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Efficiency and fairness: Compensation for takings

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ABSTRACT

Fairness as well as efficiency is an important aspect of compensation if land is condemned for public use. Much of the economics literature focuses on the efficiency aspect of compensation while equity considerations are given far smaller space. For a limited set of public projects, those for which the entire benefit is captured in land values, compensation at the market value of non-taken land is shown to induce efficient choices by both the bureau that makes the taking choice and the landowners whose property is affected by those choices. The compensation rule is self-financing if the bureau's expenditures are financed entirely by an ad valorem property tax. The generality of the conclusion is limited by the motives of the bureau and the order in which the decisions are made.

1. Introduction

It is well known that the Fifth Amendment to the US Constitution allows for the public condemnation of private property if the affected property owner is justly compensated. The constitution leaves open what is just in the face of a government taking. In practice a just compensation is equated with the market value at the time the property is condemned. The effect on surrounding land values is not considered when computing the compensable amount. This exclusion has been upheld by the courts. In the case of United States v. Reynolds[1] the Supreme Court wrote "The Court early recognized that the 'market value' of property condemned can be affected, adversely or favorably, by the imminence of the very public project that makes the condemnation necessary. And it was perceived that to permit compensation to be either reduced or increased because of an alteration in market value attributable to the project itself would not lead to the 'just compensation' that the Constitution requires."[2] Our proposal flies in the face of long precedent: we argue that in some limited circumstances, compensating condemned property owners at the public project enhanced value, rather than the market value at the time of condemnation, is both equitable and efficient. We hope to prompt a rethinking of the long-standing precedent.

There are two distinct issues when considering compensation for a public taking of private property. First it must be recognized that the compensation rule can affect the decision of both the government and the landowners. The rate at which landowners must be paid for their condemned property may affect the public's choice of how much land to condemn: the higher the compensation the smaller is the size of the condemnation. In addition, the knowledge of potential compensation can influence landowners' choice of property improvements. If landowners are compensated for all improvements to their land, they will have no incentive to incorporate the possibility of condemnation and destruction of the capital improvements. As a result more is invested than is efficient.

Equity is an equally important consideration for a just compensation. In the US Supreme Court 1960 decision on Armstrong v. United States,[3] the majority opinion was that "[t]he Fifth Amendment's guarantee . . .[is] designed to bar Government from forcing some people alone to bear public burdens which, in all fairness and justice, should be borne by the public as a whole." Condemning land for public use creates winners and losers. A large number of people, those whose property is not condemned, benefit at the expense of a much smaller minority who must surrender their property. Even when compensation is equal to the pre-taking value of property, as it is most commonly, the owners of condemned property lose relative to those escaping condemnation.

The economics literature has concentrated on the efficiency aspects of compensation with little written about the "just" part

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[1] United States v. Reynolds, 397 US 14 (1970).

[2] United States v. Reynolds, 397 US 14,16 (1970) citing e.g. Shoemaker v. United States, 147 US 282 (1893).

[3] Armstrong v. United States, 364 US 40 (1960).

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of the "just compensation" admonition. An early work by Johnson (1977) focuses on the governmentally induced distortions of a bureaucracy faced with unreasonably low prices for land taken. Without prices regulatory planning is inefficient—the need to pay compensation constrains an avaricious government. In Blume, Rubinfeld, and Shapiro (1984) another line of inquiry was launched. They suggest that full compensation induces landowners to over-invest because they will not take into account the potential of condemnation-induced loss. Fischel and Shapiro (1988, 1989) pursue a similar line of inquiry from a constitutional perspective. They derive the compensation rule a group of landowners choose if they do not know whose property is to be condemned. Unless the government is a true welfare maximizer or one that cannot be persuaded by costs, the landowners, behind the veil of ignorance, chose positive, but not full compensation. Miceli and Segerson (1994, 1996) suggest that with enlightened judicial intervention, full compensation does not distort land investment choices. They are among the first economists to raise concerns about fairness as well as efficiency. Innes (1997, 2000), notes that compensation can affect the timing of individual decisions. Without compensation landowners are induced to time investment inefficiently with potential confiscation in mind. In a paper that influenced our thinking, Nosal (2001) proposes compensation not based on the market value of the taken property, but, rather, on the average value of all property. Landowners, unable to influence their own potential compensation, are led to choose efficient levels of capital improvements. The most notable attempt to incorporate perceived equity into the analysis is found in Michelman (1967). The paper suggests quantifying (putting a dollar value on) the demoralization of citizens because they perceive a threat to the integrity of their own property rights and empathize with others so threatened.

It is our intention to examine the possibility of finding compensation rules that are both efficient and equitable. Whether or not there is such a compensation rule depends both on the motives of the participants (the government and the landowners) and the process by which the taking and property improvement decisions are made.

As a beginning we propose the following criteria for judging whether or not a compensation rule is efficient and/or equitable:

1. A compensation rule is efficient, if the resulting amount of land taken and the amount of investment on the land are such that it is impossible, by adjustments in either the amount of land taken and/or the amount of investment on the land, to increase the net output (output of both private and public goods less costs) in the community.
2. A compensation rule is equitable:
   (a) Ex post if the post-taking income for those whose land is taken and those whose land is not taken is equal. This high standard of equity is equivalent to that proposed by Epstein: "... the ideal solution is to leave the individual owner in a position of indifference between the taking by government and retention of the property."[4]
   (b) Ex ante if all landowners, regardless of whether their land is taken or not have the same expected income.

