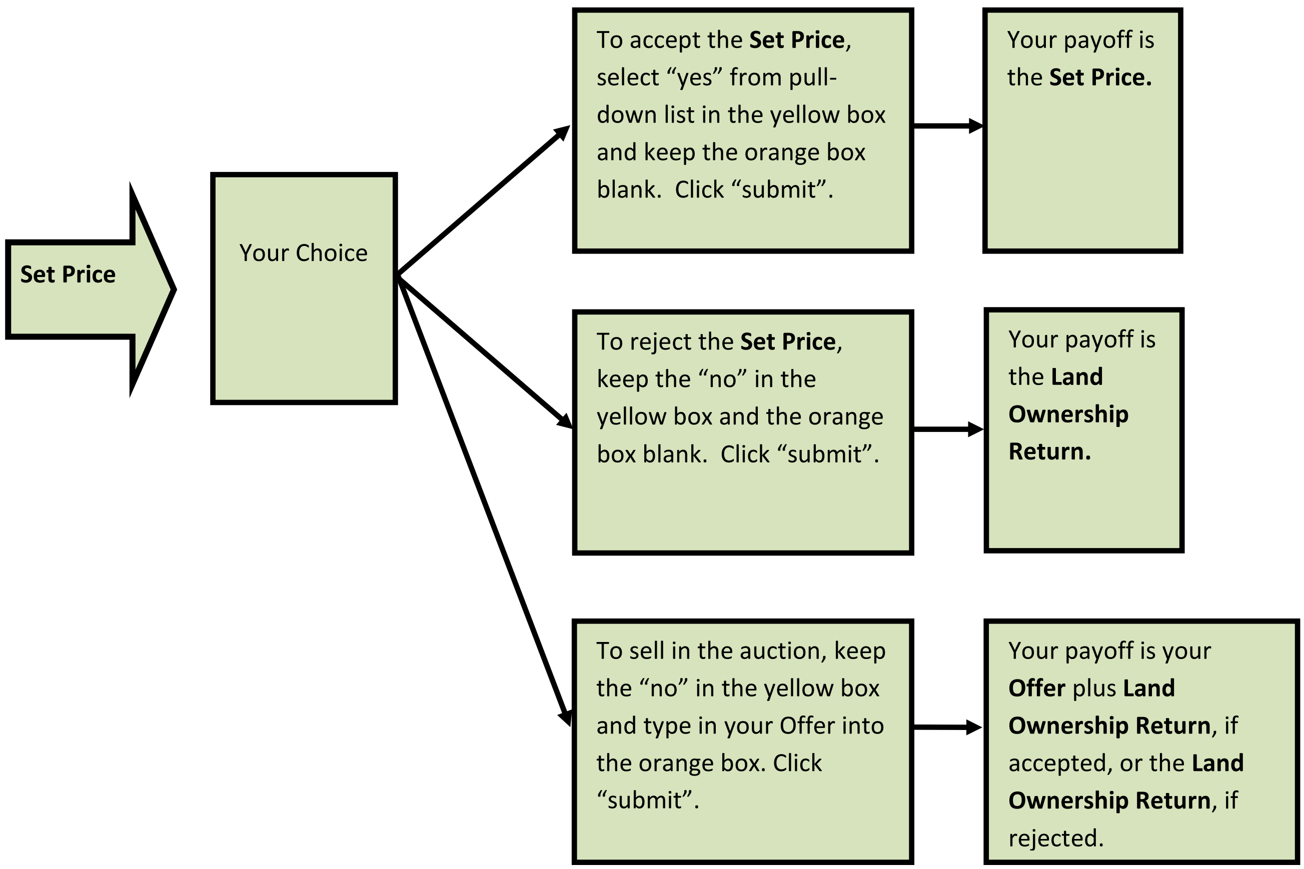
Final Earnings

Your computer will calculate your **payoffs** in each round and will keep track of your **cumulative earnings**. An exchange rate of 37,500 to 1 will be used to convert your earnings from experimental dollars to US dollars. For example, if you earn 750,000 experimental dollars will have earned $20 US to take home today.

