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IRREVERSIBLE DEVELOPMENT AND EMINENT DOMAIN: AN OPTION VALUE APPROACH TO COMPENSATION

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Irreversible Development and Eminent Domain: An Option Value Approach to Greenspace Compensation

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Abstract

This paper applies option value theory to the eminent domain problem for greenspace, where private investment permanently destroys potential social value of land. Full compensation by the government for taking vacant land by eminent domain can slow the pace of private development but does not lead to an efficient outcome when prices adjust endogenously to the taking threat. The efficiency of eminent domain compensation is sensitive to how full compensation is calculated and to the nature of the alternative potential social land use. Greenspace value leads to fundamentally different conclusions than do social values derived from roads or other public infrastructure for which irreversibility is not an issue.

Keywords: Eminent domain, compensation, greenspace, land value

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1 Introduction

The government power to use eminent domain is justified as a means of preventing strategic hold-out behavior by private property owners when assembling the land parcels needed to provide a public good. The ability to condemn private land for public use solves the hold-out problem, but it raises other concerns. Although the power of eminent domain by itself clearly alters private investment incentives, the larger question concerns how eminent domain coupled with compensation for affected property owners affects market outcomes.

The Fifth Amendment to the US Constitution ties the exercise of eminent domain to just compensation, but does not spell out the nature of the required compensation. Case law generally defines just compensation as fair market value, what the eminent domain literature labels "full compensation." An important issue in the literature concerns the relationship between alternative compensation rules, investment incentives, and efficiency. The seminal work by Blume, Rubinfeld and Shapiro (1984) finds that full compensation at market value need not be efficient. By paying full compensation to private landowners for both land and invested capital, eminent domain distorts private investment incentives. Compensating capital at full cost creates an incentive to use more capital than is efficient because it allows owners to ignore the possibility that the social value of their capital might ultimately be zero. On the other hand, Miceli (1997, 140-144) argues that full compensation restores efficiency when structured appropriately. Compensation must be lump-sum and equal to market value without the threat of eminent domain, which removes the marginal incentive for investors to over-use capital. In a different vein, Innes (1997) looks at just development timing and finds a timing result analogous to the capital density result of Blume, Rubinfeld and Shapiro. Full compensation at market value biases the market toward inefficiently early development.

These studies either explicitly or implicitly assume reversible investment. Greenspace externalities, however, represent a public interest that is fundamentally different from the typical examples of public goods like roads, public buildings, and parks that motivate those studies. While roads and government buildings can be constructed on land that was previously developed for private use, greenspaces cannot. The greenspace externality envisioned here is inherently tied to the ecological system embodied in undeveloped land. Since it is not possible to restore developed land to its true pre-development state once developed for private purposes, any potential greenspace benefit is permanently lost when the land is developed. Given uncertain future market conditions and an uncertain greenspace value, the irreversible aspect of private land development implies that the greenspace case is best analyzed within an option value framework. This approach is fundamentally different from the expected value models prevalent in the eminent domain literature. The unanswered question is: does this difference matter?

This paper applies option value theory to examine how the threat of eminent domain affects property markets when investment in structures and infrastructure is irreversible. It adapts Titman's (1986) vacant land option value model to incorporate an uncertain greenspace externality. It also embeds the partial equilibrium option value model within asset markets to incorporate the important feed-back effects of endogenous land and building prices on market development decisions.

Section 2 presents the partial equilibrium option framework. This model leads to land development timing results resembling Innes (1997) for the non-greenspace case. In particular, the threat of takings with full compensation has no effect on the market development pace when prices are exogenous. But the market development pace is too fast to begin with, so this neutrality result means that full compensation leads to inefficient investment. Of course, this does not imply that full compensation is meaningless. Threatening takings without full compensation tends to speed the development pace (Turnbull, 2002). In this context, the partial equilibrium analysis implies that full compensation of landowners restores the development pace observed in the absence of the takings threat, exactly offsetting the effect of the threat alone.

Sections 3 and 4 develop the option value within equilibrating asset markets. Eminent domain in this framework leads to conclusions surprisingly different from both the partial equilibrium case and previous studies. Here, the compensation scheme details matter profoundly. If full compensation is defined to mean that erstwhile owners are compensated with the prevailing opportunity cost of land, as measured by land value in the market under takings threat, then eminent domain slows development relative to the partial equilibrium result. Once again, though, development remains inefficiently rapid. On the other hand, if owners are compensated with land value in the unregulated market, then eminent domain speeds development. In this situation using eminent domain to capture the social benefits of greenspace decreases market efficiency. These results are new and hinge upon the effect of takings on the future supply of land and its effect on the dispersion of future building prices, a key determinant of the option value of vacant land.

The implications for the density of initial development are also discussed in Section 4. These are novel as well. The eminent domain literature concludes that full compensation leads to either inefficiently high or efficient structural densities, depending upon how the compensation for marginal capital improvements is structured (Blume, Rubinfeld, and Shapiro, 1984; Miceli, 1991). In contrast, this study finds that when development is irreversible, full compensation–regardless of how defined–systematically leads to inefficiently low structural density. Nonetheless, the takings threat affects the structural density of current development, and the direction of change is determined by how full compensation is calculated. Compensation at the regulated market value tends to increase structural density, but not enough to attain efficiency, while compensation at the unregulated market value tends to decrease structural density, driving an even greater wedge between the market and efficient outcomes. Section 5 concludes.

2 Eminent Domain with Exogenous Prices

This section presents the basic model which assumes exogenous prices. Since the analysis applies to situations in which government taking of land by eminent domain does not change market prices, it applies to situations in which the jurisdiction takes only an infinitesimal part of the overall market. Although appropriate for land taken for many types of public goods (a new police station, a small neighborhood park), it is not as applicable to the problem of greenspace externalities examined here. Greenspace externalities arise from habitat for nonurban flora and fauna or threatened species, watershed, or undeveloped park land. We therefore expect greenspace benefits to be associated with relatively large contiguous tracts of land. Since removing significant supply from the local land market affects property prices, the exogenous price assumption is admittedly somewhat tenuous for the greenspace case. Nonetheless, the results presented in this section tie the option value framework more closely to the existing literature and also present intermediate relationships that are useful for the endogenous price models presented later.

