Providing Incentives for Efficient Land Assembly

Florenz Plassmann*
Department of Economics, State University of New York at Binghamton
Binghamton, NY 13902-6000
fplass@binghamton.edu

T. Nicolaus Tideman
Department of Economics, Virginia Polytechnic Institute and State University
Blacksburg, VA 24061
ntideman@vt.edu

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Abstract:

When urban renewal requires land assembly, owners who hold out may delay or prevent efficient redevelopment. Governments that use eminent domain to take such properties might cause socially inefficient redevelopment if they underestimate the values of these properties. None of the recent proposals for dealing with land assembly is fully efficient, and many fail to ensure that owners receive full compensation for their properties. We describe two mechanisms that yield efficient land assembly, and we assess their attractiveness relative to eminent domain and other, previously proposed solutions.

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1. INTRODUCTION

Many urban development projects require assembly of a number of contiguous small parcels owned by different persons into a larger parcel. Such projects are socially worthwhile if their net social benefits exceed the sum of the values of the individual properties. Efficient land assembly thus requires that such projects be implemented if—and only if—their net social benefits exceed the values of the individual properties. In this paper we describe two mechanisms that fulfill this requirement. The first is an application of the Clarke mechanism (see Clarke 1971, 1972), and the second is an application of the self-assessment mechanism described in Plassmann and Tideman (2008), henceforth PT.

This task of ensuring efficient land assembly is non-trivial because the values of individual properties are generally not observable. A property’s appraised market price is an imprecise approximation of the owner’s subjective valuation of his property, because the market price reflects an owner’s reservation price only when the owner makes an offer to sell at the market price. Thus when the sum of the prices that owners demand for their properties exceeds a developer’s offer, it is not clear whether the owners would value their properties at these prices even if there were no possibility of redevelopment (so that the project is not socially worthwhile) or are demanding inflated prices just to try to capture larger shares of the project’s expected benefit. The later type of owner is commonly known as a “holdout.”

Government officials who believe that holdouts are preventing the implementation of a socially worthwhile project sometimes take properties under eminent domain. If government officials underestimate the values of the property that they take, then they will not compensate all owners for their true losses and they might exercise eminent domain when it is not socially optimal to do so. If, on the other hand, government officials overestimate the values of the

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1 While the literature often refers to this mechanism as the Vickrey-Clarke-Groves mechanism in view of Vickrey (1961) and Groves (1973), we consider our label more appropriate because the relevance of Vickrey (1961) is limited to second-price auctions and the relevance of Groves (1973) is limited to incentives in teams. From neither of these papers is it apparent that a related novel application of the principle of marginal cost pricing applies to collective decisions.
properties involved, then they might not take them even if it would be efficient to do so. Thus eminent domain does not lead to efficiency in land assembly, and the possibility that owners will not be fully compensated for their losses limits the social acceptability of eminent domain in societies where individual property rights are valued.

Bargaining, whether individually or collectively with individual veto-power, is the only mechanism that fully respects owners’ property rights. However, when there are multiple owners bargaining does not necessarily solve the holdout problem because it does not compel individual owners to sell their properties when it is socially efficient to do so. A mechanism that leads to efficiency in land assembly therefore requires some intrusion on established property rights. Such an intrusion might be socially acceptable as long as owners are fully compensated for their losses—which we take to mean that every owner whose property is included in the assembly receives at least his subjective valuation of his property in the absence of assembly. A complete solution to the problem of land assembly would be a mechanism that is (1) efficient and (2) fully compensates owners for their losses. Bergstrom (1978) and Mailath and Postlewaite (1990) have shown that there can be no such mechanism that is efficient and fully respects the property rights of the owners. Thus any feasible solution to the problem of land assembly needs to strike an appropriate balance between efficiency and property rights.

In the wake of the 2005 US Supreme Court decision in *Kelo v. New London*, a new literature has emerged that offers remedies for the holdout problem and the problem of land assembly. We review this literature in Section 2. None of the proposed remedies ensures efficient land assembly, and only the auction mechanism developed in Grossman *et al.* (2010) ensures that owners receive full compensation for their losses. In contrast, the two mechanisms that we describe in this paper lead to efficient land assembly, and the PT mechanism also ensures that owners receive full compensation from the developer. Both mechanisms provide owners

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2 We only consider remedies that either constrain the ability of owners to become holdouts or that are designed to provide owners with the incentive to reveal their reservation prices. Grossman and Hart (1980), Cohen (1991), McFarlane (1999), Brueckner (2000), and Shoup (2008) discuss other strategies that developers or governments can follow to make holding out less likely.
with an incentive to reveal their reservation prices by charging them a valuation tax. However, unless the government perfectly anticipates each owner’s valuation tax payment, it will refund either too much or too little. Nevertheless, the unintended redistribution under either mechanism is likely to be small.

The remainder of the paper is organized as follows: In Section 2 we formalize the problem of land assembly and demonstrate why previously proposed mechanisms do not provide complete solutions. We introduce our two new mechanisms in Sections 3 and 4, and we compare the different assembly mechanisms with each other in Section 5. Section 6 concludes.

2. PREVIOUSLY PROPOSED SOLUTIONS TO THE PROBLEM OF LAND ASSEMBLY

Consider a developer who wants to implement a project that requires simultaneous redevelopment of \( n \) properties that have multiple owners. The developer values the combined properties at \( D \), which is the difference between the net present value of the completed project and the present value of the cost of demolishing any existing structures. He offers to purchase the \( n \) properties for an amount \( X \leq D \). It is socially optimal to implement the project if the value of the assembled properties exceeds the sum of the individual property values, that is, if

\[
D > \sum_{i} V_i, \tag{1}
\]

where \( V_i \geq 0 \) is the value of property \( i \).

For the purpose of evaluating a redevelopment project, an attractive definition of a property’s monetary value is the opportunity cost of using the parcel for the project. This opportunity cost is the reservation price of the person who values the property highest in the absence of the project, who can be presumed to be its current owner. Thus a property’s monetary value \( V_i \) is the lowest amount at which its owner would be willing to sell it voluntarily to someone who is not interested in assembling multiple parcels. The owner’s reservation price and therefore the value of his property is likely to vary over time; it is higher when the owner regards moving as a nuisance, and it is lower when the owner intends to move and wants to sell
his property. It is also higher when the owner perceives the prices of alternative properties to be high and lower when the owner perceives those prices to be low. Asking the owner is generally the only way of learning such a highly subjective value.