Instructions -- Set-Price Buyer and Auction Buyer

This part is similar to the first part of the experiment, except that you have an additional choice to consider. In each round, the Set-Price Buyer will again offer a **Set Price** to purchase your parcel and you must decide whether you want to: (1) accept it; (2) reject it; or (3) reject it and participate in an auction. You now may also try to sell your land parcel to an **Auction Buyer** who makes decisions based on an **auction**. An example of the computer screen is below:

In each round, the Set-Price Buyer will again offer a **Set Price** to purchase your parcel and you must decide whether you want to: (1) accept it; (2) reject it; or (3) reject it and participate in an auction.



The Set Price may change in each round. The auction buyer's **anticipated budget** will be $8,535 in each round, though the amount actually spent will be determined by the number of sellers who participate in the auction.

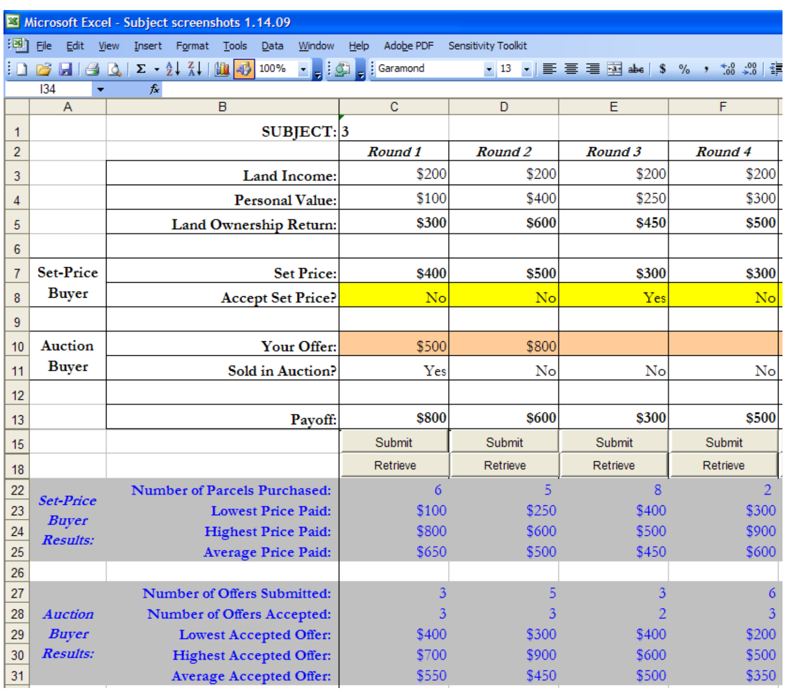
How the Auction Works

After everyone has submitted their confidential decision, the administrator will rank all the offers received for the auction from lowest to highest and then determine which participants sold their parcels based on the budget for that round. For this example, the auction buyer's **budget** will be $3,000. The auction buyer will purchase as many parcels as possible starting from the lowest offer price and moving up until the available budget is exhausted. For example, imagine a round in which seven offers were submitted (ranked from lowest to highest):

Parcel #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Offers:	**$400**	**$400**	**$500**	**$600**	**$600**	$700	$800	$900

Parcels are purchased in order (from left to right) until the auction buyer does not have enough money to purchase another parcel. In the example, the five lowest offer prices ($400 + $400 + $500 + $600 + $600) are purchased for a total of $2,500. None of the last three offers are purchased, since even the lowest non-accepted bid of $700 would bring the total cost to $3,200 ($2,500 + $700) and therefore be higher than the buyer's budget of $3,000.

In the below example, the seller submitted an Auction Offer of $500 for Round 1 and $800 for Round 2. When the offer of $500 was accepted in the auction, the seller received $500 plus the Land Ownership Return of $300, thus yielding a payoff of $800. In Round 2, when the offer was not accepted in the auction, the earnings were just the land ownership return of $600. In Round 3, no offer was submitted as the seller accepted the set price of $300. In round 4, no offer was submitted nor was the set price accepted, which means the seller receives the Land Ownership Return of $500.