We attempt to get a grip on the taking efficiency–equity problem by treating it as a game. There are some problems in setting up this game. The first is that it is difficult to fully account for the participants in the game. We focus the analysis by limiting the game to two types of players. There is the government, or perhaps, more accurately, the bureaucracy that makes the taking decisions, and the landowners. But even this two-part partition is insufficient. It is further specified that the landowners are many, none of whom have much market power and cannot collude. The important issues will be how much land should be taken, and how much an individual landowner should invest on the land. Each landowner-decision maker has power to affect only his own parcel (one that constitutes a trivial part of the whole) and not the investment on the entire land area.

While the costs of most takings are specific, they fall on the owner of condemned land, the benefits are often diffuse. We limit the forthcoming analysis to those public projects whose benefits are fully captured by the landowners in the form of increased profitability.

We find that what is feasible depends on who knows what and when. Many papers on taking rules, those that claim to have discovered ones that promote efficient choices, have compensation rules based on foreknowledge of what amount of private investment is optimal. If the efficient choices are known, it seems superfluous to use compensation rules to achieve them. The efficient options need only be mandated. What we will be looking for are compensation rules – rules that apply to the government (or bureaucracy) as well as the landowners – that are independent of knowledge of the socially efficient choices.

It is a feature of all models that players' objectives must be specified. While these objectives might be very complicated, we intend to analyze a world in which they are quite simple. The landowners seek only to make their annual income as high as possible (they are risk neutral). For the objectives of the government (bureaucracy) we use the two associated with Niskanen (1994). The government seeks to maximize its total budget or its surplus (budget less real costs). The former is labeled a Niskanen1 and the latter as a Niskanen2 government.

It is well understood what is meant by efficiency, but equity is another matter. A sensible notion of equity is that likes are treated equally. The application of the easily stated concept is more difficult. First, how do we know when two people are alike? In what follows, landowners are indistinguishable from one-another. There would appear to be no problem here, however, there is difficulty even at the conceptual level. What is meant by equal treatment? It is reasonable to assert that it is equitable, no matter the outcome, if like citizens have the same chances ex ante. Another more stringent requirement is that equity be judged on the ex post outcome. A policy is equitable if it results in an equal outcome for all citizens. Economists tend to favor the first notion while public policy is often guided by the second.

2. The model

The model aims at determining the amount of land the government chooses to take, represented by the symbol q and the amount that landowners invest in the land, represented by x. We distinguish between land that is taken and that which is not by the subscripts t and $-t$, respectively. Government revenue is raised through an ad valorem property tax, the rate of which is represented by τ. The rate of interest is denoted by r. The rate at which output is produced on land is represented by a production function $f(x, q)$, that is a strictly quasiconcave function of both the landowner's investment decision and the size of the public project, where $f_x(x, q) > 0$, $f_q(x, q) > 0$ and $f_{xq}(x, q) > 0$. Landowners will act to maximize their income denoted by y. The government must pay compensation for the land taken. Such compensation is represented by C.

The model developed here focuses on the taking of land for a public project whose full benefits are captured in the market values of the surviving property. While there are many such projects, road

[4] Epstein (1985) p. 182.

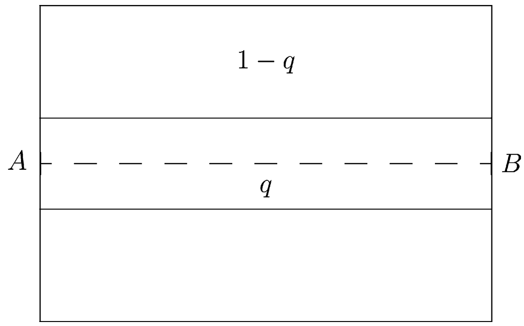

Fig. 1. The proposed road and surrounding environs.

building is a common example and is the one we will use. The particular aspects of a road is that land is consumed in its completion, surviving land benefits from increased accessibility and improved access leads to higher values for the uncondemned property.

Takings involve two distinct actors, each with their own objective and each with distinct strategic choices to achieve those objectives. There are landowners who choose the level of capital improvements in order to maximize annual income. There is the government that decides how much and which land to acquire through condemnation to satisfy its objectives. Since the decisions of one of the participants affects the choices of the others the process is modeled as a game between landowners and bureaucrats.[5] In order to model the game we first specify the components of it. The first aspect is the environment in which the game is played; the second is the technology of production from the land; the third is the landowners' objectives and strategies and the fourth is the bureaucracy's objectives and strategies.

2.1. The background

Fig. 1 represents the illustrative example. A road is to be built in a community with unit area. The bureaucracy is to decide how large a road to build, and as a consequence, how much land to take. The decision can be for any area, q, no larger than the whole, 1. Before the road is built, the land is homogeneous, one plot is indistinguishable from another. We assume that the landowner holdings run the length of the road.[6] The benefit of the road is represented by increased land productivity and the benefit is the same for all land that is not taken.[7]

All costs incurred will be stated as annual flows. The rate of interest is known and fixed in perpetuity at r. The government is required to pay C dollars per unit of land taken and its total cost is qC. It could sell bonds to finance the project that would require an annual debt service of $c = rqC$. Rather than writing the financial transactions this way, we simply state the annual payment to the landowners of the condemned property owners as c.[8] The only source of revenue for debt service is an ad valorem property tax at a fixed rate τ. The tax rate is set as a result of a complex political process to address a continuum of issues and as a result the probability that τ is set equal to any particular value is equal to zero. The amount collected must be adequate to fully service the debt.