Assume that the demand for developed real estate (e.g., building units) is stochastic so that the future price of building units is uncertain. The framework is a simple option pricing model extending over two periods based on Titman (1986). It is useful to diverge from Titman's original model construction for several reasons. First, of course, we need to adapt the framework to incorporate the social greenspace option value. Second, unlike Titman (1986), the approach taken here closely follows the standard option pricing paradigm more closely in order to focus on the nature of the underlying valuation concept. Third, this approach simplifies the introduction of endogenous building unit prices into the option value model, an important complication that turns out to be essential for the eminent domain issues being studied here.

2.1 Private Option Value of Vacant Land

The general setting is as follows. There are two periods. In the absence of regulation, in the current period an investor is free to construct structures, with the number of building units per unit of land q, at the cost $c(q)$ as above. Building units can be sold outright in the initial period for the market price p_0. With the riskless interest rate r and no depreciation, rented units earn rp_0 during the period. The market price of a building unit in the second period is uncertain. It will either rise to p_1 or fall to p_2 (i.e., $p_2 < p_0 < p_1$). Any land left vacant in the first period can be developed in the second period; the maximum profit to the owner of vacant land in the second period is either $\pi(p_1)$ or $\pi(p_2)$, where $\pi(p_i)$ is the value of the indirect profit function in state i. The usual properties pertain:

$$\pi'(p_i) > 0; \quad \pi_i''(p_i) > 0 \tag{1}$$

It follows that $\pi(p_1) > \pi(p_0) > \pi(p_2)$ in this model

When cast this way, vacant land in the first period represents an option on future buildings. The portfolio comprising one building unit coupled with selling short h units of vacant land (options on future buildings) has the initial value $p_0 - hV$ and evolves following according to one of the two indicated outcomes:

$$p_0 - hV \rightarrow \left\{ \begin{array}{c} rp_0 + p_1 - h\pi(p_1) \\ \\ rp_0 + p_2 - h\pi(p_2) \end{array} \right\} \tag{2}$$

Of course, which outcome will obtain is unknown at the outset. Nonetheless, the hedge ratio is constructed to ensure a riskless portfolio. Setting the two second period portfolio values equal to one another and solving for this riskless hedge ratio h^* yields

$$h^* = \frac{p_1 - p_2}{\pi(p_1) - \pi(p_2)} \tag{3}$$

Since h^* yields a riskless portfolio, the initial portfolio must earn the riskless rate of return in equilibrium, so that

$$(p_0 - h^*V)(1 + r) = rp_0 + p_1 - h^*\pi(p_1). \tag{4}$$

Solving for the option value of vacant land:

$$V^m = \left(\frac{p_0 - p_2}{p_1 - p_2}\right)\frac{\pi(p_1)}{(1 + r)} + \left(\frac{p_1 - p_0}{p_1 - p_2}\right)\frac{\pi(p_2)}{(1 + r)} \tag{5}$$

In equilibrium, land is developed in period one up to the point where $\pi(p_0) = V^m$. Of course, to determine this requires further specification of the demands for building units in the various states in order to find the equilibrium building prices in both $\pi(p_0)$ and V^m, the extension undertaken in the next section. Before doing so, however, consider the social value of vacant land when there is a greenspace externality.

2.2 Social Option Value of Vacant Land

Following Blume, Rubinfeld and Shapiro (1984) , Fischel and Shapiro (1989), Miceli (1991), and Innes (1997), this paper focuses on the investment incentives effects of eminent domain when investors do not know until after initial investment decisions have been made whether or not the government will be taking their land. These studies all examine the effects of threatened eminent domain when private investment in structures and other improvements to land are reversible, for example, when the land is used for public roads, buildings, or other infrastructure. The situation examined here, however, requires a different approach.

Suppose that vacant land will have a social value of G_1 as an undeveloped greenspace in the second period high demand state, where G_1 exceeds the private value, $G_1 > \pi(p_1)$. This value does not arise in the low demand state. (Or, equivalently, $G_2 < \pi(p_2)$ in the low demand state.) The development irreversibility assumption is crucial to the greenspace case. We assume that the land is no longer habitat for specific flora and fauna once developed, or perhaps the topography is altered to accommodate urban use. In any event, once changed, the land cannot generate greenspace value even if cleared of all capital improvements.

To find the social option value of vacant land, imagine a social planner whose job it is to build structures and allocate land to achieve Pareto efficiency. The marginal social value of building units is given by the market price. The social planner, however, follows the Pareto rule, using vacant land in the second period for greenspace in state one (since it yields a social return greater than the return to its use for buildings) and for buildings in state two.

The fictional social planner's problem resembles that of a private investor examined earlier. In this case, though, vacant land in the first period represents an option on future buildings or greenspace. In the initial period the planner forms an activity portfolio by hedging each building unit constructed in the first period with h units of vacant land as options on future buildings or greenspace. The initial value of the social planner's portfolio $p_0 - hV$ evolves following one of the two indicated outcomes:

$$p_0 - hV \to \left\{ \begin{array}{c} rp_0 + p_1 - hG_1 \\ \\ rp_0 + p_2 - h\pi(p_2) \end{array} \right\} \tag{6}$$

Like the private investor, the planner does not know which outcome will obtain in the second period. Once again, the hedge ratio is that which ensures a riskless portfolio. Setting the two second period portfolio values equal to one another and solving for this riskless hedge ratio,

$$h^* = \frac{p_1 - p_2}{G_1 - \pi(p_2)} \tag{7}$$

In order for the social investment in greenspace options to meet the opportunity cost of capital, the socially efficient riskless portfolio must earn the riskless rate of return, so that

$$(p_0 - h^* V)(1 + r) = rp_0 + p_1 - h^* G_1 \tag{8}$$

Solving for the social option value of vacant land, we have

$$V^s = \left(\frac{p_0 - p_2}{p_1 - p_2}\right)\frac{G_1}{(1+r)} + \left(\frac{p_1 - p_0}{p_1 - p_2}\right)\frac{\pi(p_2)}{(1+r)} \tag{9}$$

Comparing (5) and (9) reveals the policy maker's conundrum. The social option value of land exceeds the unregulated market value, $V^s > V^m$, which suggests that the market will initially develop more land than is efficient. This is not at all surprising as it merely reflects that fact that the market does not capture the greenspace option value in the vacant land value.