	A	B	C	D	E	F
1		SUBJECT:	3			
2			*Round 1*	*Round 2*	*Round 3*	*Round 4*
3		Land Income:	$200	$200	$200	$200
4		Personal Value:	$100	$400	$250	$300
5		Land Ownership Return:	$300	$600	$450	$500
6						
7	Set-Price	Set Price:	$400	$500	$300	$300
8	Buyer	Accept Set Price?	No	No	Yes	No
9						
10	Auction	Your Offer:	$500	$800		
11	Buyer	Sold in Auction?	Yes	No	No	No
12						
13		Payoff:	$800	$600	$300	$500
15			Submit	Submit	Submit	Submit
18			Retrieve	Retrieve	Retrieve	Retrieve
22	*Set-Price*	Number of Parcels Purchased:	6	5	8	2
23	*Buyer*	Lowest Price Paid:	$100	$250	$400	$300
24	*Results:*	Highest Price Paid:	$800	$600	$500	$900
25		Average Price Paid:	$650	$500	$450	$600
26						
27		Number of Offers Submitted:	3	5	3	6
28	*Auction*	Number of Offers Accepted:	3	3	2	3
29	*Buyer*	Lowest Accepted Offer:	$400	$300	$400	$200
30	*Results:*	Highest Accepted Offer:	$700	$900	$600	$500
31		Average Accepted Offer:	$550	$450	$500	$350

Payoffs in Each Round

After all subjects make their decisions, the administrator will conduct the auction to determine which parcels were purchased. You will then click on the "Retrieve" button. If you submitted an Offer, you will learn whether you sold your parcel. There are four possible **payoff** scenarios:

i) Sellers who accept the Set-Price Buyer's price (and thus do not submit to the auction) will receive the Set Price. For example in Round 3, the seller would have earned $300.

ii) Sellers who do not accept the Set-Price Buyer's price nor submit an offer in the auction will receive their ownership return for the parcel. For example in Round 4, the seller earned a profit of $500.

iii) Successful sellers in the auction receive a payoff equal to their offer plus their Land Ownership Return. In Round 1 in the example above, the subject earned $500 by successfully selling his parcel for an offer of $500.

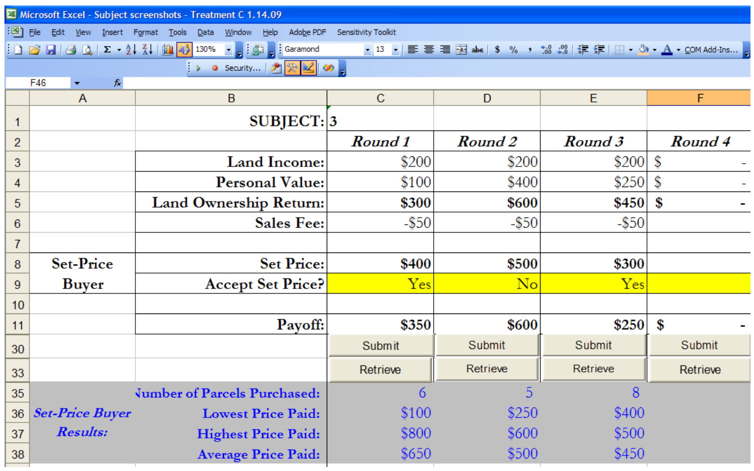
iv) Subjects that submit an offer that is too high for the available budget will not receive their offer, but instead their payoff will be their Land Ownership Return. For example in Round 2, the subject earned $600 even though she did not sell her parcel.

Market Information

In addition to the Set-Price market information shown in the first part of the experiment, you will also receive market information about the auction. The auction market information includes the number of subjects submitting offers and the number of offers accepted. It also includes the lowest and highest offers accepted and the average offers accepted.