Let

\[ V_i = \frac{V_i}{\sum_j V_j} \]  

be the relative value of property \( i \) among the \( n \) properties. All mechanisms that we discuss below require that the government estimate these relative values, and some mechanisms also require that the government estimate the joint value of the properties. Let \( \alpha_i \) be the estimate of \( V_i \) and let \( A \) be the estimate of the joint value \( \sum_i V_i \), so that \( \alpha_i A \) is the estimate of the value of property \( i \).

The more precise these estimates are, the more attractive are the proposed mechanisms.

Once an owner learns of a land assembly plan, he knows that the developer believes that the sum of the values of the properties to their current owners is less than the value of the combined properties to the developer. The difference between the values of the assembled and unassembled parcels, \( D - \sum_i V_i \), is the return to assembling the parcels. To capture part of the gain from assembling the parcels, owner \( i \) has an incentive to demand an amount \( S_i \) that exceeds his reservation price in the absence of a possibility of assembly, \( V_i \).\(^3\)

We define any owner who demands an amount \( S_i > V_i \) as a holdout. As long as \( D > \sum_i S_i \), holding out affects only the distribution of the gains from trade and does not lead to inefficient use of land. Holdouts cause social costs when \( \sum_i S_i > D > \sum_i V_i \), because then they force a developer to either abandon a worthwhile project or implement a less efficient version of the project, either on the subset of parcels that he can acquire or at a less desirable location. The social cost of holding out is a direct consequence of each owner’s incentive to free-ride on the

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agreements between the other owners and the developer. With a single owner and a single developer, “holding out” describes the general bargaining situation between two monopolists. With multiple owners who bargain individually with the developer, all owners compete with each other for being the last one to sell his property to the developer and thus for the opportunity to bargain for the entire benefit of assembling the properties that remains after the other owners have been paid off.

Efficiency requires that projects be implemented if and only if $D > \sum_i V_i$, so knowledge of $\sum_i V_i$ is necessary to ensure efficient land assembly. Similarly, knowledge of the $V_i$s is necessary to ensure that all owners receive full compensation for their losses. Because the reservation prices are the owners’ private information, a mechanism that seeks to achieve efficient land assembly and to ensure that all owners receive full compensation must provide each owner with the incentive to reveal truthfully his subjective valuation of his property. However, owners have such an incentive only if the information that they provide will not be used to lower their expected compensation. Thus assembly mechanisms like the one proposed in Shapiro and Pincus (2009) that elicit truth-telling by letting owners directly influence their compensation will not be fully efficient if the total compensation that would need to be paid to elicit truth-telling exceeds $D$ when $D > \sum_i V_i$. In contrast, assembly mechanisms like those that we describe in Sections 3 and 4 that elicit truth-telling by requiring side-payments can lead to efficient land assembly, because the schedule of side-payments can be designed so as to elicit truth-telling when owners expect to receive no more than $V_i$ for their properties. However, such mechanisms might undercompensate some owners when they refund the revenue from the side-payments because the government cannot use the revealed information to determine the appropriate refunds without distorting the owners’ incentive to reveal the $V_i$s. These two types

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4 The same applies to the case of a single developer and a group of owners who are represented by a single entity that bargains on their behalf (see the proposal by Lehavi and Licht, 2007, in Section 2.1).
of assembly mechanisms therefore exemplify the classical tradeoff between efficiency and equity.

2.1. Land assembly mechanisms that do not provide information about $\sum_i V_i$

Lehavi and Licht (2007) accept the need for eminent domain in land assembly but propose separating the taking decision from the problem of compensating the owners by establishing a Special-Purpose Development Corporation that holds the rights to the properties that the government has taken. The government obtains an estimate $A$ of the value of the taken properties by conventional means, and assigns to each owner $i$ a share of the corporation that corresponds to its estimate $\alpha_i$. Every owner has the option of selling his share to the government, thus accepting compensation determined by conventional means. The corporation either enters negotiations with or holds an auction among all competing developers, and distributes among its shareholders the proceeds of selling the properties to the highest bidder. By establishing a single entity that negotiates on behalf of all owners, Lehavi and Licht’s proposal eliminates the opportunity for individual owners to become holdouts.

Heller and Hills (2008) propose replacing eminent domain with private collective bargaining. Their proposal requires owners of properties that are or may become the target of a land assembly to establish a Land Assembly District. The owners of properties within this district collectively decide whether to accept a developer’s offer and how to divide the proceeds from the sale. Heller and Hills propose that each owner receive votes proportional to the relative value of his property within the district, as assessed by conventional means. Because the members of the district do not need to make their decisions unanimously but only according to some qualified majority, individual owners of properties whose market value is a small share of the joint market value cannot become holdouts.
Neither proposal ensures that land assembly occurs if and only if $D > \sum V_i$ because these mechanisms do not provide information about $\sum V_i$. Similarly, neither proposal ensures that owner $i$ receives at least $V_i$, even if the properties are sold for an amount $X > \sum V_i$, because these mechanisms do not provide information about the relative values $v_i$.

Bell and Parchomovski (2007) suggest a self-assessment mechanism in which the government (1) assesses property $i$ at $\alpha_i A$ by conventional means, (2) requires the owner to report a value $S_i$, (3) levies a tax on the amount $\max(\alpha_i A, S_i)$ if the owner does not sell, and (4) requires that the owner be unable to sell his property, for as long as he lives, for any amount less than $S_i$ (or, alternatively, that the owner must remit any difference between $S_i$ and the selling price to the government). The tax liability on $S_i - \alpha_i A$ raises the owner’s cost of overstating $V_i$ (if $V_i > \alpha_i A$) while the elimination of any benefits to the owner from ever selling his property below $S_i$ raises the owner’s cost of understating $V_i$.