2.3 Full Compensation

The social planner's problem envisioned above only establishes an efficiency benchmark for comparison purposes and does not fully capture the policy maker's problem. Here we envision the policy maker as a government following the Pareto rule, taking land only when its social value as a greenspace exceeds its private value for buildings.[1] The vacant land is taken only in state one, the high building demand state. Further, the government pays full compensation equal to market value of the land in that state when exercising its power of eminent domain. Thus, in state one, the government takes the land and pays the landowner $\pi(p_1)$. Since we are assuming that building prices are exogenous in this section, this full compensation leaves V^m unchanged in the face of the threat of taking. Comparing (5) and (9) reveals a result

[1] The Pareto behavior assumption is popular and can be justified by Fischel's (2001) homevoter hypothesis in which local governments adopt policies that yeild non-negative net fiscal impacts on voters, hence their property values. The question of government behavior, however, is unsettled. See Blume, Rubinfeld and Shapiro (1984), Fischel and Shapiro (1989) and Miceli (1991) for additional relevant discussion. In this study, the Pareto rule behaviorial assumption is in part justified by the desire to compare these results with the previous literature using that assumption.

reminiscent of Innes' (1997) for the reversible investment case with exogenous prices; eminent domain with full compensation does not affect the development pace, but the presence of the externality that motivates the eminent domain slows the efficient development pace so that the market generates an inefficiently fast development pace under full compensation. Our result is also consistent with Hermalin (1995) in that efficiency requires something more than full compensation. It requires that the private landowner be compensated with the full social value of the land in its public use.

This discussion has laid out the general problem of eminent domain in a simple dynamic context when the social value of land arises from the undeveloped nature of land, hence the private investment process creates an irreversibility aspect. The next section formalizes the above discussion by endogenizing the market prices of buildings and vacant land.

3 Eminent Domain with Endogenous Prices

3.1 The Unregulated Market

We now introduce endogenous building unit prices into the option value framework. Let the inverse demand for building units in state i be $Q_i = f(p_i)\theta_i$, where $\theta_0 = 1$ and $\theta_1 > 1 > \theta_2 > 0$ underlies our earlier assumption $p_1 > p_0 > p_2$. With n parcels of land initially developed with q_0 building units per parcel, equilibrium in the market for building units requires that each developer is building the profit-maximizing number of building units ($q_i = \pi'(p_i)$ using the properties of the indirect profit function) and that the price of building units equates demand and supply for building units:

$$n\pi'(p_0) = f(p_0) \tag{10}$$

Given the total supply of land to the market is N, the quantity of newly built building units in the second period high demand state is $(N-n)\pi'(p_1)$. Adding this number to the $n\pi'(p_0)$ units previously built, the building unit price in the high demand state satisfies the equilibrium condition

$$(N-n)\pi'(p_1) + n\pi'(p_0) = f(p_1)\theta_1 \tag{11}$$

Similarly, the price of building units in the low demand state satisfies the condition

$$(N - n)\pi'(p_2) + n\pi'(p_0) = f(p_2)\theta_2 \tag{12}$$

Land market equilibrium in the initial period (10) drives the current building price and future building prices via (11) and (12) to equate the return to developed land, $\pi(p_0)$, and vacant land (5).

In order to characterize the market equilibrium graphically, first find the vacant land option value as a function of the amount of land developed in the first period (that is, the amount of land left vacant for the second period). To do so, begin with the implicit equilibrium price functions $\{p_0^m(n), p_1^m(n), p_2^m(n)\}$ as follows, where superscript m indicates the market benchmark solution (i.e., without the threat of takings in the second period). Solve (11) for $p_0^m(n)$ where implicit differentiation reveals that the first period equilibrium price of buildings decreases as the quantity of developed land rises,

$$\frac{dp_0^m}{dn} = -\frac{\pi'(p_0)}{n\pi''(p_0) - f'(p_0)} < 0 \tag{13}$$

Now substitute $p_0^m(n)$ into (11) and (12) and solve for $p_1^m(n)$ and $p_2^m(n)$, respectively. We do not need the derivative properties of $p_1^m(n)$ or $p_2^m(n)$ for what follows.

To find the market option value of land as a function of initial land development, $V^m(n)$, substitute $\{p_0^m(n), p_1^m(n), p_2^m(n)\}$ into (5).

$$V^m(n) = \left(\frac{p_0^m(n) - p_2^m(n)}{p_1^m(n) - p_2^m(n)}\right)\frac{\pi(p_1^m(n))}{(1+r)} + \left(\frac{p_1^m(n) - p_0^m(n)}{p_1^m(n) - p_2^m(n)}\right)\frac{\pi(p_2^m(n))}{(1+r)} \tag{14}$$

This is the $V^m(n)$ curve depicted in Figure 1. While the sign of dV^m/dn is ambiguous a priori, none of the results derived herein depend upon the slope of this curve.

The initial period demand for developed land is easily derived. Substitute the implicit building price function $p_0^m(n)$ into the indirect profit function to get $\pi(p_0^m(n))$, where

$$\frac{d\pi}{dn} = q_0^m\left(\frac{dp_0^n}{dn}\right) < 0 \tag{15}$$

Thus, this curve is unambiguously negatively sloped as drawn in figure 1.

The benchmark market equilibrium initial land development n_m is where the π and V^m curves intersect.[2] The amount of initially vacant land in equilibrium is $N - n_m$. The total number of building units built initially is $n_m\pi'(p_0^m(n_m))$. The numbers of units newly built in the second period are $(N - n_m)\pi'(p_1^m(n_m))$ and $(N - n_m)\pi'(p_2^m(n_m))$ for the high and low demand states, respectively.