2.2. The technology

We consider the possible takings as a choice between land that, prior to the taking decision, is indistinguishable: every piece is as productive as every other. However, once the condemnation policy is in place there are two types of land: the taken and untaken. We distinguish between these two types with the subscripts t and $-t$, respectively. If a property is taken it produces no output. The output from the untaken land is a function of the capital improvements, x, and the size of the public project, q. We have the road example in mind with this formulation: output is land-based produce at market. Thus, without a road, it would be impossible to get goods to market and without some capital investment it would be impossible to grow the crops. The goods-at-market is a strictly quasiconcave function, $f()$, of the amount of capital expenditures and the size of the public project. The output of untaken land is $f(x_{-t}, q)$ and is zero from that condemned, with the conditions that $f_{-t}(0, q) = f_{-t}(x, 0) = 0$, and both of the first partial derivatives are positive. We also assume that the cross partial derivative is positive as well. The quasiconcavity of the production function implies that both second derivatives are negative and that the Hessian matrix is negative semi-definite.

2.3. The landowner

There are many landowners, enough so that no one of them has significant market power. Whether or not there is a continuum of landowners or simply many makes no difference here. Naturally, landowners will have discrete parcels, but the taken amount does not necessarily conform to an individual's entire holdings. For our analysis, if a fraction of a landholding is condemned, the owner pursues two separate interests, those of the taken and those not taken, independent of each other. In effect, fractional condemnation creates two separate landowners. We will assume that the landowners are unable to form coalitions.

The lucky landowners, those whose land escapes condemnation, will have an annual income equal to the land product, less annual costs. In order to simplify the stock-flow accounting we assume that all quantities are annual flows. Capital is financed with bonds that are serviced for rx_{-t} per annum. In addition to the capital service, the landowners must pay an annual ad valorem property tax of τV_{-t}, where V is the property market value and τ is the property tax rate that is set and unchanged by the contemplated public project. If the market price of land is the discounted value of its annual income, with a market rate of interest of r, the net income of the non-taken landowner is

$$y_{-t} = \frac{r}{r+\tau}[f(x_{-t}, q) - rx_{-t}].$$

The flow of income to the condemned land is the amount of compensation paid for the taking less the annual capital service

$$y_t = c - rx_t.$$

2.4. The bureaucracy

We recognize with this version of the taking problem, that the public action is made by government agencies. There is no standard

[5] This perspective is not unique and original to this paper. The idea was first suggested to us in a paper by Nosal (2001). But Innes (1997, 2000), applies the game analogy to the taking problem with great success as well.

[6] Without the border-to-border continuity, it is necessary to consider the beliefs of one landowner regarding what the other landowners will do. We chose not to explore the implications of various assumptions regarding the beliefs of landowners in this paper.

[7] The extension of the homogeneity assumption to land after the completion of the road is difficult to justify given what is known about transport benefits. Land closer to the road enjoys larger accessibility benefits than does a plot farther away. Allowing for differential accessibility benefits would complicate the analysis without changing the basic result. For this reason the post-road homogeneity assumption is maintained.

[8] This is equivalent to making the landowner the holder of the government debt.

way to model the actions of these agencies, but widely recognized and used are the ones proposed by Niskanen (1994).

The objective of the bureaucracy, labeled Niskanen1, is to have as large a budget as possible. We embed this bureaucracy in an environment common to many public projects in the United States: the bureau will receive all the property tax revenue from its condemnation area.[9] What we have in mind is similar to tax increment financing, commonly used for redevelopment projects.[10]

With Niskanen1 the bureau's objective is to maximize its tax collections with its condemnation choice given two very important constraints. The first is that the property tax rate, τ, is fixed and not subject to change (by either the bureau or the landowners). The second is that the tax revenues collected must be sufficient to cover the annual debt service, qc, for the public project. The bureau's welfare is then

$$b_1(q,x)=\tau(1-q)V_{-t}=\frac{\tau}{\tau+r}(1-q)[f(x_{-t},q)-rx_{-t}]. \tag{1}$$

if $b_1(q,x)\geq qc$ otherwise $b_1(q,x)=0$.

The objective of the bureaucracy that we label Niskanen2 is to maximize net revenue. For this specification of the bureaucracy's objectives we still hold the tax rate constant at τ. Thus the bureau's payoff is now

$$b_2(q,x)=\frac{\tau}{\tau+r}(1-q)[f(x_{-t},q)-rx_{-t}]-qc. \tag{2}$$

2.5. Social welfare

With this formulation the social welfare function is straightforward; it is the aggregate net income of the area:

$$(1-q)[f(x_{-t},q)-rx_{-t}]-qrx_t. \tag{3}$$

If the production function is quasi-concave, as assumed, maximization of social welfare, and, thus, efficiency requires that the amount of land taken satisfies

$$(1-q)f_q(x_{-t},q)-[f(x_{-t},q)-rx_{-t}]-rx_t=0. \tag{4}$$

This condition has a sensible interpretation: the sum of the marginal benefit from expanding the size of the taking, $(1-q)f_q(x_{-t},q)$, must equal the marginal cost that is the loss of net income from taking the marginal parcel instead of leaving it to benefit from the project, $[f(x_{-t},q)-rx_{-t}]$, plus the cost of the capital lost, rx_t.