The suggestion of imposing a tax as an incentive against overassessment has been part of earlier discussions of self-assessment. However, an arbitrary tax does not provide the owner with the incentive to report $V_i$ truthfully. A tax that is too low (say, 1 cent per $1,000,000 of announced value above $\alpha_i A$) does not provide a sufficient penalty against overassessment, while a tax that is too high (say $0.75 per $1 announced value above $\alpha_i A$) makes it too expensive to

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5 As an example, assume that in a proposed assembly of ten properties, eight owners value their properties at $190,000 each, two owners value their properties at $500,000 each, and the developer is prepared to pay $D = 2,000,000 for the ten properties. The project should not be implemented because $D < \sum V_i$, but it will nevertheless go forward under Heller and Hills’ proposal because the amount offered satisfies 80 percent of the district’s constituents whose eight parcels are worth 60 percent of the joint property value of $2,520,000. If the government underestimates the joint property value—for example, if it estimates the values of the eight low-valued properties correctly but estimates the joint value of the two highly-valued properties at $480,000 or less, then the project will also go forward under Lehavi and Licht’s proposal. In both cases, some owners will necessarily be undercompensated because the proceeds of the sale are not sufficient to fully compensate all owners.

disclose any $V_i > a_iA$. Similarly, the requirement that the owner never benefit from selling his property below $S_i$ creates an appropriate incentive against underassessment only if the owner expects that his subjective valuation will never decrease. Because the mechanism—as Bell and Parchomovsky acknowledge—does not provide accurate information about the $V_i$s, it neither leads to efficient land assembly nor provides full compensation to owners. In addition, a requirement that owners not be allowed, as long as they live, to benefit from selling their properties below the self-assessed values is likely to be viewed as an unacceptable intrusion into property rights when the owners’ subjective valuations fall.

2.2. Land assembly mechanisms that provide owners with an incentive to reveal their subjective valuations

Miceli et al. (2008) devise a reassessment mechanism that leads to efficient land assembly and provides full compensation if either all parcels are owned by a single person who values his properties at the combined value $V$, or all property owners’ subjective valuations are identical. Assume that the government assesses, by conventional means, the properties jointly at $A$ and levies a property tax at rate $t$ on the assessed value. Whenever a developer makes a legitimate offer $X > A$, the government reassesses the properties jointly at $X$, regardless of whether or not the owners accept the offer. Consider the case of a single owner who values his properties jointly net of tax at $V - tA$. A necessary condition for the owner to sell his properties is that the developer’s offer $X$ exceeds the owner’s net-of-tax valuation after reassessment, $V - tX$, or $X > V/(1 + t)$. The developer values the properties net of tax at $D - tX$, and therefore offers $X \leq D/(1 + t)$. Thus the owner will accept the developer’s offer $X$ if

$$\frac{D}{1+t} \geq X \geq \frac{V}{1+t} \iff D \geq V, \tag{3}$$

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7 We show in Section 4 that truthful self-assessment requires that the tax be harmonized in a specific way with the probability that a developer will purchase the property at $\sum S_i$. 
which is the efficiency condition for redeveloping properties that are valued jointly at $V$.

Miceli *et al.* show that their reassessment mechanism leads to efficient land assembly in the case of multiple owners if and only if the owners’ valuations $V_i$ are identical. The intuition for the inefficiency when the $V_i$ are not identical is straightforward—because the developer makes a joint offer for all parcels, it is not obvious how to divide $X$ to ensure that owner $i$’s share at least equals the unknown $V_i/(1 + t)$ so that owner $i$ has an incentive to accept the offer. Because the reassessment mechanism does not provide information about $\sum_i V_i$ when the $V_i$ differ from each other, it does not lead to efficient land assembly. The mechanism also does not guarantee full compensation because the lack of information about the $v_i$s prevents the division of $X$ according to the owners’ relative subjective valuations.

To our knowledge, the mechanism described in Grossman *et al.* (2010) is the only mechanism developed so far that ensures that (1) land assembly occurs only if $D \geq \sum_i V_i$ and (2) owner $i$ receives at least $V_i$ in exchange for his property. However, Grossman *et al.* acknowledge that their mechanism does not provide an efficient solution to the problem of land assembly because it does not ensure that land assembly occurs if $D \geq \sum_i V_i$—that is, the ability of a land assembly proposal to fulfill their requirements represents a sufficient but not a necessary condition for the proposal to be efficient. We will refer to their mechanism by the name they propose—the SP auction.\(^8\)

The SP auction operates as follows: Assume that the government requires each owner to self-assess his property. The government assigns to each property $i$ a fixed share $a_i$ that is independent of the owner’s announcement $S_i$. The government uses the ratio of announced values and estimated shares to set a limit price $M = \max(S_i / a_i)$ that it does not disclose to the

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\(^8\) The authors assume that multiple developers bid for the combined properties in a first-price auction. Because their mechanism ensures that no owner is undercompensated, they label it “Strong Pareto auction,” or “SP auction.”
developer. A developer who offers $X \geq M$ is allowed to assemble the properties, in which case owner $i$ receives $a_i X$.

Owner $i$ announces the amount $S_i$ that maximizes his expected return

$$E_i = F_i(M)V_i + (1 - F_i(M))a_i \int_M^{\bar{X}} X \frac{f_i(X)}{1 - F_i(M)} dX,$$

(4)

where $f_i(X)$ is the density function of owner $i$’s beliefs about the developer’s offer $X$, $\bar{X}$ is the upper limit of the support of $f_i(X)$, and $F_i(M) = \int_0^M f_i(X)dX$ is the owner’s assessment of the probability that the developer’s offer does not exceed $M$. The fraction within the integral is the conditional probability that $X > M$. Setting the derivative of (4) with respect to $M$ equal to zero shows that $E_i$ is maximized if $M = V_i / a_i$. Owner $i$ can affect his expected return only if his announced valuation sets the limit price $M$, so his best strategy is to reveal his subjective valuation $V_i$. If all owners announce their reservation prices and the developer acquires the properties, then owner $i$ receives at least his subjective valuation because $a_i X \geq a_i M = a_i \max(V_j / a_j) \geq V_i$.

Because $M = \max(V_i / a_i) \geq \sum_j V_j$, if owners behave optimally, any arbitrary set of shares ensures that land assembly occurs only if $D \geq \sum_i V_i$. However, for land assembly to occur if $D \geq \sum_i V_i$, it is necessary that $a_i = v_i = V_i / \sum_j V_j$ so that $M^* = v_i / v_i = \sum_j V_j \forall i$. If the government underestimates the subjective valuation $v_i$ of even one owner, then $M = \max(S_i / a_i) > M^*$ and socially worthwhile land assembly projects for which $M > D \geq M^*$ will not be implemented.