3.2 An Efficient Benchmark

Following convention, we use the socially efficient equilibrium as a benchmark outcome. The social marginal values of building units, p_0^s, in the initial state equals the market price, since that is where the social surplus from building units is maximized in the first period, $n\pi'(p_0) = f(p_0)$. Similarly, for state two, p_2^s is determined by the building market equilibrium condition (12) above. In state one, however, only $n\pi'(p_0)$ building units are available. This is the number carried forth from the initial period development. All new construction in state one on this plot of land is forestalled since the land has greater value as a vacant greenspace. The social value of buildings in state one is therefore determined by the modified condition

$$n\pi'(p_0^s) = f(p_1^s)\theta_1 \tag{16}$$

Finally, the socially efficient allocation of land also satisfies the allocation condition that land be put to its highest valued social use in the first period, or

$$\pi(p_0^s) = V^s \tag{17}$$

in the first period, where the social option value of vacant land is (9) as before.

The efficient equilibrium is the implicit solution to equations (9) (10), (12), and (16). In order to illustrate the relationships graphically, follow the general procedure

[2] Now we can see why the slope of the V^m curve does not matter in the analysis. Assume that if the return to land in current development exceeds the option value, the market will draw more land into current development. Similiarly, if the option value of vacant land exceeds the return to land currently developed then the market will draw more land out of current development. This is a Marshallian quantity adjustment process (like the long run adjustment assumed in competitve goods markets: profits draw entry, losses push exit by resources). Stability requires that the π curve cuts the V curve from above. Therefore, if the V^m curve is negatively sloped, by the correspondence principle we only consider the stable case in which its slope is shallower than that of the π curve.

used for the market model. Solving (10), (12), and (16) for the implicit functions $\{p_0^s(n), p_1^s(n), p_2^s(n)\}$, we note that

$$p_0^s(n) \equiv p_0^m(n) \tag{18}$$

$$p_2^s(n) \equiv p_2^m(n) \tag{19}$$

while

$$p_1^s(n) > p_1^m(n) \tag{20}$$

This last inequality arises because the socially efficient supply of building units in the second period high demand state is less than the market supply when efficiency calls for all vacant land to be used as greenspace. Substituting the implicit building value functions for the socially efficient outcome $\{p_0^m(n), p_1^s(n), p_2^m(n)\}$ into the social option value (9) yields

$$V^s(n) \equiv \left(\frac{p_0^m(n) - p_2^m(n)}{p_1^s(n) - p_2^m(n)}\right) \frac{G_1}{(1+r)} + \left(\frac{p_1^s(n) - p_0^m(n)}{p_1^s(n) - p_2^m(n)}\right) \frac{\pi(p_2^m(n))}{(1+r)} \tag{21}$$

Similar to the option value in the unregulated market case, the slope dV^s/dn is ambiguous in general. None of our conclusions is affected by concentrating on the upward sloped case in figure 1.

Since the price function $p_0^m(n)$ applies to both the benchmark market and the socially efficient equilibria, the $\pi(p_0^m(n))$ curve derived earlier also applies to the efficient benchmark. The intersection of the V^s and π curves in figure 1 gives the efficient quantity of land to be developed in the initial period, n_s.

3.3 Unregulated Market Efficiency

In order to compare the benchmark market and the socially efficient outcomes, the higher price of building units in the high demand state tends to lower V^s relative to V^m, but $G_1 > \pi(p_1)$ ensures that $V^s(n) > V^m(n)$ at each n, as shown in the appendix. The social option value curve lies above the unregulated market curve as drawn. Given that the same current period land profit curves apply to both cases, the figure reveals that the efficient development pace is slower than the unregulated market outcome without takings: $n_s < n_m$ so that there will be fewer units of vacant land available in the second period should the high-state greenspace externality arise. Further, $n_s < n_m$ also implies that the price of building units is lower in the unregulated market than if the socially efficient outcome were pursued ($p_0^m(n_m) < p_0^m(n_s)$) so that the unregulated market structural or capital density is less than the efficient level in the initial period: $q_0^m < q_0^s$ from (1).

4 Full Compensation

This section examines the implications of an eminent domain policy with full compensation awarded to owners of land taken by the government. Full compensation in this case means that the owner of vacant land taken by the government in the second period will either receive full value or full compensation for his lost land in the high demand state, $\pi(p_1)$. A problem arises, however, from the fact that the price of building units in the high demand state is generally higher than if the government did not take vacant land to preserve greenspace (recall $p_1^s(n) > p_1^m(n)$). This problem does not arise in the previous literature and in the preceding section because prices are exogenous in those applications. When prices are endogenous, however, the rule is not so straightforward: there is a divergence between opportunity cost of the land and the landowner's loss from the takings regime. Further, the constitutional specification of fair compensation is not very helpful here. Although this requirement is usually interpreted to mean compensation at fair market value, when prices are endogenous, the compensation question becomes one of choosing *which* market value to pay landowners: the value of land in private use when the supply of land has been reduced by the taking or the value of land in the unfettered market? The opportunity cost of the land in the regulated market is its market value when the supply is constrained by the government, $\pi(p_1^s(n))$; this is the regulated market value case below. The compensation needed to cover the loss of landowner wealth, though, is measured by the market value of land in the absence of the taking threat, $\pi(p_1^m(n))$; this is the unregulated market value case considered later.

In both cases compensation is lump-sum in the sense that it cannot be affected by actual variation in the private owner's investment plans, a property generally thought to promote efficient private investment under the threat of taking (Miceli and Segerson, 1996, 47-60). Nonetheless, it turns out that the two compensation measures lead to very different positive and normative results. In order to draw out these differences, we examine the two compensation measures in turn.