2.6. Features of compensation

We propose that there are four distinct desiderata for a compensation rule. The first is that it should not induce inefficient uses of resources. The inducements of compensation should not promote resource expenditures to augment compensation if land is taken or to affect taking choices by other resource using means such as political lobbying. The second is that the rule should be equitable: similar individuals should have similar outcomes. There is little dispute about this definition, but its implementation is problematic. It is reasonable to label as equitable a public policy that gives no individual a better chance at a good outcome than anyone else, even though the realizations are widely disparate. However, it is likely that treating the outcome of a public choice process as a simple gamble does not coincide with the popular notion of distributive justice. For instance, it may be "just" if one person wins a fortune while another looses the farm at the same horse race, but the same distributive outcome from a political process is judged to be wildly unfair. An outcome in which identical people end up with similar outcomes is more consistent with commonly held notions of equity and is thus more policy relevant than is an ex ante equal chance. The third is that there must be a way to finance the taking: the taxes collected by the agency making the taking choice must be sufficient, at least, to service the taking-induced debt. Finally, the fourth criterion, is that the compensation rule is chosen without presumed foreknowledge of what is an efficient outcome. If the efficient level of resource use is known in advance a regulation imposing that level is an alternative with lower transaction costs and fewer chances of error than individuals acting in response to the price signals of the compensation rule.

The features of ideal compensation can be summed up as

[**E**] Efficiency: amount of land taken and the level of investment are jointly social welfare (aggregate net output) maximizing. That is the efficient outcome, (x^*_{-t},x^*_t,q^*), are such that:

$$(x^*_{-t},x^*_t,q^*)\in arg\max(1-q)(f(x_{-t},q)-rx_{-t})-qrx_t.$$

[**Q**] Equity: like individuals have like outcomes.
- Q_P ex post: $y_t=y_{-t}$.
- Q_A ex ante: every landowner has the same expected income.

[**B**] Balanced budget: the amount collected in taxes must be least as much as the compensation paid:

$$\tau V_{-t}\geq qc.$$

[**K**] Reasonable knowledge: the compensation rule cannot be based on foreknowledge of the efficient choices, that is to say that c is not a function of (x^*_{-t},x^*_t,q^*).

3. An ideal compensation scheme

In this section, we will examine the efficiency implications of equitable compensation schemes within the context of the Road Project model. We propose that *compensation be awarded for condemned land at the market price of the remaining land after the public project is completed*. Using the previously defined symbols

$$c=\frac{r}{r+\tau}[f(x_{-t},q)-rx_{-t}]$$

The remainder of this section addresses whether or not, and under what conditions, this compensation rule satisfies the four desiderata.

This rule is undeniably equitable, both ex ante and ex post. Because the wealth of all landowners is the same, no matter the taking choice, there is no question of unfairness. It also satisfies condition [**K**] in that its implementation does not require foreknowledge of the efficient level of capital improvements. The balanced budget condition, [**B**], will be met because of the tax increment financing—the agency whose job it is to condemn land must collect sufficient tax revenues to service the debt incurred by the public project. Note that this compensation scheme does not depend on the value of investment in the land to be taken. Whether or not the compensation rule induces efficient choices from both sets of actors – the landowners and the bureaucracy – is to be examined.

3.1. Efficiency

We model the decision on takings and land investment as a game in which the players are the government bureaucracy and the landowners. The government's strategy set is the amount of land

[9] With our example, the project area is the entire rectangular area.

[10] See Brueckner (2001).

taken and the landowners' is the level of capital improvements. In Niskanen1 the bureaucracy is constrained in its decision by the amount of taxes it can collect at a fixed and predetermined ad valorem property tax rate. Within these constraints it seeks to make its tax collections, and thus its size, as large as possible. The landowners choose the level of investment to make their annual income as large as possible.

The efficient outcome, (x_t^*, x_{-t}^*, q^*), maximizes Eq. (3). For the landowners whose land is not taken, efficiency requires the usual equation of marginal product with the price of capital.

$$f_x(x_{-t}, q^*) = r$$

For the owners of condemned property all investment in the land is lost as a result of the taking. It is clearly optimal in this case for $x_t = 0$. Thus applying Eq. (4), the efficient taking decision satisfies

$$-[f(x_{-t}^*, q^*) - rx_{-t}^*] + (1-q^*)f_q(x_{-t}^*, q^*) - rx_t^* = 0$$

but recall that x_t is zero at the optimum so we have:

$$(1-q^*)f_q(x_{-t}^*, q^*) = f(x_{-t}^*, q^*) - rx_{-t}^*$$

With this specification, we first look at the equilibrium (Nash equilibrium) of the implicit simultaneous move game. The conclusion, specified in Theorem 1, is promising. The game produces unique equilibrium choices of private investment and quantity of condemned land that are efficient.

3.2. Government maximizes tax revenue

We will now look at the road model in the case where the government is interested in maximizing its tax revenues (Niskanen1). In this case its objective from Eq. (1) is

$$\frac{\tau}{\tau + r}(1-q)[f(x_{-t}, q) - rx_{-t}].$$

With the proposed compensation the payoff for all landowners is

$$\frac{r}{\tau + r}[f(x_{-t}, q) - rx_{-t}].$$

We will now look at the game in which both the landowners and the government move at the same time.