By requiring the developer to pay $\max(V_i / a_i) \geq \sum_i V_i$, the SP auction accepts the possibility of reallocating part of the return to assembling the parcels from the developer to the owners. Because the amount of reallocation is determined independently of the return to
assembling the parcels, $D - \sum_i V_i$, it can exceed the return to land assembly and thereby prevent efficient redevelopment. The SP auction cannot ensure efficient land assembly because the government cannot use the revealed $V_i$s to set $M^* = \sum_i V_i$ if it discovers that some of the estimated $\alpha_i$s differ from the revealed $v_i$s, because doing so would lower the return to some owners and thus eliminate the owners’ incentives to reveal the $V_i$s. In the following two sections, we describe two mechanisms that ensure efficient land assembly by eliciting truth-telling through side-payments rather than by adjusting the owners’ compensations directly.

3. EFFICIENT LAND ASSEMBLY UNDER THE CLARKE MECHANISM

Assume that a developer approaches the government with an offer $X$ for the $n$ properties. The government estimates the relative value of each property and assigns to each owner $i$ the amount $\alpha_i X$ as potential compensation. It then requires each owner to state his willingness to pay to secure either the adoption or the rejection of the proposed development, given the compensation payment $\alpha_i X$ that he will receive if the development takes place. Because we have defined the value of property $i$ as the price at which its owner would voluntarily sell the property in the absence of a possibility of assembly, owner $i$ values the opportunity to sell his property for the amount $\alpha_i X$ at $W_i = \alpha_i X - V_i$. A negative $W_i$ represents owner $i$’s willingness to pay to avoid selling his property at $\alpha_i X$. Thus the sum of all owners’ willingnesses to pay is positive if and only if the sum of the offers exceeds the sum of the owners’ reservation prices, or

$$\sum_i W_i > 0 \iff \sum_i \alpha_i X > \sum_i V_i.$$  

(5)

If $\sum_i W_i > 0$, then the developer pays to each owner $i$ the respective compensation $\alpha_i X$ that the government had specified, assembles the parcels, and implements the project. If $\sum_i W_i < 0$, then the project is rejected and the parcels remain unassembled.
To provide owners with an incentive to reveal their willingnesses to pay, each owner \( i \) whose announcement of \( W_i \) causes the sign of \( \sum_j W_j \) to differ from the sign of \( \sum_{j \neq i} W_j \) (a “pivotal” owner) must pay a Clarke tax equal to the absolute value of \( \sum_{j \neq i} W_j \). For example, if \( \sum_{j \neq i} W_j < 0 \) and \( \sum_j W_j > 0 \), then the project would have been rejected had owner \( i \) announced a willingness to pay below \( \left| \sum_{j \neq i} W_j \right| \), but the project is accepted because owner \( i \) has announced \( W_i > \left| \sum_{j \neq i} W_j \right| \). Owner \( i \) therefore pays a Clarke tax equal to \( \left| \sum_{j \neq i} W_j \right| \), which is the margin by which those in favor of rejecting the project would have won in owner \( i \)’s absence. Because the Clarke tax cannot exceed \( W_i = a_iX - V_i \), pivotal owners receive at least their reservation prices if a project is accepted. Non-pivotal owners whose individual announcements do not alter the project’s acceptance or rejection do not pay anything. It is straightforward to show (see, for example, Tideman and Tullock, 1976) that an owner can only make himself worse off by announcing a value that differs from his true willingness to pay for the outcome he desires.

Equation (5) shows that the Clarke mechanism ensures that no inefficient project is implemented. Provided that the developer’s offer is a true measure of the project’s net benefit \( D \), the Clarke mechanism also ensures that efficient projects are implemented. Thus the Clarke mechanism leads to efficiency in land assembly. However, the application of the Clarke mechanism to land assembly will make no owner worse off if and only if either (1) no owner objects to selling his property at \( a_iX \) so that every owner reports a non-negative \( W_i \) and receives \( a_iX \geq V_i \), or (2) the project is rejected by a large enough margin that there are no pivotal owners who must pay Clarke taxes. If a project is accepted when some owners are unwilling to sell their properties at \( a_iX \) and thus announce \( W_i < 0 \), then the owners who object receive \( a_iX < V_i \). If a project is rejected and there are pivotal owners without whom the project would have been accepted, then a pivotal owner’s Clarke tax could be as high as the loss that he reported that he
would suffer from the project. Because the only owners that the Clarke mechanism can make worse off are those who object to selling their properties at \( a_i X \), such redistribution is necessarily the result of underestimating some owners’ relative reservation prices. If all \( a_is \) are accurate and \( X < \sum_i V_i \), then all owners object to selling their properties and no owner pays a Clarke tax. Conversely, if all \( a_is \) are accurate and \( X \geq \sum_i V_i \), then all owners agree to selling their properties and no owners pays a Clarke tax either. Thus like the SP auction, the Clarke mechanism leads to a complete solution of the problem of land assembly if all \( a_is \) are accurate.

To avoid distorting the owners’ incentives to report their \( V_i \) truthfully, the government must dispose of any revenue from Clarke taxes that result from inaccurate estimates \( a_i \) in such a way that no owner receives any part of the Clarke taxes that he pays or causes. This budget imbalance is an unattractive feature of the Clarke mechanism, although the expected tax revenue falls as the number of owners increases. The haphazard redistribution that the Clarke mechanism causes if the government estimates some \( v_is \) incorrectly is problematic as well. Thus it is useful to examine whether there is a more attractive alternative.

4. EFFICIENT LAND ASSEMBLY UNDER THE PT MECHANISM

Consider a government that requires every owner to state the price at which he would voluntarily sell his property. The government makes underassessment costly by requiring that the owner accept a developer’s offer to buy the property at the stated price. The government makes overassessment costly by requiring that the owner pay a valuation tax that varies with the price that he states. The task is to harmonize both incentives in a way that motivates each owner \( i \) to reveal his reservation price \( V_i \).