4.1 Compensation at Regulated Market Value

When the government follows the Pareto rule and imposes eminent domain in the high demand state, the private value of vacant land under this type of full compensation is $\pi(p_1^s(n))$. With the threat of eminent domain and full compensation, the market equilibrium is determined by the building equilibrium conditions determining building prices in each state, (10), (12), and (16), the option value equation (5) with $\pi(p_1^s(n))$ for the high demand state return, and the initial land market equilibrium condition, $\pi(p_0) = V^r$, where the superscript r indicates that compensation is being made at the regulated market prices. The building market equilibrium conditions are the same conditions as in the benchmark efficient outcome, and so yield the price functions $\{p_0^m(n), p_1^s(n), p_2^m(n)\}$. So, in order to take into account the endogenous price adjustments to differences in land and building unit supply in each state, simply substitute $\{p_0^m(n), p_1^s(n), p_2^m(n)\}$ and the compensation into (5) to obtain the option value of vacant land under full compensation at private opportunity cost

$$V^r(n) = \left(\frac{p_0^m(n) - p_2^m(n)}{p_1^s(n) - p_2^m(n)}\right) \frac{\pi(p_1^s(n))}{(1+r)} + \left(\frac{p_1^s(n) - p_0^m(n)}{p_1^s(n) - p_2^m(n)}\right) \frac{\pi(p_2^m(n))}{(1+r)} \qquad (22)$$

The earlier result $p_1^s(n) > p_1^m(n)$ decreases V^r relative to V^m, but also leads to $\pi(p_1^s(n)) > \pi(p_1^m(n))$, which by itself increases the value of V^r relative to V^m. The net effect of eminent domain on vacant land value appears to be ambiguous at this point. However, the appendix shows that the higher price of building units in state 1 coupled with the higher compensation than without takings unambiguously increases the option value of land under threatened taking relative to the free market: $V^r(n) > V^m(n)$ at any given n and the V^r curve lies everywhere above V^m as in figure 1.

On the other hand, by construction the social value of land in the high demand state exceeds the private value of land, $G_1 > \pi(p_1^s(n_r))$. Comparing (21) and (22), it follows that $V^s(n) > V^r(n)$ and the option value with full compensation based on opportunity cost lies below the social option value of vacant land as pictured in the figure. Compensating owners with the private value of land in the high demand state, $\pi(p_1^s(n_r))$, leads to a lower land option value than is efficient, with the result that too much land is developed at the outset, $n_r > n_s$. Recall Innes (1997) finds that full compensation does not change the market determined development pace for the reversible development case. In contrast, we see that full compensation does change the market determined development pace when development is irreversible and prices endogenous, further slowing development in the initial period $(n_r < n_m)$. Nonetheless, like Innes (1997), full compensation still leads to an initial market development pace that is too rapid for efficiency. Anything short of compensating at the full social value of land will leave the market at a less than efficient outcome (Hermalin, 1995). The inefficiency of the market under the threat of taking appears to be robust across the reversible and irreversible development cases.

How does compensation affect structural density of development? Not surprisingly, given that the initial quantity of land developed is greater than the efficient level under compensated takings, the price of building units is lower than what would exist in an efficient outcome, and the number of units per land parcel is lower, too (since $p_0^m(n_r) < p_0^m(n_s)$ and the indirect profit function properties imply $q_0^r < q_0^s$). So, while Blume, Rubinfeld and Shapiro (1984) find that full compensation leads to over-investment in structures and Miceli (1991) that it leads to the efficient investment, here we find that *compensation at opportunity cost leads to a lower current structural density than is efficient when investment is irreversible.*

Given this normative conclusion, why not have the government exercise eminent domain in the initial period? If the government were to do so, it would remove enough land from the market in the first period to drive the value of developed land to equality with the social value of vacant land, or $\pi(p_0) = V^s$. There are several problems with this type of policy. One problem is that the efficient strategy requires that the government sells land to private developers in the second period if the demand for buildings is low enough. But using eminent domain to speculate in the land market in this fashion violates the public use rule. Even though the courts have not established the public use rule as a bright line constraint,[3] as a practical matter, a public use rule is essential to retain a reasonable degree of transparency in the eminent domain process and forestall the potential corrupting effects of the government using its police power to manipulate the market in order to gain arbitrage profits or to transfer property to rent seekers at favorable below market prices.

Another policy variant is for the government to eschew eminent domain and simply buy enough land in the initial period to ensure efficiency in the second period. Following the Pareto rule, if state one obtains then the land is put to public use as a greenspace. If state two obtains then the land is sold to private investors. By not using eminent domain to acquire the land, the government avoids violating the public use rule. But this scheme again raises the issue about keeping government actions as transparent as possible. And since it also raises the likely outcome for efficiency that land purchased at a high value price at the outset might have to be sold at a lower value at later date (e.g., $\pi(p_2) < V$ in the second period), one can easily imagine the public outcry against the government for selling vacant land to private investors at a loss, even when such behavior is efficient. In addition, the opportunities for corruption in this type of land investment process are so immense that few would argue for a governmentally managed dynamic land bank program. There are clearly downsides to allowing local governments to speculate in their constituent land markets that could overshadow the potential efficiency advantages.

4.2 Compensation at Unregulated Market Value

Now suppose that owners are compensated for takings at the unregulated market value, that is, the private value of land in the absence of the threat of taking. This compensation scheme fulfills the usual interpretation of fair compensation because it compensates the land owner for the actual lost land value arising from both the threat of taking and the act of taking. But because the market price of building units rises in the high demand state when land is taken out of private use, basing compensation

[3]For example, local governments sometimes use eminent domain to acquire land in order to transfer it to private investors for industrial development. Whether such use passes the public use threshhold is a matter of ongoing popular debate.

on unregulated market value leads to lower compensation than in the regulated value case immediately preceding: $p_1^m(n) < p_1^s(n)$ implies $\pi(p_1^m(n)) < \pi(p_1^s(n))$. It turns out that this method of compensation leads to an even faster development pace and lower density than found in the unregulated market.

To see why, notice that the building market equilibrium conditions take the same form as above and the general option formula remains (5). The option value of vacant land when compensation is based on unregulated market value is

$$V^u(n) = \left(\frac{p_0^m(n) - p_2^m(n)}{p_1^s(n) - p_2^m(n)}\right)\frac{\pi(p_1^m(n))}{(1+r)} + \left(\frac{p_1^s(n) - p_0^m(n)}{p_1^s(n) - p_2^m(n)}\right)\frac{\pi(p_2^m(n))}{(1+r)} \tag{23}$$

For a given n, the only difference between this and the option value formula under opportunity cost compensation is the compensation term in the first right hand side numerator: $\pi(p_1^m(n))$ versus $\pi(p_1^s(n))$. Recall that $p_1^s(n) > p_1^m(n)$ so that $\pi(p_1^m(n)) < \pi(p_1^s(n))$. This means that $V^u(n) < V^r(n)$ at any given n, that is, the option value under this compensation formula lies everywhere below the option value under compensation based on opportunity cost. Not surprisingly, lower compensation for land taken by the government lowers the value of vacant land in the market.