3.2.1. Simultaneous move game

In the simultaneous move game the landowners and the government will simultaneously decide on the level of investment and the fraction of taking, respectively. From such a game we get the following theorem.

Theorem 1. *The strategy profile (x_t^*, x_{-t}^*, q^*) (the efficient levels of investment and land taken) is the unique Nash equilibrium for the game in which all landowners and the government move simultaneously.*

Proof. Consider first the landowners whose land lies outside of q^*, that is, those landowners whose land is not to be taken. The landowners will act to maximize the payoff from their land, equivalent to solving

$$\max_{x>0} \frac{r}{\tau + r}[f(x, q^*) - rx].$$

The first-order condition yields

$$f_x(x_{-t}, q^*) = r.$$

The non-taken landowner has no reason to deviate from the efficient strategy.

Consider the landowners that own land that is taken. These landowners will receive a compensation that is independent of their investment. Any investment in their land is lost. Thus there is no reason to invest and $x_t = 0$.

Next consider the government. It is bound by the need to collect at least as much tax revenue as it spends. To achieve this the project size can be no larger than $\tau/(\tau + r)$. Thus the government's best response solves

$$\max_{q \in [0,(\tau/(\tau+r))]} \frac{\tau}{\tau + r}(1-q)[f(x_{-t}^*, q) - rx_{-t}^*].$$

Let's first consider the case where the balanced budget constraint is not binding, that is where $q^* < (\tau/(\tau + r))$. For an interior solution the first order condition is

$$(1-q)f_q(x_{-t}^*, q) = f(x_{-t}^*, q) - rx_{-t}^*.$$

The government chooses the efficient level of taking—or more accurately has no incentive to deviate from the efficient level of taking and the efficient outcome is a result of a Nash equilibrium in the simultaneous move game.

Consider now the case in which the balanced budget constraint is binding for some $\tilde{q} < q^*$.

$$\tilde{q} = \frac{\tau}{\tau + r} < q^*$$

Let $\tilde{x} = x(\tilde{q})$. By the envelope theorem $(\mathrm{d}x(q)/\mathrm{d}q) = -(f_{xq}/f_{xx})$ and since, by assumption $f_{xq} > 0$, then $(\mathrm{d}x(q)/\mathrm{d}q) > 0$. Therefore the derivative of the bureau's objective $b_1(x, q)$ with respect to q is positive for all $q < q^*$. It follows that the budget constrained equilibrium is $(\tilde{q}, \tilde{x})$. It is efficient conditional on the tax rate constrained balanced budget condition. The concavity of the production function ensures that the equilibrium is unique. □

In the light of Theorem 1 we can see that if those whose land is condemned are compensated at the value of the land had it enjoyed the benefit of the public project, all of the criteria of ideal compensation are fulfilled. With post-project compensation there is:

[**E**]fficiency: the efficient levels of capital improvements are chosen by those who lose their property and those who do not and the bureaucracy is led to select the efficient project size. It is important to note that this is the only equilibrium of the implicit game between the bureaucrats and the landowners.
E[Q_p]uity: since both the taken and untaken landowners share equally in the benefits of the project the post-project compensation satisfies the more stringent ex post criterion.
[**B**] alanced budget: the taxes collected cover the project cost or the project is not undertaken.
Reasonable [**K**]nowledge: the post-project value compensation does not depend on foreknowledge of the efficient outcome.

The plan to pay ex post compensation is a viable and practical alternative to the existing practice. One question raised by this compensation plan is the determination of post-project value. The just payment can be accomplished with reasonable simplicity. The payment is an IOU whose value will be determined after the completion of the public project and the reassessment of uncondemned property. This procedure is consistent with tax increment financing that is now applied to redevelopment projects. With such a payment contract the market value of uncondemned land after the public project is announced and known by the market with certainty will reflect the post-project value. The anticipated payment will be capitalized into the value of the property marked for condemnation.

If the tax rate is sufficient, the tax revenue maximizing bureau will choose the efficient amount of land to take. One issue that is left open is the possibility that the set property tax rate is such that at the efficient project size the bureau enjoys a surplus of tax revenue over compensation costs. If the bureau is motivated to maximize its surplus, as is the Niskannen2 type, then its taking choice might be suboptimal. Even if the surplus plays no part in the bureaus objective, one can still wonder at its disposition. One possibility is that whatever the surplus, it is absorbed into the budget of another level of government and used for other public purposes. If this is the case then a larger, and more global, notion of efficiency might be employed: the welfare benefits of the surplus-supported public expenditures should be considered. If the surplus user is the level of government that sets the property tax rate, the social benefits can be used to determine the optimum tax rate. As long as the decision on the tax rate is taken independently from the taking decision, the conclusion is unchanged. If, however, the tax rate is set by the bureau, the necessary conditions for efficiency are not satisfied.

One limitation to the generality of Theorem 1 is that it is based on a particular assumption about the nature of the bureaucracy, one that we labeled Niskanen1. An interesting feature of the Niskanen1 bureaucracy is that its interests, given the tax increment financing, are aligned with the social welfare. As we shall show in what follows, the equilibria of games played with the same compensation rule by a differently motivated bureaucracy, for instance a Niskanen2 type, do not satisfy equity and efficiency simultaneously.