To simplify the notation, define \( S = \sum_i s_i \) as the sum of the values that the owners announce. Let \( p(S) \) be the probability that a developer will offer to purchase the \( n \) properties if the price is \( S \). It is reasonable to assume that this probability does not rise with \( S \), so we assume
dp(S)/dS = dp(S)/dSi ≤ 0 ∀ i. The government requires that owner i pay a valuation tax Ti(S) if no developer purchases the properties at S, then owner i’s return πi is πi = Vi − Ti(S), while his return is πi = Si − Ti(S) if he has to sell his property to a developer at Si. The owner receives utility Ui(πi) from his property. We assume that his utility function is twice differentiable with U'′(πi) > 0 and U'′′(πi) < 0, which corresponds to the assumption that the owner is risk averse.9

We assume further that each owner considers only his personal loss when his property becomes part of a land assembly and ignores the effect of dp(S)/dSi on the expected losses of other owners. Owner i therefore maximizes his expected utility

\[
E[U_i] = [1 − p(S)]U_i(V_i − Ti(S)) + p(S)U_i(S_i − Ti(S))
\]

by identifying the value of Si that satisfies his first order condition

\[
dE[U_i] = \frac{dp(S)}{dS_i} \left( U_i(S_i − Ti(S)) − U_i(V_i − Ti(S)) \right) - U'_i(V_i − Ti(S)) \frac{dT_i(S)}{dS_i} [1 − p(S)] + U'_i(S_i − Ti(S))(1 − \frac{dT_i(S)}{dS_i})p(S) = 0.
\]

To provide the owner with an incentive to reveal Vi, the government sets Ti(S) so that the first order condition holds if and only if Si = Vi, which requires10

\[
\frac{dT(S)}{dS_i} [1 − p(S)] = (1 − \frac{dT_i(S)}{dS_i})p(S)
\]

⇔ \[
\frac{dT_i(S)}{dS_i} = p(S)
\]

⇔ \[
T_i^*(S) = \int_{L_i}^{S} p(z)dz − C_i,
\]

where Li does not vary with Si and Ci is a constant that we interpret as a lump-sum tax refund below. The optimal tax simplifies owner i’s first order condition (7) to

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9 If the probability that someone buys the n properties at S strictly falls as Si increases (that is, if dp(S)/dSi < 0), then we can also admit risk neutral owners for whom U'′(πi) = 0. The PT mechanism fails if owners are risk loving.

10 Thus an arbitrary tax, as in the mechanism proposed in Bell and Parchomovsky (2007), does not provide owner i with an incentive to reveal Vi.
\[
\frac{dE[U_i]}{dS_i} = \frac{dp(S)}{dS_i} \left( U_i(S_i - T_i^*(S)) - U_i(V_i - T_i^*(S)) \right) \\
+ \left[ p(S) - p(S)^2 \right] \left( U_i'(S_i - T_i^*(S)) - U_i'(V_i - T_i^*(S)) \right) = 0
\] (9)

so that \(dE[U_i]/dS_i < 0\) if owner \(i\) reports \(S_i > V_i\), and \(dE[U_i]/dS_i > 0\) if owner \(i\) reports \(S_i < V_i\).\(^{11}\)

We show in the appendix that \(dE[U_i]/dS_i\) is strictly concave if \(T_i(S) = T_i^*(S)\), which implies that owner \(i\) maximizes his utility by announcing \(S_i = V_i\).\(^{12}\)

A developer who wants to assemble multiple parcels can acquire them by simply paying \(S_i\) to each owner \(i\). The mechanism solves the holdout problem because owners cannot revise their reservation prices when they learn the developer’s offer. Because the mechanism provides owners with the incentive to announce their true reservation prices \(V_i\) and because the developer will acquire the properties only if \(D \geq \sum_i V_i\), the mechanism also ensures that only worthwhile projects are implemented. Finally, because each owner receives his reservation price when the developer assembles the parcels, the mechanism ensures that owners are fully compensated for their lost properties, apart from their valuation tax payments. If society accepts the principle of eminent domain and thus considers it socially advantageous to transfer properties to a developer if \(D \geq \sum_i V_i\), then the requirement that owner \(i\) sell his property at \(V_i\) ought to constitute a socially acceptable intrusion into established property rights.

If \(L_i = S - S_i\) (which implies \(dL_i/dS_i = 0\) as required for truth-telling) and \(C_i = 0\), then owner \(i\)’s valuation tax equals his expected loss if the developer purchases his property. Thus

---

\(^{11}\) First, assume that \(dp(S)/dS_i < 0\) and \(U_i'(\pi_i) \leq 0\). If \(S_i > V_i\), then the first term in equation (9) is negative because of the assumptions \(dp(S)/S_i < 0\) and \(U_i'(\pi_i) > 0\), and the second term is non-positive because of the assumptions \(0 < p(S) \leq 1\) and \(U_i'(\pi_i) \leq 0\), which implies that \(dEU/dS_i\) is negative. The same assumptions imply that, if \(S_i < V_i\), then the first term is positive and the second term is non-negative so that \(dEU/dS_i\) is positive. Second, assume that \(dp(S)/S_i = 0\) and \(U_i'(\pi_i) < 0\), in which case the first term is always zero. If \(S_i > V_i\), then the second term is negative, and if \(S_i < V_i\) then the second term is positive. It is straightforward to verify that \(dEU/dS_i = 0\) if \(S_i = V_i\).

\(^{12}\) If owner \(i\)’s net valuation tax burden is small so that the income effect of the tax can be ignored (for example, if the government reduces the tax burden by returning the tax revenue or by paying assessment compensation, see below), then the owner does not need to know his actual net tax burden when deciding whether or not to reveal \(V_i\) as long as he believes that the government will charge him the optimal tax \(T_i^*(S)\) once it learns \(S\).
the valuation tax can be interpreted as an insurance premium, and it is intuitive that a tax that equals the expected loss provides an owner with the incentive to fully insure his property (that is, to reveal his subjective valuation). Because the developer rather than the government compensates the owner for such a loss if the property becomes part of a land assembly, the government can reduce the valuation tax burden by returning the tax revenue to the owners as “assessment compensation.” It can do so without distorting the owners’ incentives to reveal their reservation prices by assigning each owner to one of two groups, and using the tax proceeds from each group to compensate the members of the other group, in proportion to estimates $a_i$ that are independent of the revealed $S_i$. The owners then do not bear any tax burden on average. We will refer to this compensation rule as C1. An alternative compensation rule, C2, requires that the government use its estimate $a_iA$ together with the valuations of all owners other than owner $i$ to determine owner $i$’s expected valuation tax $C_i = \int_{S_i}^{S-S_i+a_iA} p(z)dz$ and pay this amount to owner $i$ as assessment compensation. If $A < S$, then the government must dispose of a surplus, which it can return to the owners in the same way as under C1, and it must cover a deficit if $A > S$.