But we can say more. Holding compensation unchanged, differentiate V^m at a given n to show that option value declines with a greater high demand state building price,

$$\frac{\partial V^m}{\partial p_1} = \frac{\pi(p_2)/(1+r) - V^m}{p_1 - p_2} < 0 \tag{24}$$

using $\pi(p_2)/(1+r) < V^m$. Because V^u declines with greater state one prices when holding compensation unchanged, the option value under this lower compensation is also less than the option value for the unregulated market: $V^u(n) < V^m(n)$ at any given n. Thus, not only does V^u lie below the V^r curve, it also lies everywhere *below* the V^m curve in figure 1.

Intuitively, the lower compensation by itself is not the only culprit lowering V^u. Market participants recognize that the price of building units will rise in the high demand state should the government take all of the remaining vacant land for greenspace, that is, should the high demand state be realized. Driving up the market price in the high demand state reduces the state price of the high value outcome (i.e., the price of an Arrow-Debreu security for state one) and increases the state price of the low value outcome (i.e., the price of an Arrow-Debreu security for state two). This by itself shifts the state price-weighted expected value of second period earnings–and the option value of vacant land–toward the low demand state. In the scheme where compensation is based on regulated market value (opportunity cost), the higher building price in the high value state increases compensation to the landowner. It turns out that this additional effect outweighs the state price effect and therefore is entirely responsible for increasing the option value under the threat of takings in that case. The unregulated market value compensation scheme, however, bases compensation on the value of vacant land in the absence of takings. This value does not respond to regulation-induced price changes. Thus, the factor that increases option value in the other eminent domain compensation scheme is missing here, and leads to the surprising situation in which the threat of takings drives the market even farther from the efficient outcome.

Summarizing the implications of these option value differences using figure 1, we have the following:

Proposition 1 $n_u > n_m > n_r > n_s$.

A consequence of this ranking of the development paces under different regimes is that $q_0^u > q_0^m > q_0^r > q_0^s$, and full compensation either increases or decreases the initial structural development density, depending on whether regulated or unregulated market values are used as the basis for compensation. Since the amount of land initially developed under the lower compensation, n_u, is even farther from the efficient level than is the market equilibrium without takings, n_m, eminent domain in this case reduces the efficiency of the land market. In terms of figure 2, compensation at regulated market value increases social surplus by area A while compensation at unregulated market prices decreases social surplus by area B. The sum of these two areas therefore represents the social cost of compensating landowners at unregulated market value rather than at regulated market value.

Finally, we note that these results are the same for case in which the greenspace value arises in the low demand state rather than the high demand state (i.e., when $\pi(p_1) > G_1$ and $G_2 > \pi(p_2)$).

5 Conclusion

This paper examined the consequences of eminent domain with full compensation when the land development decision is irreversible. The motivation for an option value framework originates with the nature of greenspace externalities and other types of public land uses for which any private investment in improvements destroys potential social value. It turns out that endogenous prices drive the results. Full compensation by the government for taking vacant land by eminent domain slows the pace of private development, in contrast with Innes (1997) analysis for reversible investment. But even full compensation does not lead to an efficient outcome when structural investment is irreversible. Further, while Blume, Rubinfeld and Shapiro (1984) find that full compensation leads to excessive capital investment per unit of land when such investment is reversible, this paper shows why irreversible private development leads to lower initial structural density than is consistent with efficiency.

The analysis also shows why the efficiency of eminent domain compensation policies is highly sensitive to the nature of the potential social use for the land. Greenspace value leads to fundamentally different conclusions than do social uses like roads or other infrastructure. The analysis also illustrated that the dynamic efficiency conclusions are more complicated than previously found.

Although not addressed here, the option framework also implies that the regulatory problem is complicated when *specific* parcels of land can be identified as potential sources of greenspace externality. The market does not distinguish such land from all other land, so whether or not it is kept vacant is indeterminate at the market level. But even if the parcels that have potential greenspace value can be identified in advance, this does not mean that these parcels will be kept undeveloped for just such an eventuality. The compensation policy plays an important strategic role in this case. If owners expect overcompensation then they have an incentive to hold such land in reserve. If they expect under compensation (compensation at the unregulated market value) then they have an incentive to develop their land sooner in order to extinguish any potential future greenspace claims. What can the government do to ensure that such land will be kept available? Development fees, tax abatement or subsidies for these parcels or even carefully selected development moratoria can forestall development to keep the social greenspace option open. But it is not yet clear how feasible such policies would be given the tug-and-pull of local land use politics nor is it clear how such policies will interact with the resource allocation effects of threatened eminent domain. These remain questions for further study.

Appendix

The derivative properties of the social option value of vacant land (9) referred to in the text are:

$$\frac{\partial V^s}{\partial G_1} = \left(\frac{p_0 - p_1}{p_1 - p_2}\right)\frac{1}{1+r} > 0 \tag{25}$$

$$\frac{\partial V^s}{\partial p_0} = \frac{G_1 - \pi(p_2)}{(p_1 - p_2)(1+r)} > 0 \tag{26}$$

$$\begin{aligned}\frac{\partial V^s}{\partial p_1} &= \frac{\pi(p_2)}{(p_1 - p_2)(1+r)} - \frac{V^s}{(p_1 - p_2)} \\ &= \left(\frac{1}{p_1 - p_2}\right)\left(\frac{\pi(p_2)}{1+r} - V^s\right) < 0 \end{aligned}\tag{27}$$