While Niskanen1 bureaucratic behavior aligns its interest with the social welfare, this is not the case with Niskanen2 types. The bureau instead of maximizing its size makes choices that maximize its surplus as shown in Eq. (2)—the difference between the taxes collected and the cost of the project. The ex post equitable compensation where taken landowners are paid the post-taking value, does not induce an efficient equilibrium.

Theorem 2. *In the simultaneous move game in which the government maximizes net revenues, the strategies* (x_t^*, x_{-t}^*, q^*) *a* re not a Nash equilibrium.

The theorem can be proved by noting that the necessary condition for maximizing Eq. (2) with respect to q does not match the social welfare maximum necessary condition. The Niskanen 2 bureaucracy condemns less than the efficient amount of land.

There is another issue that relates to implementation. Our very favorable outcome of Theorem 1 is the equilibrium of a simultaneous move game. While such an equilibrium is a compelling outcome prediction, it is legitimate to question whether or not there is a dynamic process from which the equilibrium can be expected. It is impossible to examine all possible dynamics, but a reasonable one to study is a stage game in which one of the participants announces a first choice and the other responds based on the commitment of the opponent. Subgame perfection is the natural equilibrium choice for such games. We note, however, that the adoption of this equilibrium choice stretches our prohibition against unreasonable knowledge. It requires the first mover to know the reaction of the second mover to all first mover choices.

Since ex post compensation fails to induce efficient equilibria choices when the bureau behaves as Niskanen2, it is not surprising that the sequential game results are no more optimistic. For that reason the Niskanen1 assumptions are maintained in the dynamic setting to be analyzed.

4. Dynamics of the taking process

The dynamic process is a simple two stage sequential game. As is common the first mover is the Stackleberg leader—the optimal choice is governed by the *known* reaction of the follower.

4.1. Government first mover

There are two possibilities for first mover—the bureaucracy and the landowners. It is not surprising, since the bureau's objective mirrors the social welfare that when the government is the leader the subgame perfect equilibrium choice is both efficient and equitable.

Theorem 3. *In the sequential game in which the government moves first, the strategies* (x_t^*, x_{-t}^*, q^*) *are a subgame perfect equilibrium.*

The proof is similar to that for Theorem 1 except that the landowners know exactly what q is when they make their move whereas in the simultaneous move game they conditioned on the government strategy.

4.2. Landowners first mover

The story is quite different if the landowners move first. By the extreme knowledge assumption, the landowners know that the productivity of land increases with the project size q. There are two consequences of this. The first is that the compensation for a taking increases with the size of the project and that the bureau will condemn all unimproved property constrained by the size of the budget. Because of this the coincidence of equilibrium and efficiency is accidental.

Let (x_t, x_i, x_{-t}) be the vector of investment. The variables x_t, x_i, and x_{-t} represent the investment decision of those whose land is taken, those who are the marginal landowner and those whose land is not taken, respectively. The marginal landowner is defined as a landowner whose land is bordered on one side by non-taken, fully invested land and on the other side by taken/zero investment land.[11]

The ex post equitable compensation scheme is such that the tax revenues collected must be greater than or equal to the compensation to be paid:

$$\tau(1-q)\frac{r}{\tau+r}[f(x_{-t},q)-rx_{-t}] \geq q\frac{r}{\tau+r}[f(x_{-t},q)-rx_{-t}]$$

This implies that $q \leq (\tau/(1+\tau))$. This provides a constraint on the amount of land that can be taken. We assume that the project is worth undertaking so that the optimal taking is not zero.

Theorem 4. *If compensation is the ex post equitable compensation scheme, there is no unreasonable knowledge of the efficient strategies and the budget is balanced then the subgame perfect equilibrium of the two stage dynamic game in which the landowners move first is efficient only if* $\tau = (q^*/(1-q^*))$.

The nature of the proof of this theorem is to note that in this case the landowners drive the government's taking decision. Every landowner who invests nothing is confident that the government will take their land and pay compensation. For this reason, the landowners are interested in maximizing the value of the compensation. By investing nothing they induce the government to ever increase the size of the public project and thus increase the value of the compensation. Such inducements are profitable until there is only a single landowner left or until the balanced budget constraint is reached. The equation is efficient only if the tax rate is set to the specific value $q^*/(1-q^*)$ *accidentally*.

[11] Recall that we have assumed that land is owned in continuous strips along the road. If land ownership is not continuous in this way, an analysis of dynamic response would need to account for one landowner's conjecture about the other landowners' reactions.

5. Conclusion

It is difficult to know whether or not a person whose house is condemned would be satisfied with an equal share of the public project-induced benefits and acquiesce to the condemnation without a legal challenge. They may value their property so highly that there is no sufficient financial inducement. One could ask whether a larger share of the benefits, perhaps the entire project value, is sufficient. If the truth is that all the benefits are insufficient compensation then the project itself should not be undertaken—the benefits do not exceed the costs. However, the owner's subjective reservation price is impossible to know because self interest induces the owner to reveal highly inflated values. For this reason, it may be impossible to satisfy every landowner sufficiently that none is aggrieved by condemnation. However, with the compensation we propose, the public sympathy for owners of condemned property will be limited: the public interest is served by the condemnation and the owners financially benefit as much as anyone else. No matter if they are satisfied with the compensation or not, such owners do not have an incentive to excessively invest in their property in order to affect their compensation because the compensation amount does not depend on their capital improvements.