There is a third compensation rule, C3, that requires only an estimate $A$ but does not require estimates of the shares; it involves setting $L_i = 0$, so that the integral in equation (8) does not depend on $S_i$ and all owners pay an identical tax. If each owner’s assessment compensation equals his expected tax payment, $C = \int_0^A p(z)dz$, then his valuation tax net of assessment compensation is

$$T_i^*(S) = T^*(S) = \int_0^S p(z)dz - \int_0^A p(z)dz. \quad (10)$$

As under compensation rule C2, the government must dispose of a surplus if $A < S$ and it must cover a deficit if $A > S$. If $A = S$ and owners behave optimally so that $S = \sum_i V_i$, then there is no budget imbalance and each owner’s net valuation tax payment is zero. In Section 5, we evaluate the social costs of the unintended redistribution that arise from the three compensation rules.
It is not necessary to apply the PT mechanism before a potential developer has been identified; the mechanism works equally well if the government requires owners to self-assess their properties after a developer has expressed interest in assembling the parcels but before he has made an offer. The government determines the probability schedule $p(S)$ using its own density function of beliefs about the developer’s offer. If it turns out that the developer’s offer $X$ exceeds $S$, then the developer pays $S$ to acquire the properties and, if rule C2 or C3 is in use, the government uses the remaining $X - S$ to cover or reduce the deficits that arise when $A > S$. Like the SP auction, the PT mechanism provides total net compensation to owners that exceeds $S$ under compensation rules C2 and C3 if $A > S$, although taxpayers need to fund the part of the deficit not covered by $X - S$. In contrast to the SP auction, however, the PT mechanism motivates efficient land assembly even when $A > D > S = \sum_i V_i$ because taxpayers rather than the developer are asked to bear the cost of the overassessment, $A - D$. The main problem of applying the PT mechanism after a developer has expressed interest in assembling the parcels is that $p(S)$ and therefore the valuation tax payments are likely to be high, which increases the degree of unintended redistribution that arises from the assessment compensation payments if either $A$ or the $a_i$’s are not very accurate.

Owners have an incentive to announce their true reservation prices only if they believe that their marginal valuation taxes equal the probability that a developer will assemble the properties at $S$. Equation (7) indicates that owner $i$ will report $S_i > V_i$ if he believes that $dT(S_i)/dS_i$ exceeds $p(S)$, and $S_i < V_i$ if he believes that the marginal valuation tax is smaller than the probability of development. Unlike the SP auction, which assumes that owners act upon their own beliefs about the distribution of $D$, the PT mechanism requires that owners believe that the government has identified this distribution and has determined the correct probability schedule. However, while owners are likely to have reasonably accurate knowledge of the conditions and salability of their properties in regular sales, they are much less likely to have private information about how attractive their properties are for developers who want to acquire
and redevelop multiple properties. Thus it is not entirely unreasonable to expect that owners will agree with an honest third-party estimate of the probability schedule of redevelopment.

We acknowledge that it may be difficult for anyone to assess the probability distribution of land assembly with any acceptable degree of accuracy. While it would be unrealistic to expect anyone to gather such information in general, it might nevertheless be possible to obtain such estimates for blighted areas that local governments have identified as targets for urban redevelopment. To reduce the possibility that motivations other than efficiency considerations affect the estimate of $p(S)$, it is desirable to entrust someone with the task of estimating these probabilities who does not have a direct stake in the outcome. For example, citizens may put higher trust in estimates obtained by a federal agency that provides such estimates for development projects in different localities than in estimates obtained by the local government. It is also worth noting that the PT self-assessment mechanism does not require a correct estimate of the probability of land assembly, but only that owners believe that the estimate is correct and that the government has set the appropriate valuation tax rate. Nevertheless, the fact that the owners’ incentives to reveal their reservation prices depend on the owners’ beliefs that the estimate of the probability schedule of land assembly is correct is a genuine limitation of the PT mechanism.

5. COMPARISON OF LAND ASSEMBLY MECHANISMS
Table 1 compares the seven mechanisms discussed in this paper according to their efficiency and whether they compensate owners for their losses. The mechanisms proposed by Bell and Parchomovsky (2007) and Miceli et al. (2008) do not lead to efficient land assembly if there are multiple owners whose subjective valuations of their properties differ. The five mechanisms that can solve the land assembly problem in principle perform very well if it is possible to obtain accurate estimates of the joint value and/or the relative values of all properties in ways other than asking the owners to reveal their valuations, and poorly otherwise. However, the requirements
differ across mechanisms. Eminent domain as well as the mechanisms proposed in Lehavi and Licht (2007) and Heller and Hills (2008) lead to efficient land assembly if it is possible to estimate $\sum_i V_i$ accurately, and they provide owners with full compensation if it is possible to obtain accurate estimates of the $V_i$s. The SP auction always provides owners with at least full compensation, and it leads to efficient land assembly if the estimates of all $v_i$s are accurate. The Clarke mechanism always leads to efficient land assembly as long as losses and gains are weighted equally, and it ensures full compensation and no budget imbalance if all $v_i$s are accurate. Finally, the PT mechanism always leads to efficient land assembly, provided that the owners believe that the government uses an accurate estimate of $p(S)$ when setting the valuation tax, and it provides owners with full compensation if the government obtains $n$ accurate estimates of the $v_i$s (for compensation rule C1), the $V_i$s (for compensation rule C2), or an accurate estimate of $\sum_i V_i$ (for compensation rule C3). Thus the PT mechanism requires a believable estimate of $p(S)$ and either one accurate estimate of the joint property value or $n$ accurate estimates of either the individual property values or their shares to solve the land assembly problem, while all other mechanisms require $n$ accurate estimates of either the individual property values or their shares to solve the problem of land assembly.