$$\begin{aligned}\frac{\partial V^s}{\partial p_2} &= \frac{V^s}{(p_1 - p_2)} + \frac{(p_1 - p_0)\pi'(p_2) - G_1}{(p_1 - p_2)(1+r)} \\ &= \left(\frac{1}{p_1 - p_2}\right)\left(V^s - \frac{G_1}{1+r}\right) + \frac{(p_1 - p_0)\pi'(p_2)}{(p_1 - p_2)(1+r)} \\ &= \left(\frac{(p_1 - p_0)}{(p_1 - p_2)^2(1+r)}\right)(\pi(p_2) - G_1 + (p_1 - p_2)\pi'(p_2)) \\ &= \left(\frac{(p_1 - p_0)}{(p_1 - p_2)^2(1+r)}\right)(\pi(p_1) - \varepsilon - G_1) < 0 \end{aligned}\tag{28}$$

where the signs follow from $G_1/(1+r) > V^s$ and $G_1 > \pi(p_1)$ and the last equality uses the strict convexity of the indirect profit function to show $\pi(p_2)+(p_1-p_2)\pi'(p_2)+\varepsilon = \pi(p_1)$ where $\varepsilon > 0$. Thus, $p_1^s(n) > p_1^m(n)$ by itself lowers V^s relative to V^m but at the same time $G_1 > \pi(p_1^m(n))$ raises V^s relative to V^m.

Claim 1: $V^s(n) > V^m(n)$.

Proof. Differentiate V^m with respect to p_1

$$\begin{aligned}\frac{dV^m}{dp_1} &= \left(\frac{\partial V^m}{\partial p_1}\right) + \left(\frac{\partial V^m}{\partial \pi'(p_1)}\right)\pi'(p_1) \\ &= -\left(\frac{(p_0 - p_1)}{(p_1 - p_2)^2(1+r)}\right)(\pi(p_1) + (p_2 - p_1)\pi'(p_1) - \pi(p_2)) \\ &= -\left(\frac{(p_0 - p_1)}{(p_1 - p_2)^2(1+r)}\right)(\pi(p_2) - \varepsilon - \pi(p_2)) \\ &= \left(\frac{(p_0 - p_1)}{(p_1 - p_2)^2(1+r)}\right)\varepsilon > 0. \end{aligned}\tag{29}$$

again using the convexity of the indirect profit function to find $\pi(p_1)+(p_2-p_1)\pi'(p_1)+\varepsilon=\pi(p_2)$ where $\varepsilon>0$ for the third line. See, for example, figure A.1. It follows that

$$\begin{aligned} V^s(n) &= \left(\frac{p_0^m(n)-p_2^m(n)}{p_1^s(n)-p_2^m(n)}\right)\frac{G_1}{(1+r)}+\left(\frac{p_1^s(n)-p_0^m(n)}{p_1^s(n)-p_2^m(n)}\right)\frac{\pi(p_2^m(n))}{(1+r)} \\ &> \left(\frac{p_0^m(n)-p_2^m(n)}{p_1^s(n)-p_2^m(n)}\right)\frac{\pi(p_1^s(n))}{(1+r)}+\left(\frac{p_1^s(n)-p_0^m(n)}{p_1^s(n)-p_2^m(n)}\right)\frac{\pi(p_2^m(n))}{(1+r)} \\ &> \left(\frac{p_0^m(n)-p_2^m(n)}{p_1^m(n)-p_2^m(n)}\right)\frac{\pi(p_1^m(n))}{(1+r)}+\left(\frac{p_1^m(n)-p_0^m(n)}{p_1^m(n)-p_2^m(n)}\right)\frac{\pi(p_2^m(n))}{(1+r)} \\ &= V^m(n) \end{aligned} \tag{30}$$

where the second line follows from $G_1>\pi(p_1^s(n))$, the third line from (29) and $p_1^s(n)>p_1^m(n)$ with (1). Thus, $V^s(n)>V^m(n)$, which is the result to be shown. ■

Claim 2: $V^r(n)>V^m(n)$.

Proof. $V^r(n)$ is the second line in (30) so that the result immediately follows from (30). ■

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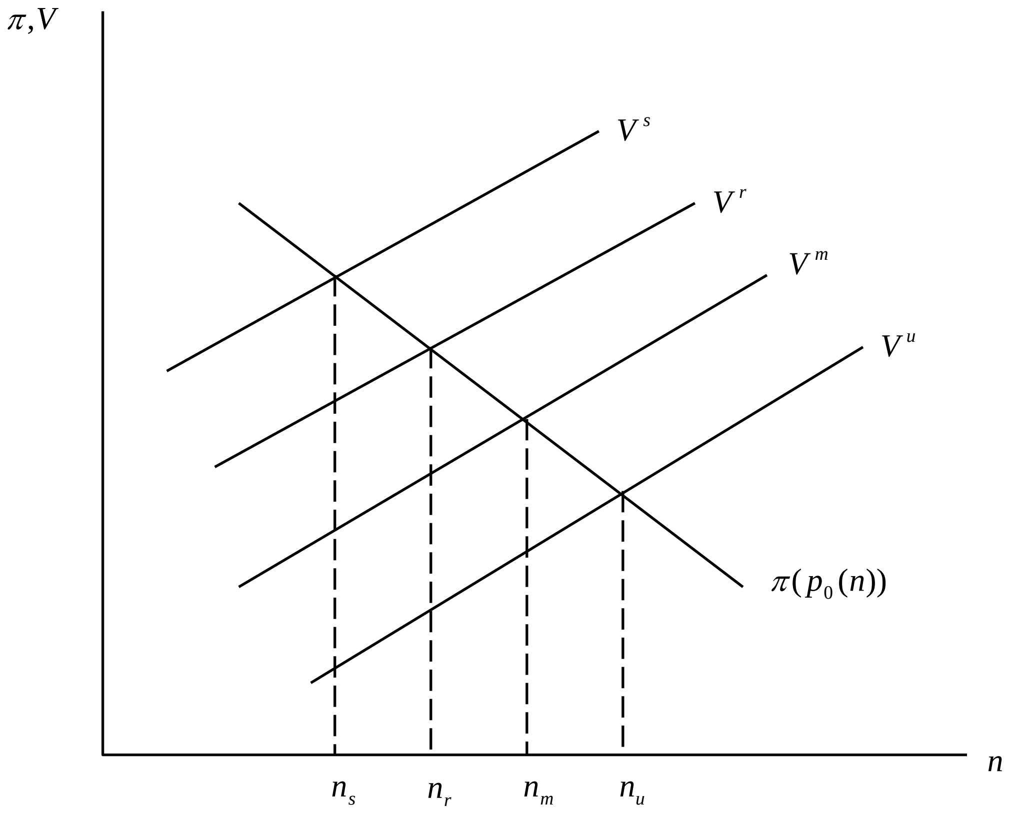

Figure 1

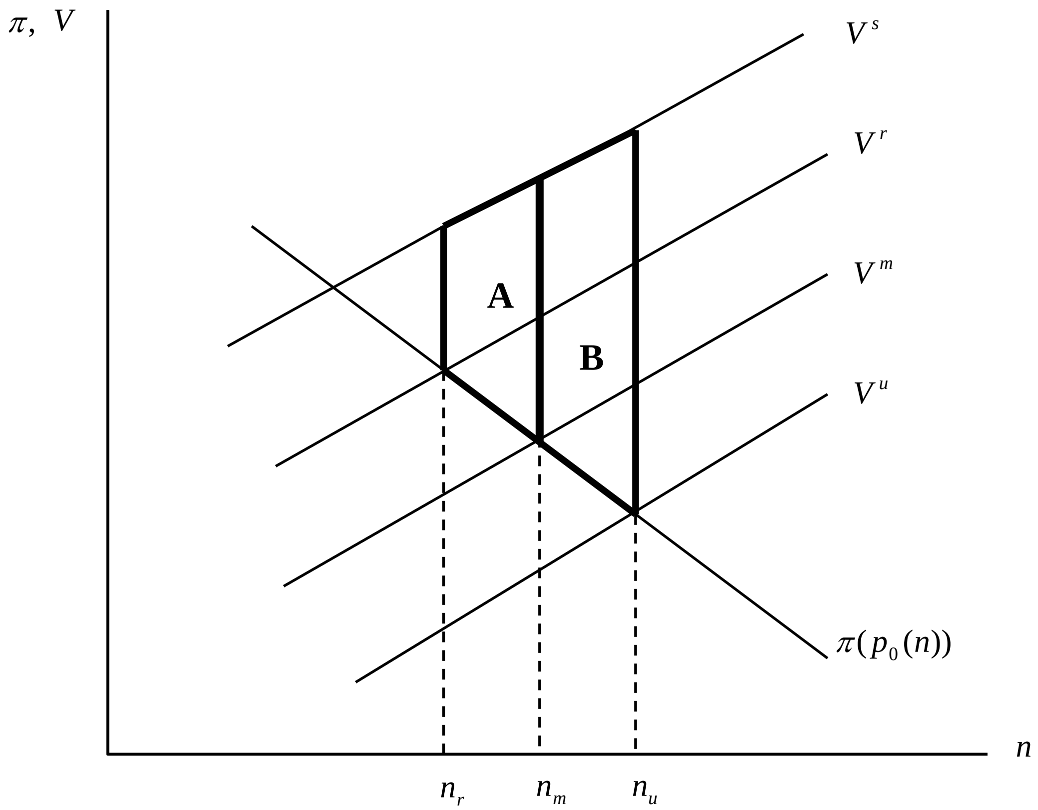

Figure 2

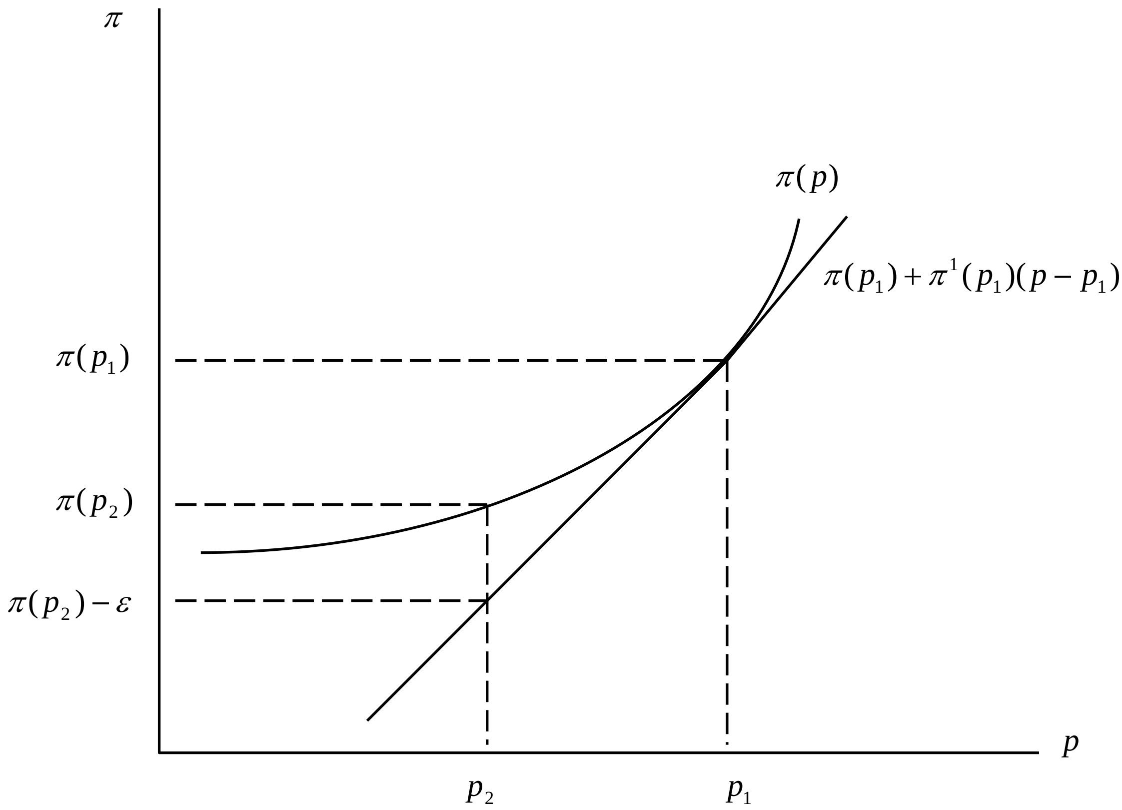

Figure A.1