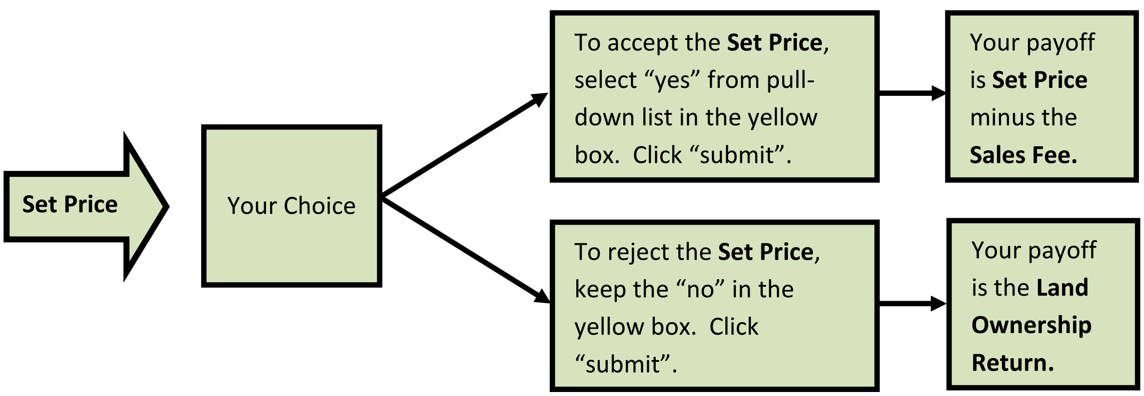
Instructions -- Set-Price Buyer with Sales Fee

This part is almost identical to the first part of the experiment. The only change is that if you accept the **Set Price**, then you have to pay a **Sales Fee**. An example of the computer screen is:


Microsoft Excel - Subject screenshots - Treatment C 1.14.09

	A	B	C	D	E	F
1		SUBJECT:	3			
2			*Round 1*	*Round 2*	*Round 3*	*Round 4*
3		Land Income:	$200	$200	$200	$ -
4		Personal Value:	$100	$400	$250	$ -
5		Land Ownership Return:	$300	$600	$450	$ -
6		Sales Fee:	-$50	-$50	-$50	
7						
8	Set-Price	Set Price:	$400	$500	$300	
9	Buyer	Accept Set Price?	Yes	No	Yes	
10						
11		Payoff:	$350	$600	$250	$ -
30			Submit	Submit	Submit	Submit
33			Retrieve	Retrieve	Retrieve	Retrieve
35		Number of Parcels Purchased:	6	5	8	
36	*Set-Price Buyer*	Lowest Price Paid:	$100	$250	$400	
37	*Results:*	Highest Price Paid:	$800	$600	$500	
38		Average Price Paid:	$650	$500	$450	

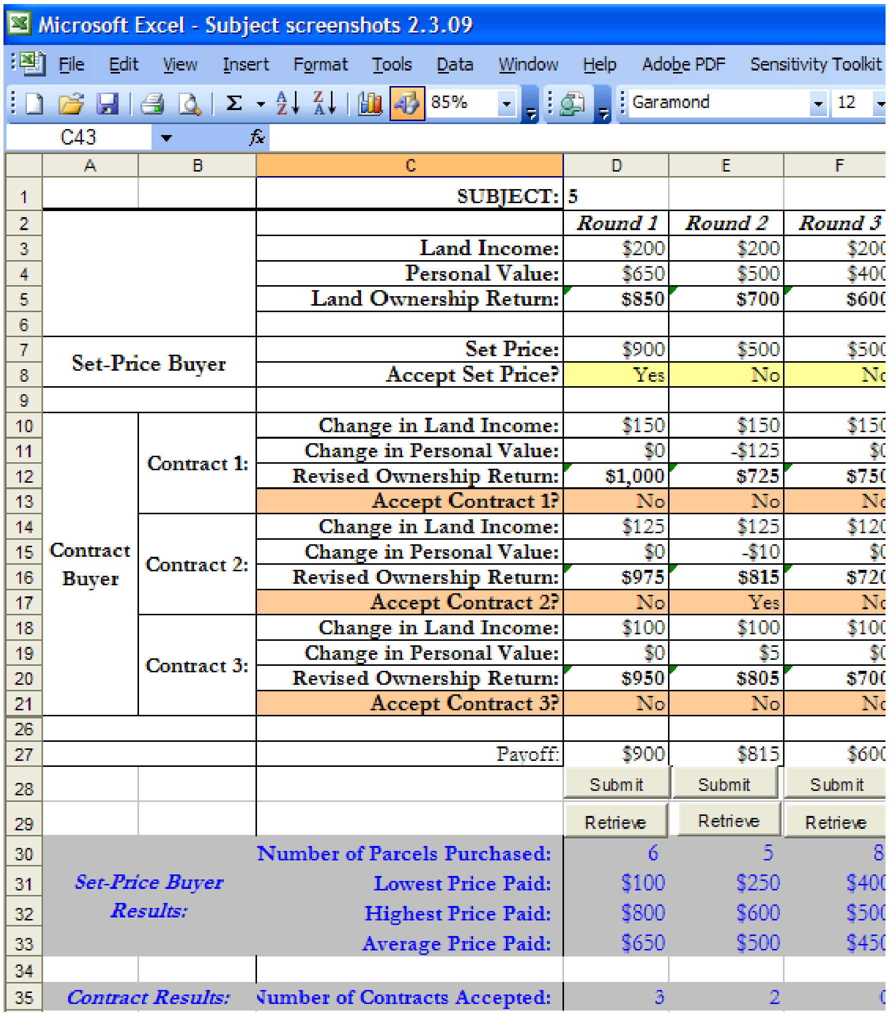
Your decision is similar to the first part of the experiment:



Your payoffs in each round will be determined almost exactly as in the first part of the experiment. The only difference is that, when you accept the Set Price, your payoffs are calculated as the Set Price **minus** the Sales Fee.

Instructions -- Set-Price Buyer and Contract Buyer

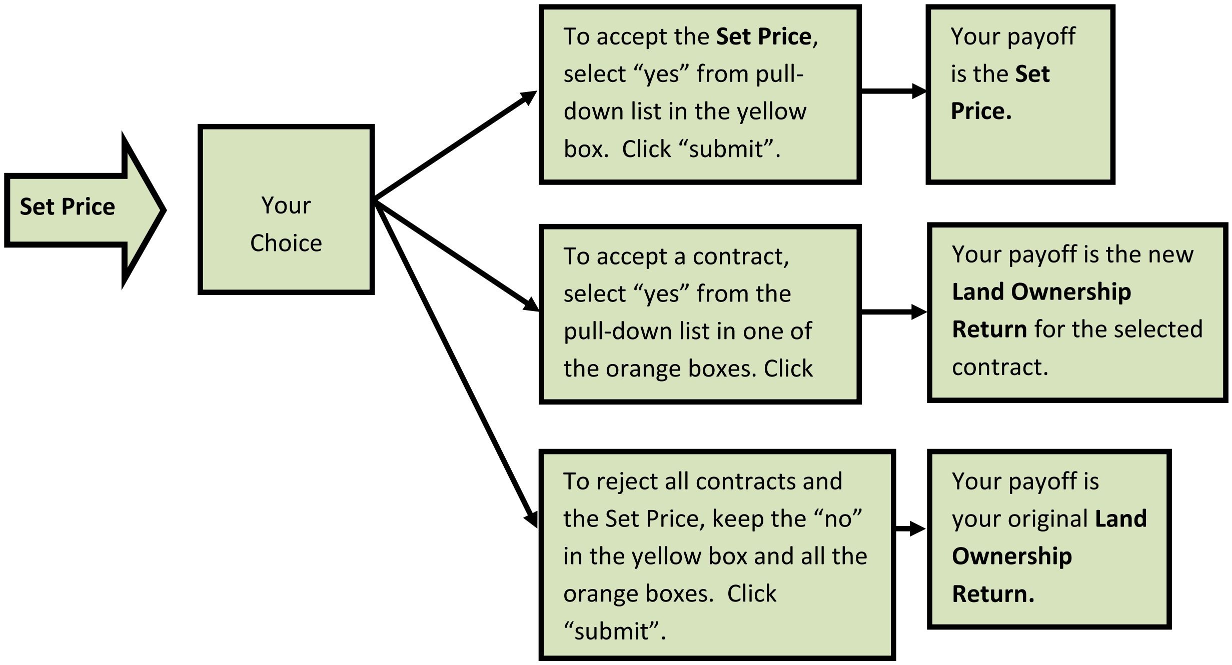
This part of the experiment is similar to the first part, except that you have additional choices to consider. You now may also try to sell it to a **Contract Buyer** who offers a series of possible contracts, from which you can select one or none. See sample computer screen:



Microsoft Excel - Subject screenshots 2.3.09

	A	B	C	D	E	F
1			SUBJECT:	5		
2				*Round 1*	*Round 2*	*Round 3*
3			Land Income:	$200	$200	$20
4			Personal Value:	$650	$500	$40
5			Land Ownership Return:	**$850**	**$700**	**$60**
6						
7	Set-Price Buyer		Set Price:	$900	$500	$50
8			Accept Set Price?	Yes	No	N
9						
10		Contract 1:	Change in Land Income:	$150	$150	$15
11			Change in Personal Value:	$0	-$125	$
12			Revised Ownership Return:	**$1,000**	**$725**	**$75**
13			Accept Contract 1?	No	No	N
14		Contract 2:	Change in Land Income:	$125	$125	$12
15	Contract Buyer		Change in Personal Value:	$0	-$10	$
16			Revised Ownership Return:	**$975**	**$815**	**$72**
17			Accept Contract 2?	No	Yes	N
18		Contract 3:	Change in Land Income:	$100	$100	$10
19			Change in Personal Value:	$0	$5	$
20			Revised Ownership Return:	**$950**	**$805**	**$70**
21			Accept Contract 3?	No	No	N
26						
27			Payoff:	$900	$815	$60
28				Submit	Submit	Submit
29				Retrieve	Retrieve	Retrieve
30	*Set-Price Buyer Results:*		Number of Parcels Purchased:	6	5	8
31			Lowest Price Paid:	$100	$250	$40
32			Highest Price Paid:	$800	$600	$50
33			Average Price Paid:	$650	$500	$45
34						
35	*Contract Results:*		Number of Contracts Accepted:	3	2	

In each round, the Set-Price Buyer will offer a **Set Price** to purchase your parcel and the Contract Buyer will offer a set of contracts for you to consider. You must decide whether to: (1) accept the Set Price; (2) to accept one of the contracts and, if so, which one; or (3) reject all contracts and the Set Price, thus keeping your original Land Ownership Return. You cannot accept the Set Price <u>and</u> a Contract.



Payoffs in Each Round

After everyone has submitted their confidential choice, the administrator records which sellers sold their parcels or accepted contracts, and then pays each player. There are three possible **payoff** scenarios:

i) Sellers who accept the Set-Price Buyer's price will receive the Set Price. For example in Round 1, the seller would have earned $900.

ii) Sellers may accept a contract if they do not accept the Set-Price. If a contract is selected, then a new Land Ownership Return is calculated for the payoff. For example in Round 2, the seller accepted the second contract and earned a new Land Ownership Return of $810.

iii) Sellers may reject the Set Price and reject all the contracts. These sellers receive the original Land Ownership Return. For example, in Round 3 the seller rejects the Set Price and all the contracts. This seller's payoff is the original Land Ownership Return of $600.

Market Information

The market information is the same as in the first part of the experiment. Now, however, the screen also displays the total number of contracts accepted by subjects in the experiment.