The Clarke mechanism and the PT mechanism both apply the principle of marginal cost pricing to achieve efficient land assembly. The Clarke mechanism requires knowledge of the developer’s offer $X$; it leads to efficient land assembly by charging each pivotal owner whose announcement either leads to or prevents a land assembly the net cost that changing the outcome imposes on all other owners. In contrast, the PT mechanism requires knowledge of the density function of $X$ for different total announcements $S$, and it charges each owner the expected cost if a developer acquires them. If $L_i = 0$, then each owner is asked to pay the expected loss of all owners, while each owner must bear only his own expected loss if $L_i = S - S_i$. Because the marginal effect of each owner’s announcement on the expected joint loss and his expected
individual loss is the same, both $L_i$ provide owner $i$ with the incentive to reveal $V_i$. By asking each owner at which value he would be willing to sell his property rather than how much he would be willing to pay to either avoid selling or be able to sell his property at $a_i X$, the PT mechanism avoids the Clarke mechanism’s unattractive characteristic of charging pivotal owners a fee for announcing an amount that prevents an inefficient land assembly.

To assess the cost of inaccurate estimates, we compare the expected social cost of foregone efficient development under the SP auction with the net valuation tax payments under the PT mechanism. To link the two mechanisms, we assume that developers always offer $X = D$ and that all owners agree with the government’s estimate of the density function of the offer, so that $f_i(X) = f_i(D) = f(D)$, and $p(D) = 1 - F(D)$. Given a set of estimates of the relative shares and the resulting limit value $M$, the probability of foregoing efficient development under the SP auction, which occurs if $M > D > \sum_i V_i$, is $F(M) - F(\sum_i V_i)$. Thus the expected social cost of the SP auction for a given value of $M$ is

$$
\Gamma_{SP} = (F(M) - F(\sum_i V_i)) \int_{D-\sum_i V_i}^M (D-\sum_i V_i) \frac{f(D)}{F(M) - F(\sum_i V_i)} dD
$$

and the net valuation tax revenue of the PT mechanism is

$$
\Gamma_{PT} = \sum_i \left( \int_{L_i}^{\sum_i V_i} (1 - F(z)) dz - C_i \right),
$$

where the functions $L_i$ and $C_i$ determine the assessment compensation rule.

As a numerical example, we consider a land assembly project with eight properties that are valued jointly at $2$, where four owners value their properties at $0.2$ and four owners at $0.3$. We assume that $f(D)$ is exponentially distributed with unit scale parameter, so that the probability

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13 The social cost of the Clarke mechanism depends on the distributions of the $v_i$s and the $a_i$s. In our numerical example, we assume symmetric deviations of the $a_i$s from the $v_i$s so that no owner pays a Clarke tax and the Clarke mechanism is fully efficient. We leave a more systematic analysis of the social cost of the Clarke mechanism for future research.
of land assembly at $\sum V_i = 2$ is 22.31%. We compare positive and negative net valuation tax payments by assuming that each dollar of positive (= uncompensated) net payments is weighted twice as heavily as a dollar of negative (= overcompensated) net payments.\(^{14}\)

Figure 1 shows the social costs, expressed as shares of $\sum V_i$, of the SP auction and the PT mechanism, under the three assessment compensation rules, for degrees of accuracy of $A$ and the $a_i$s that decrease from perfect accuracy to underassessment of 80%.\(^{15}\) For the SP auction, the social cost of not assembling the eight properties when $M > D > \sum V_i$ increases with inaccuracy and levels off at about 20% of joint property value if the largest underestimate of a share exceeds 50%. For the PT mechanism, under compensation rules C1 (when $L_i = S - S_i$) and C2 (when $L_i = S - S_i + a_iA$) and the government returns the valuation tax revenue according to the estimated $a_i$s, the social cost increases linearly and reaches only 4% of joint property value when the $a_i$s differ from the $v_i$s by 50%. Under rule C3, when $L_i = 0$ and each owner’s assessment compensation equals his expected tax $\int_0^1 (1 - F(z))dz$, the social cost reaches one fourth of the joint property value when the government underestimates $\sum V_i$ by about 40%. Thus the social cost of the PT mechanism under C3 increases quickly as the accuracy of $A$ and the $a_i$s falls, while the social cost of the PT mechanism under C1 and C2 increases much more slowly and is likely to be below the social cost of the SP auction for all relevant degrees of accuracy.

\(^{14}\) Because the government can return the tax revenue to the owners without distorting their incentives to reveal the $V_i$s so that the average loss is zero (see section 4), the expected social cost of the PT mechanism is zero if gains and losses are weighted equally. Thus the relative attractiveness of the PT mechanism and the SP auction depends on how much additional weight society assigns to losses.

\(^{15}\) To keep the analysis simple, we assume that the accuracies of $A$ and the $a_i$s decrease at the same rate, and we ignore cases where $A > S$ and the PT mechanism leads to budget deficits under compensation rules C2 and C3 that would need to be covered by (possibly distortive) additional taxes.
7. CONCLUSION

The difficulty of identifying holdouts makes it difficult to obtain a reliable estimate of the frequency and the social cost of holdouts. A holdout can be identified unambiguously only when a developer and an owner agree on a selling price after the owner had initially demanded a higher price. In all other cases, one has only the owner’s statement about his reservation price. A developer who anticipates costly holdouts might not attempt to assemble the parcels, so that the possibility of refusing to sell does not arise. Similarly, if governments are permitted to take private properties under eminent domain, then the mere threat of invoking eminent domain may induce owners to sell their properties if they fear that their compensation for taken properties would be below the developer’s offer, thereby creating the appearance that the developer and owners were able to reach voluntary agreements. Conversely, invoking eminent domain precludes any agreement between the developer and the owners that might otherwise have been reached, thereby creating the impression of a holdout problem that bargaining could not resolve. The same appearance of a socially costly holdout arises whenever a developer decides to implement his project elsewhere after encountering owners who decline to sell, when it could be the case that no agreement was possible.

The lack of reliable estimates of the frequency and cost of holdouts makes it impossible to determine whether either private bargaining or government intervention generally minimizes the expected social cost of land assembly. However, the expected cost of relying on private bargaining is highest when socially costly holdouts are most likely to occur. Owners are most likely to hold out when they believe that purchases of multiple properties may be motivated by a plan to assemble the parcels, when they believe that the value of the assembled parcels is much higher than that of the unassembled properties, when all parcels need to be assembled to
implement the project, and when developers find it difficult to implement a comparable project elsewhere. Urban renewal projects are the land assembly projects most likely to meet these criteria, which makes it most relevant to consider alternatives to private bargaining in this context.