We note the limits of the optimality of equal share compensation. While it continues to meet our stringent ex post equity test, the efficiency conclusion is not general. It depends, in the simultaneous move game first presented, on the motives of the bureau directing the condemnation: it must be self-financing from an ad valorem property tax and be motivated to have as large of a budget as possible. If its aim is to maximize its surplus, rather than size, the resulting equilibrium remains equitable, but not efficient. For the stage game the efficiency conclusion depends on which of the players – the bureaucrats or the landowners – are the first movers. The subgame perfect equilibrium is efficient only if the government moves first. If the landowners are first to move they are induced to encourage a taking of their property by under-investing in it.

Lehavi and Licht (2007) make a similar proposal for condemnation for which the acquired land is to be used for private development projects. They propose that the "... landowners [be turned] into pro rata shareholders in a development corporation that would acquire unified ownership of the land and the development project." This is a practical extension of our rule, whose implementation requires that all public project benefits are captured in land values. We have provided support for the Lehavi–Licht model in that we show that such a scheme will induce efficient choices and survive a stringent equity standard. This compensation solves one of the equity problems associated with current market value compensation, the one that Fennell (2004) labels "The Uncompensated Increment." By allowing the condemned landowner to share in the public project enhancement, they have are allowed, in Fennell's words "a chance of surplus from transfer." While compensation at enhanced value contributes to a more equitable (just) outcome it does not do away with all problems. Landowners' subjective values, if they are larger than the project-enhanced value, are not recovered. The mental stress of forced sale (what Fennell labels "autonomy") is uncompensated as well.

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Appendix A

Proof of uniqueness of Nash equilibrium. The strict quasiconcavity of $f()$ ensures that there is a unique optimal x for every value of q and r. Let the mapping from q and r to the optimal level of investment be denoted by $x_t(r, q)$ and $x_{-t}(r, q)$ for the taken and untaken property, respectively. We have established that

$$x_t(r, q^*) = 0 \quad \text{and} \quad x_{-t}(r, q^*) = x^*_{-t}.$$

By way of contradiction suppose that there is a second equilibrium $\hat{q} > q^*$ (the proof for $\hat{q} < q^*$ is analogous). Then the government first order condition is

$$(1 - \hat{q})f_q(x_{-t}(r, \hat{q}), \hat{q}) = f(x_{-t}(r, \hat{q}), \hat{q}) - rx_{-t}(r, \hat{q}) \tag{5}$$

From the envelope theorem the derivative with respect to q of the right-hand side of this equation is equal to $f_q(x_{-t}(r, \hat{q}), \hat{q}) > 0$ for all values of q. Therefore

$$f(x_{-t}(r, \hat{q}), \hat{q}) - rx_{-t}(r, \hat{q}) > f(x_{-t}(r, q^*), q^*) - rx_{-t}(r, q^*)$$

The partial derivative with respect to q of the left-hand side of the government's optimizing Eq. (5) is

$$\frac{\partial}{\partial q}(1 - \hat{q})f_q = (1 - \hat{q})\left(f_{qx}\frac{\partial x_{-t}}{\partial q} + f_{qq}\right) - f_q$$

From the envelope theorem we know that $(\partial x_{-t}/\partial q) = -(f_{xq}/f_{xx})$ and thus:

$$\frac{\partial}{\partial q}(1 - \hat{q})f_q = (1 - \hat{q})\left(\frac{-f_{xq}^2 + f_{qq}f_{xx}}{f_{xx}}\right) - f_q < 0.$$

The inequality follows from the concavity of $f()$. Therefore we can conclude that

$$(1 - \hat{q})f_q(x_{-t}(r, \hat{q}), \hat{q}) < (1 - q^*)f_q(x_{-t}(r, q^*), q^*).$$

Thus we have

$$(1 - \hat{q})f_q(x_{-t}(r, \hat{q}), \hat{q}) < f(x_{-t}(r, \hat{q}), \hat{q}) - rx_{-t}(r, \hat{q})$$

that contradicts Eq. (5). Therefore the efficient Nash equilibrium is unique. □

Proof of Theorem 2. The argument follows the same lines as for the other simultaneous game for the road model for the two types of landowners. The landowners' strategies will be the efficient ones—namely those whose land is not taken will invest to the point that $f_x = r$, while those landowners whose land is taken will invest zero. That leaves us to check the government's strategy choice. Recall that the government's payoff function from Eq. (2) is[12]:

$$\frac{1}{\tau + r}[\tau(1 - q) - rq][f(x_{-t}, q) - rx_{-t}].$$

First order condition is

$$(-\tau - r)[f(x, q) - rx_{-t}] + [\tau(1 - q) - rq][f_q(x, q)] = 0.$$

[12] Note that the annual tax collected is

$$\tau(1 - q)\frac{[f(x_{-t}, q) - rx]}{\tau + r}$$

and the annual payments are

$$\frac{rq[f(x_{-t}, q) - rx]}{\tau + r}.$$

and rearranging is

$$\left(\frac{\tau}{\tau+r}-q\right)f_q(x_{-t},q)=f(x_{-t},q)-rx_{-t}.$$

This does not match the efficiency first-order condition with respect to q. Since $(\tau/\tau+r)$ is less than 1 we are able to conclude that the taking will be less than the efficient amount.

This only proves that there exists *a* Nash equilibrium that is not efficient. In order to prove that the efficient strategies are not a Nash equilibrium we will prove that the Nash equilibrium we found is unique.

Recall that there are two first order conditions: For the government:

$$(\tau(1-q)-rq)f_q(x_{-t},q)-(\tau+r)[f(x_{-t},q)-rx_{-t}]=0$$

and for the landowner (for untaken land):

$$f_x(x_{-t},q)-r=0.$$

From the solution to the two equations comes the best response functions $q(x)$ and $x(q)$.

Take the derivative of both equations with respect to x, inserting the best response functions in the appropriate places. First for the government:

$$-(\tau+r)\frac{dq}{dx}f_q+(\tau(1-q)-rq)f_{qx}+(\tau(1-q)-rq)f_{qq}\frac{dq}{dx}-(\tau+r)f_x$$
$$-(\tau+r)f_q\frac{dq}{dx}+(\tau+r)r=0$$

Notice that $f_x=r$, and solving for the slope of the government's reaction function we find:

$$\frac{dq}{dx}=\frac{(\tau(1-q)-rq)f_{qx}}{2(\tau+r)f_q-(\tau(1-q)-rq)f_{qq}}$$

By virtue of the fact that $f_{qx}>0$ and $f_{qq}<0$ then $(dq/dx)>0$.

Now for the landowner:

$$f_{xx}\frac{dx}{dq}+f_{xq}-r\frac{dx}{dq}=0$$

The slope of the landowner's reaction function is

$$\frac{dx}{dq}=\frac{f_{xq}}{r-f_{xx}}>0$$

The slope of the landowners' reaction function is (larger, equal to or smaller) than the slope of the governments reaction function as

$$\frac{f_{xq}}{r-f_{xx}}\gtreqless\frac{2(\tau+r)f_q-(\tau(1-q)-rq)f_{qq}}{(\tau(1-q)-rq)f_{qx}}$$

Notice that the numerator and denominators of both sides of the inequality are positive and thus we can cross multiply without changing the direction of the inequalities.

$$(\tau(1-q)-rq)[f_{qx}^2-f_{qq}f_{xx}]\gtreqless 2(\tau+r)rf_q-2(\tau+r)f_qf_{xx}$$

By virtue of the strict quasiconcavity of $f(\cdot)$ in both x and q, the right-hand side of the inequality is positive and the left hand side is negative (Hessian with alternating sign).[13] Thus we can conclude that

$$\frac{dx}{dq}|_{\text{landowner}}<\frac{dx}{dq}|_{\text{government}}.$$

[13] The term in the square brackets is the negative of the Hessian.

Thus the reaction functions will intersect at most once. Thus if there exists a Nash equilibrium, it must be unique.

Therefore we have shown that there exists an inefficient Nash equilibrium and that such equilibrium is unique. □

Proof of Theorem 4. By way of backward induction consider the reaction of the Government first. The government wishes to maximize tax revenues. Define $\bar{q}$ such that

$$\bar{q}\in \mathit{arg\,max}\ \frac{\tau}{\tau+r}(1-q)[f(x_{-t},q)-rx_{-t}]$$

Let l be the amount of land that has zero investment. The government as the second mover in this game will be faced with some fraction $l\in[0,1]$ of empty land. If $l<\bar{q}$ then the government will take $\bar{q}$ because that will maximize its tax revenue by the definition of $\bar{q}$. Now suppose that $l>\bar{q}$. In this case the value of the land with zero investment is zero, which means that the tax revenue from this land is zero. The best the government can do is to take the land with zero investment in order to boost q and subsequently boost the value of the remaining land thereby increasing the tax revenue. This is the case since $f_q(x,q)>0$. Thus the government will take $\max\{l,\bar{q}\}$. Note that since the project is worth undertaking $\bar{q}>0$.

Now let us consider the landowners. Let us start with the primary landowner; that is, consider the landowner whose land is right in the center of the land that is proposed for the road. Given that $\bar{q}>0$, this landowner knows that her land will be taken, thus in order to maximize utility she will invest nothing in the land since all investment will be forfeit. Similar logic holds for all of the people whose land lie within $\bar{q}$. Now consider the marginal landowner whose land is on the periphery of $\bar{q}$. This landowner has to choose between keeping her land and investing x_i. Keeping the land will give a payoff of:

$$\frac{r}{\tau+r}[f(x_i,q(0,x_i,x_{-t}))-rx_i] \tag{6}$$

The marginal landowner can also invest nothing and, knowing the government will take the land, be paid compensation. The compensation paid will give a payoff of:

$$\frac{r}{\tau+r}[f(\bar{x}_{-t},q(0,0,\bar{x}_{-t}))-r\bar{x}_{-t}] \tag{7}$$

Note that $q(0,x_i,x_{-t})<q(0,0,\bar{x}_{-t})$ by the previous argument regarding the government's strategy. Since $f_q(x,q)>0$ it must be that Eq. (7) is greater than Eq. (6). It is easy to see that this is the case. As q increases the value of the payoff increases.[14] Now consider the case of the next landowner. She will face the same decision and for the same reasons come to the same conclusion—invest nothing, let the government take the land and receive the compensation. In fact, every marginal landowner will invest nothing in favor of the compensation. This will continue until the balanced budget condition is reached. Specifically until $q=\tau/(1+\tau)$. This is efficient only if the tax rate happens to be set so that $\tau/(1+\tau)=q^*$. □

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[14] This is the case no matter how x changes since the value would be higher with no change in x and any change in x made by the landowners would only increase their payoff.

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