Of the seven mechanisms that we discuss in this paper, we consider the SP auction and the PT mechanism the most attractive alternatives to eminent domain. However, neither mechanism is perfect. The main shortcoming of the SP auction is that governments are likely to underestimate the relative subjective value of at least one owner so that the limit price at which the developer is permitted to acquire the parcels exceeds the sum of the owners’ reservation prices. Thus those in favor of the redevelopment have an incentive to pressure the government to reconsider its estimates. After all, a major objection to the use of eminent domain is that governments tend to underestimate the value of property, and underassessment that leads to inefficient redevelopment under eminent domain can prevent efficient redevelopment under the SP auction. Thus the complaints about government assessments that arise with the use of eminent domain are likely to continue under the SP auction.

The main shortcoming of the PT mechanism is the requirement that owners and the government have identical beliefs regarding the probabilities with which a developer is willing to purchase the properties at different prices. Even if a developer has already expressed interest in assembling the properties, the characteristics of his project might be sufficiently different from those of comparable projects to make it very costly to obtain a believable estimate of this probability schedule. However, government takings under eminent domain do not lead to efficient land assembly if the government estimates the values of the properties involved incorrectly. The estimation of property values is particularly difficult for properties that have not
been sold recently, as it is often the case with properties in areas targeted for urban renewal, and obtaining acceptable estimates of either the total or the relative property values in ways other than asking the owners may be impossible in such cases. Thus whether citizens prefer their government to use eminent domain, the SP auction, or the PT mechanism can be expected to depend on their beliefs about the ability of their government to estimate actual values of properties, relative values of properties, or the probability of land assembly. If they do not trust their government to do any with acceptable accuracy, then they must require that all land assembly projects be resolved through bargaining alone, and they must be prepared to bear the cost when holdouts prevent socially beneficial redevelopment.
Table 1. Comparison of Recent Proposals to Solve the Problem of Land Assembly

<table>
<thead>
<tr>
<th></th>
<th>Efficient land assembly:</th>
<th>Full compensation:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eliminates the incentive possibility for individual holdouts</td>
<td>Ensures that development occurs if $D &gt; \sum_i V_i$</td>
</tr>
<tr>
<td>Lehavi and Licht (2007)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Heller and Hills (2007)</td>
<td>X$^1$</td>
<td></td>
</tr>
<tr>
<td>Bell and Parchomovski (2008)</td>
<td></td>
<td></td>
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<tr>
<td>Miceli et al. (2008)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>owners’ subjective valuations are identical</td>
<td></td>
</tr>
<tr>
<td></td>
<td>owners’ subjective valuations differ</td>
<td></td>
</tr>
<tr>
<td>SP auction (Grossman et. Al., 2010)</td>
<td>X</td>
<td>X</td>
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<tr>
<td>PT self-assessment mechanism</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Clarke mechanism</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Notes:
$^1$ For any owner whose property is a small share of the combined value.
$^2$ Estimating all relative subjective valuations correctly ensures that development will occur if $D > \sum_i V_i$. 

Requires government to estimate $v_i$ correctly so as to:
- achieve efficiency
- achieve full compensation
- avoid unintended redistribution
Figure 1. Comparison of the relative social costs of the SP auction and the PT mechanism
Appendix: The 2nd order condition for the PT mechanism

The derivative of the first-order condition (7) with respect to $S_i$ is
\[
\frac{d^2 \mathbb{E}[U_i]}{(dS_i)^2} = \frac{d^2 p(S)}{(dS_i)^2} [U_i(S_i - T_i(S)) - U_i(V_i - T_i(S))] \\
+ U_i'(S_i - T_i(S))[1 - \frac{dT_i(S)}{dS_i}] p(S) + U_i''(V_i - T_i(S)) \left( \frac{dT_i(S)}{dS_i} \right)^2 [1 - p(S)] \\
+ U_i''(S_i - T_i(S)) [2 \left(1 - \frac{dT_i(S)}{dS_i}\right) \frac{dp(S)}{dS_i} - \frac{d^2 T_i(S)}{(dS_i)^2} p(S)] \\
+ U_i''(V_i - T_i(S)) [2 \frac{dp(S)}{dS_i} \frac{dT_i(S)}{dS_i} - [1 - p(S)] \frac{d^2 T_i(S)}{(dS_i)^2}].
\] (A1)

Evaluating (A1) at $\frac{dT_i(S)}{dS_i} = p(S)$ yields
\[
\frac{d^2 \mathbb{E}[U_i]}{(dS_i)^2} = \frac{d^2 p(S)}{(dS_i)^2} [U_i(S_i - T_i(S)) - U_i(V_i - T_i(S))] \\
+ U_i''(S_i - T_i(S)) [1 - p(S)]^2 p(S) + U_i''(V_i - T_i(S)) p(S)^2 [1 - p(S)] \\
+ U_i''(S_i - T_i(S)) [2 \frac{dp(S)}{dS_i} (1 - p(S)) - \frac{dp(S)}{dS_i} p(S)] \\
+ U_i''(V_i - T_i(S)) [2 \frac{dp(S)}{dS_i} p(S) - \frac{dp(S)}{dS_i} [1 - p(S)].
\] (A2)

Owner $i$ maximizes his utility by choosing $S_i = V_i$, which implies
\[
\frac{d^2 \mathbb{E}[U_i]}{(dS_i)^2} = U_i''(V_i - T_i(S)) [p(S) - p(S)^2] \\
+ U_i'(V_i - T_i(S)) \frac{dp(S)}{dS_i} (3 - 2p(S)).
\] (A3)

The first term is non-positive because of the assumptions $U_i'' \leq 0$ and $0 \leq p(S) < 1$, and the second term is non-positive because of the assumptions $U_i' > 0$ and $dp(S)/dS_i \leq 0$. Because we assume $dp(S)/dS_i < 0$ for risk-neutral owners ($U_i'' = 0$) and $dp(S)/dS_i \leq 0$ for risk-averse owners ($U_i'' < 0$), equation A3 is always negative. It follows that $S_i = V_i$ maximizes owner $i$’s utility.
References:


