Efficient Compensation for Regulatory Takings

and Oregon's Measure 37

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In regulating land-use, governments must balance societal interests in environmental protection, control of urban sprawl, and similar issues with the interests of private owners in developing and using land. Since restricting land use in order to meet public goals often entails private losses—decreased market value of land or foregone profits—the question arises of whether property owners should be compensated for these losses, often called regulatory takings. Compensation requirements, such as the recently enacted Measure 37 in Oregon, may be advocated for reasons of both fairness and economic efficiency. This article examines the efficiency aspect of full-compensation rules, which require regulators to pay property owners for losses due to regulation.

Previous analyses have generally found that full-compensation rules lead to inefficient outcomes in the form of overinvestment by property owners. However, given the continued political support for such rules, one naturally wonders whether they might be justified in some settings. In this article, I first develop a model showing one set of conditions under which the overinvestment problem is eliminated and a full-compensation rule can therefore be justified on efficiency grounds. This result provides a possible positive explanation for why such rules are advocated. It also provides a normative prescription for improving the efficiency of such rules when they are desirable for other reasons (e.g. simplicity of implementation, fairness). Finally, this result provides a benchmark for considering the efficiency of full compensation when I extend the model to include budget constraints and taxation, two important real-world considerations largely absent from previous analyses. Using this extended model, I show that, when

governments face budget constraints and limited powers of taxation, a full-compensation rule leads to inefficiency in the form of under-regulation.

Literature Review

Innes, Polasky, and Tschirhart (1998) survey the economics literature on regulatory takings and the efficiency effects of compensation schemes. Much of this literature analyzes whether incentive schemes will lead to efficient choices by two agents: private property owners and government regulators. In particular, it studies whether rules requiring monetary compensation promote optimal decisions at two junctures.

First, the rule should encourage the property owner to make the socially optimal choice for the use of the land, including any investment in it. For example, the owner may choose among growing timber for harvest, clearing the land for crops, and subdividing the property for residential development. These alternative uses may have different initial investment costs for the owner, which may be unrecoverable if he is later forced to switch to a different use. Also, these alternatives will likely offer different potential returns to the owner and incur different external costs (or benefits) for society. Economic models generally assume that the property owner will consider only his private costs and benefits when making the land use decision. If there are significant externalities associated with some of the uses, his profit-maximizing decision may not lead to the optimal choice from a social perspective. Thus, maximizing social welfare may necessitate regulation or prohibition of certain land uses. An efficient compensation rule will combine with regulation to ensure socially optimal decisions by the land owner.

Second, the rule should encourage efficient regulatory decisions by the government, such as determining whether to allow a particular land use for any given parcel. In general, a government is often assumed to employ the Kaldor-Hicks (i.e. potential Pareto improvement) criterion in its regulation decisions, leading to efficient regulation. In the context of takings and regulatory takings, however, observers have long feared that the government may not always act in society's best interest without proper incentives. Such concerns contribute to support for compensation requirements, such as the Fifth Amendment takings clause: "…nor shall private property be taken for public use, without just compensation." This rationale for the takings clause is a moral hazard argument: the government will tend to exercise eminent domain too often if takings are costless to it. Extending this argument to regulatory takings, some fear that the government will ignore the costs of regulation to property owners, leading to overregulation. This "fiscal illusion," as it is called in the literature, would require some constraint on regulatory behavior, such as a compensation requirement, to bring the regulator's decision into alignment with maximizing aggregate social welfare.

Economists have investigated various compensation rules that attempt to balance these two distortions—land owners' disregard for externalities and government's fiscal illusion—and lead to socially optimal decisions by all parties. In a seminal article, Blume, Rubinstein, and Shapiro (1984) found that if the owner is compensated for lost market value, he will have an incentive to over-invest (e.g. choose land uses that require upfront investments that are wasted when regulation is enacted). A full-compensation rule essentially insures the owner against the risk of regulation. This model suggests that a no-

compensation rule[1] would lead the owner to make the socially optimal choice. This result assumes that government takings are exogenous to the level of investment and are presumed efficient. (I.e. Fiscal illusion is not present.)

Miceli and Segerson (1994, 1996) develop a model to provide a positive explanation for the common law approach to regulatory takings. In their model, the takings decision is endogenous and subject to fiscal illusion. As did Blume et al, they find that full compensation leads to inefficiency, as the owner will tend to over-invest. They find two efficient rules that feature compensation conditioned on efficiency, echoing Supreme Court decisions that allow compensation only when a regulation "goes too far." Their ex ante rule provides full compensation to the land owner if and only if his investment decision was ex ante efficient (i.e. with regard to expectations about externalities). The efficiency of the government's decision is irrelevant for determining compensation. Under their ex post rule, alternatively, full compensation is paid if and only if the government's regulatory decision was ex post inefficient (i.e. given the owner's investment choice and the realized externality). Under either rule, both the property owner and the government should make efficient choices.

Hermalin (1995) investigates efficient compensation for endogenous takings under several information structures. He finds that full compensation (i.e. lost market value) is generally inefficient, leading to overinvestment due to the owner's moral hazard. He also finds that a zero-compensation rule is inefficient. Under such a rule, the owner has an incentive to over-invest in order to discourage government takings. The

[1] The Blume, Rubinfeld, and Shapiro result requires lump-sum compensation, which does not vary with the investment level. Zero compensation, the best-known version of the rule, is a special case of this result.

difference between this result and the Blume et al result stems from the endogeneity of the takings decision in Hermalin's model, whereas Blume et al assume exogenous takings.[2] Hermalin shows that when fiscal illusion does not exist, either because the government is benevolent or because the amount of the externality is common knowledge, the efficient compensation rule pays the private owner the social benefit in the event of a taking. As Innes et al (1998) point out, this rule is essentially Pigouvian compensation. When the state is not benevolent and the externality is the state's private information, Hermalin's efficient rule involves two-part compensation. First, the state announces its interest in a taking and asks the owner to state a price reflecting his private value. This announcement triggers a transfer equal to the state's expected surplus if the taking proceeds at the owner's stated price. This mechanism induces the owner to truthfully reveal his private value. The state then has the option to continue with the taking, which requires a further payment at the owner's stated price.

Innes (1997) introduces multiple parcels and a time dimension, to investigate the effects of the relative treatment of developed and undeveloped parcels. He finds that the compensation rule has a significant effect on the timing of development. In particular, a full-compensation rule induces owners to develop too early, in order to gain the beneficial treatment that developed properties receive in a taking under such a rule. He further finds that over-compensating owners of undeveloped land would restore the

[2] The exogenous taking assumption is made in the basic model (Section II) in Blume et al (1984), resulting in the zero-compensation rule. In their Section III, the authors consider endogenously determined takings, still without fiscal illusion, and find that both zero- and full-compensations rules induce inefficiency in the form of overinvestment, paralleling Hermalin's (1995) later result.

equality of incentives necessary for efficient timing of development. He then advocates the use of tradable development rights as an alternative to monetary compensation.

Fiscal Illusion

The assumption of fiscal illusion plays a key role in most arguments for a compensation rule of some form. The usual narrative is that the government is more responsive to one segment of society (e.g. conservationists) than to others (e.g. land owners). Thus, it bases its regulatory decisions disproportionately on the first group's costs and benefits, ignoring or discounting the other groups' interests.

Buchanan (1962) argues that it is inconsistent for economic models to assume that individuals are motivated by self-interest in their personal affairs while also assuming that government decision-makers pursue only maximum social welfare in performing their jobs. The theories of the public choice field instead use models of self-interested government actors, motivated by re-election, bureaucratic empire-building, and similar objectives. In such a setting, a regulator's weighting of one group's interests over another's seems quite reasonable. One group may possess more political clout than another. A regulatory agency may push for more regulation, to justify its existence and extends its sphere of influence. Thus, government agents, in rationally pursuing their own self-interests, lead government to deviate from the goal of maximizing societal welfare.

However, Innes (1997) argues that fiscal illusion may be an unrealistic assumption. He develops a model of the political behavior of an unfettered government—one free to set both taxation and regulation—that responds more to one interest group than to another. Innes finds that the government is best served by using efficient

regulation, thus maximizing the surplus that it has available to tax, even when it favors one group over another.

However, if a government taxation's and redistribution powers are not unfettered, fiscal illusion may still exist. Suppose the government is unable to tax the full surplus of the disfavored group. Using regulation to transfer surplus from the disfavored group to the favored group may yield a greater benefit to the latter than would taxation, even if some loss occurs from the inefficiency of regulation. In the extended model, I incorporate both a limited power to tax and a budget constraint that limits the government's ability to pay compensation. Under these institutional constraints, fiscal illusion can still exist.

Basic Model

In this section, I develop a model with which I will compare compensation rules under two possible sequences of events. Scenario 1 follows the sequence used in much of the previous literature, and the model replicates the familiar result that a full-compensation rule is inefficient. Scenario 2 presents an alternative institutional framework, under which a full-compensation rule performs more favorably.

A parcel of land has two potential uses: developed and undeveloped. Development requires an upfront investment, $I > 0$, and incurs a potential external cost to society in the form of pollution, lost environmental services, reduction in aesthetic value, or similar harm. The amount of the external cost is a random variable, s. Undeveloped property requires no investment and incurs no external cost to society. The private value of undeveloped property to the owner is normalized to 0. The private value of developed property is a random variable, p, with an expected value of $\overline{p}$.

The government may choose to regulate land use on the parcel, preventing development. If regulation is imposed, any upfront investment I is lost, the owner receives a private benefit of 0, and society avoids external harm of s. The government may also have to pay compensation, C, to the property owner, depending upon the compensation rule in place.

Variables p and s have density functions $f(p)$ and $g(s)$ with cdfs $F(p)$ and $G(s)$, respectively, and p and s are independently distributed. In order to simplify the problem and restrict attention to interesting cases, assume that $F(I) = 0$, so that development is always privately optimal. Also assume $G(0) = 0$, so that the realized social cost of development will always be positive. I assume that both the property owner and the regulator are risk-neutral.

The sequence of events will follow one of two scenarios. Scenario 1 follows the pattern established in the previous literature, and the model replicates the familiar results concerning compensation rules. Scenario 2 presents an alternative framework, in which different results follow. In particular, a full-compensation rule performs favorably. A discussion of which scenario best reflects the issues facing policy-makers follows.

Scenario 1

Under scenario 1, the sequence of events is as follows. At time 1, the owner chooses a land use, paying I if development is chosen. At time 2, the random variables p and s are realized, and the government chooses whether to regulate land use on the parcel. At time 3, any required compensation is paid.

First-Best Solution

A hypothetical social planner seeks to maximize expected aggregate welfare: private benefit less investment and external social cost. This planner makes decisions in place of the private owner at time 1 and in place of the regulator at time 2.

> *PROPOSITION 1: Under scenario 1, the social planner would invest for development at time 1 if and only if* $\int_{-\infty}^{\infty} g(s) \int_{s}^{\infty} f(p)(p-s)\,dp\,ds > I$ *and would allow development to proceed at time 2 if and only if* $p - s > 0$.
>
> *(Proofs for all propositions are presented in the appendix.)*

The hypothetical social planner's decision rules at times 1 and 2 provide a benchmark for analyzing the efficiency of the decisions the private owner and the government regulator would make under various compensation rules.

Regulator's Problem

At time 2, the decision whether to proceed with development (assuming the investment was made) falls to the government regulator. The regulator is assumed to operate under fiscal illusion, essentially ignoring the private owner's interests.[3] The regulator instead acts to maximize the welfare of the rest of society, subject to any required compensation. When the private owner has invested for development, the regulator's decision problem can be expressed as $\underset{r}{\text{Max}} -(1-r)s - rC$, where $r = 1$ when the government chooses to regulate, disallowing development, and $r = 0$ otherwise. The form and value of C will depend on the compensation rule in place. Under a full-compensation rule, $C = p$,

[3] A less restrictive version of fiscal illusion would allow different, but non-zero, weights for the interests of the owner and the rest of society. Blume et al (1984) present such a model in their Section V. In order to retain simplicity, I use an implicit weight of zero for the owner's welfare.

because the government must pay the private owner the lost value of development that is precluded by the regulation. Under a no-compensation rule, $C = 0$, because the government pays no compensation regardless of whether it regulates.

> *PROPOSITION 2: Under a no-compensation rule in scenario 1, the regulator will prevent development if and only if $s > 0$. Under a full-compensation rule in scenario 1, the regulator will allow development if and only if $p - s > 0$.*

Under the no-compensation rule, the government always regulates, since $s > 0$ is true by assumption. This amounts to over-regulation whenever $p > s$ is realized, because the socially optimal outcome is no regulation in that case. Under this rule, the regulator never under-regulates (i.e. chooses $r = 0$ when $s > p$). The full-compensation rule, in contrast, internalizes the private owner's value and induces a decision rule equivalent to the social planner's rule. Thus, the regulator's objective function under full compensation is aligned with maximizing aggregate welfare.

Owner's Problem

At time 1, the private owner is faced with the choice of whether to make the upfront investment that will allow development. Since the private benefit and social cost of development are not yet realized, he makes his investment choice based on expectations of his private benefits and the social cost, the regulator's decision rule, the compensation rule, and his investment cost. His problem can be expressed as $\underset{d}{\text{Max}}\ d\text{E}\left[(1-r)p + rC - I\right]$, where $d = 1$ if he makes the investment for development and $d = 0$ otherwise. Again, the form of C depends on the compensation rule in effect.

PROPOSITION 3: Under scenario 1, an owner facing a no-compensation rule never invests for development. An owner facing a full-compensation rule always invests for development.

Thus, a no-compensation rule leads the owner to under-invest in response to the expectation that the regulator will disallow development, even when it would be efficient. The full-compensation rule induces the owner to over-invest, choosing to invest I in all cases, even though efficiency requires that he should forego investment in some cases, given the possibility that regulation will be chosen.

Summary

In scenario 1, a full-compensation rule leads to efficient regulation but inefficient overinvestment, a result consistent with the previous literature. A no-compensation rule leads to overregulation and corresponding underinvestment as a response. More complicated compensation rules, such as those of Miceli and Segerson (1994, 1996) and Hermalin (1995), would be necessary to achieve efficiency under these conditions. The key element of the scenario is that the property owner chooses investment before the government has the opportunity to assess social cost and regulate land use.

Scenario 2

Suppose instead that events occur in the following sequence. At time 1, the government implements a permit requirement, requiring the owner to apply for a permit before developing his property. At time 2, random variable p is realized and the owner submits a permit application, specifying p and I. At time 3, random variable s is realized, and the government chooses whether to allow development. At time 4, any required

compensation is paid or investment and development proceed if permitted. All other elements of the model remain unchanged.

This sequence corresponds to an environment in which a system of regulations is already in place. When a new development opportunity arises, the land owner is required to apply for approval from the appropriate regulatory agency before investing for development. If the agency choose to enforce the regulation, then compensation may be required. If the regulation is waived for that property, development proceeds and no compensation is due.

First-Best Solution

The social planner maximizing expected aggregate welfare has only one choice to make, at time 3, whether to allow investment and development.

> *PROPOSITION 4: Under scenario 2, the social planner will proceed with development at time 3 if and only if* $p - I > s$.

This decision rule maximizes aggregate welfare, because it allows development exactly when the aggregate benefits outweigh the aggregate costs, including upfront investment.

Regulator's Problem

As in scenario 1, the regulator determines whether to allow development to proceed, at time 3 under this scenario. The assumption of fiscal illusion is maintained, so the regulator effectively ignores the private owner's interest unless the compensation rule makes it relevant.

> *PROPOSITION 5: Under scenario 2, a government facing a full-compensation rule will allow development at time 3 if and only if* $p - I > s$.

Thus, the government's regulation decision is efficient, replicating that of the social planner.

Owner's Problem

In scenario 2, the owner's problem is trivial. He will always develop at time 4 if permitted, but development will be permitted only when it is efficient. Thus, the owner's decision at this stage also conforms to the social planner's rule and is efficient.

At time 2, the owner submits an application indicating his desire to develop land, as well as information on p and I. For the sake of simplicity, this analysis assumes truthful revelation by the owner at this stage. However, if p and I are private information, the potential for dishonest applications exists. The owner may overstate the profit potential from development, $p - I$, particularly in a no-compensation setting.[4] Even under a full-compensation setting, the owner may overstate $p - I$ in order to increase his potential compensation, although doing so decreases the probability that regulation will in fact be enforced. Of course, the state may require evidence to substantiate the owner's claim, in order to mitigate the potential for dishonesty. A full analysis of the information and verifiability aspects of this process is beyond the scope of this article.

Summary

In scenario 2, a full-compensation rule leads to efficient decisions. Because the owner is prevented from investing until the regulation choice is made, investment will be efficient. The full-compensation rule internalizes the owner's private costs (lost benefit) in the regulator's objective function, leading to efficient regulatory decisions as well.

[4] Under a no-compensation rule, revelation of $p - I$ is relevant only if the regulator is assumed to place some weight on the private benefits of the land owner (i.e. partial fiscal illusion).

Which Scenario Is More Realistic?

The U.S. common law has generally drawn a distinction between physical takings (e.g. using eminent domain to seize land for building a highway) and regulatory takings (e.g. a prohibition against development while the owners retain title to the land). For a physical taking, the government has been obligated under the Fifth Amendment to pay "just compensation" to the owner, usually interpreted as fair market value for the property. For regulatory takings, the Supreme Court has articulated several criteria (see Miceli and Segerson 1994, 1996 for a description) for determining under what circumstances the government must pay compensation. However, the standard is far from clear and, in practice, compensation is not found to be required in the vast majority of court cases.

In contrast to the common law, the economics literature has generally treated physical and regulatory takings as a single issue, varying in the proportion of property rights taken but similar enough conceptually for the same theoretical models to apply. The early literature focused on physical takings and developed models reflecting the sequence in scenario 1. This sequence seems very reasonable in the case of physical takings, since any relevant actions by the owner must occur before the taking; he will have little opportunity for investment once he loses title.

Subsequent literature began to address regulatory takings, although often using models derived from analyses of physical takings. Thus, the sequence from scenario 1 forms the basis of these models. However, it may be that scenario 2 represents a better approximation of reality, at least in some regulatory situations. Oregon's Measure 37, for example, follows the sequence of scenario 2. Under that law, long-standing regulations of

various sorts preclude development unless owners apply for and receive a waiver of the regulation.

From a prescriptive perspective, scenario 2 offers guidelines for implementing a full-compensation rule in a more efficient way if such a rule is desirable for reasons beyond the efficiency criterion. Such a rule might be appealing because of its relative simplicity or because it is consistent with notions of procedural fairness (e.g. spreading the costs of societal benefits widely among taxpayers). In such a case, designing mechanisms to prevent investment in land uses before a final regulatory decision is made may avoid some inefficiency in land owners' choices, while retaining the efficient incentives a full-compensation rule provides for regulators.

For purposes of this article, scenario 2 provides a desirable benchmark. Under scenario 2, a full-compensation rule achieves the efficient outcome in the basic model, which omits budget and taxation issues. By examining scenario 2 under an extended model incorporating those elements, I can isolate the efficiency impacts of those elements with regard to a full-compensation rule.

Budget Constraints and Taxation

A frequent criticism of Measure 37 is that the law is a de facto repeal of the state's comprehensive land use plans. These critics claim that, since the state agencies have little money for paying compensation claims, they will be forced to waive the regulatory restrictions in many cases. There seems to be some empirical support for this criticism. As of January 2006, in no resolution of any claim had compensation been paid; that is, waivers had been chosen for all legitimate claims (Martin and Shriver, 2006).

Budget and taxation issues are realistic concerns for an analysis of government decision-making. For example, the budget of the government as a whole is constrained by its taxation power; it cannot spend more money than it can raise via taxes.[5] Individual agencies may not possess the power to tax, and therefore rely on appropriations to fund their spending. These factors support the relevance of a budget constraint.

Government may be prevented from taxing the entire surplus for several reasons. For example, re-election motives on the part of politicians may prevent the government from taxing all of the surplus from a strong constituent group. Also, taxes are well noted for their strong disincentive effects on activities that produce the taxed surplus, so policy-makers may be unwilling impose taxes above certain rates. Additionally, certain types of surplus may be hard to measure and, therefore, more difficult to tax. For example, it would be more difficult to obtain political support for and implement a tax on the enjoyment of environmental services than a tax on corporate profits. Thus, incorporating some form of budget constraint in conjunction with limited taxation should improve the model, allowing for analysis of these important effects.

Extended Model

I next develop an extension of the basic model, incorporating a budget constraint and limited powers of taxation, as well as encompassing multiple properties. The analysis focuses on the regulator's decisions under scenario 2.

[5] There are several caveats to this simplification. Governments may also raise funds by printing money or issuing debt. Since this article focuses on state governments, which lack the federal government's power to print money, I omit this issue. Similarly, I omit debt issuance for two reasons. First, my model is fairly simple in the time dimension, and incorporating debt would complicate this aspect considerably. Second, if one assumes that debt must eventually be repaid (i.e. disallowing bankruptcy and debt-forgiveness), then taxes remain the ultimate source for spending.

Suppose that there are n properties under the jurisdiction of the government. Each property has its own private benefit, investment, and social cost as before and the regulator makes a separate decision for each property, so the variables are indexed by property: $p_i, I_i, s_i, r_i, C_i, \forall i = 1,..., n$.

In addition, the government has a budget constraint on the total compensation paid, $\sum_n r_i C_i \leq \alpha + t_s \sum_n r_i s_i + t_p \sum_n (1 - r_i)(p_i - I_i)$, where r_i is a variable indexing regulation as before. $r_i C_i$ is the compensation paid for property i, with $C_i = p_i - I_i$ under a full-compensation rule and scenario 2. $t_s < \beta$ is the tax rate on the social benefit of (damage avoided by) regulation, and $t_p < \gamma$ is the tax rate on owners' private benefits.

Parameters α, β, and γ capture the government's ability to raise tax revenue from various sources. Parameter α is lump-sum funding not associated with either private property values or the social benefits of property. For an individual agency, for example, this amount represents the appropriations allocated to it from the state budget, which do not vary with land-use decisions.

The coefficient $\beta < 1$ shows the maximum proportion of the *social* benefit of land-use choices (i.e. avoided social cost) that the government is able to capture via taxation. The coefficient $\gamma < 1$ shows the maximum proportion of the *private* benefit of land-use choices that the government is able to capture via taxation. For the government as a whole, these parameters reflect limits on the government's taxation power due to political constraints, the difficulty of measuring certain types of surplus, and so forth. For individual agencies, these parameters could reflect increases in budget allocations based

on the performance of the agency. Thus, various combinations of α, β, and γ would reflect different assumptions about the nature of the government decision-making entity.

First Best Solution

As in the basic model, a hypothetical social planner's aggregate welfare-maximizing decision provides a benchmark for efficiency. The social planner attempts to maximize expected aggregate welfare: private benefit less investment and external social cost, summed across all properties. The planner is not constrained by a budget.

> *PROPOSITION 6: Under scenario 2, the social planner will disallow development on parcel i at time* 3 *if and only if* $\frac{s_i}{p_i - I_i} > 1$.

Regulator's Decision

As before, I assume that the regulator operates under fiscal illusion, ignoring the private benefits of land owners and attempting to maximize the welfare of the rest of society, net of taxes paid. The regulator's problem is expressed as $\underset{r_i}{\text{Max}} -\sum(1-r_i)s_i - t_s \sum_n r_i s_i$,

subject to the budget constraint, constraints on t_s and t_p, and the definition of C_i above. The form of the solution to this problem depends on the nature of parameters α, β, and γ. Therefore, I will analyze two representative cases of interest.

Case 1 – No Endogenous Tax

Assume $\alpha > 0$ and $\beta = \gamma = 0$. These parameters describe the case of a particular regulatory entity within the larger government, one that has no independent taxation authority and relies on a fixed allocation for its funding. From this fixed allocation, the agency must pay any compensation required by its regulatory decisions. The regulator's problem is to

choose a combination of parcels to regulate that will avoid the most social harm while keeping total compensation within the fixed budget. The problem can be expressed as $\underset{r_i}{\text{Max}} - \sum (1 - r_i) s_i$, subject to $\sum_n r_i (p_i - I_i) \leq \alpha$.

This problem is analogous to a benefit-cost problem with a fixed budget for cost. The solution can be approximated by first ranking the parcels by a criterion such as the ratio of social benefit to required compensation, $\frac{s_i}{p_i - I_i}$. Then the regulator would choose to regulate the parcels from the highest ratio to the lowest, until the budget is exhausted.

From Proposition 6, efficient regulation requires that exactly those parcels for which $\frac{s_i}{p_i - I_i} > 1$ would be regulated. To the regulator, however, the benchmark ratio of 1 is of little importance. Instead, the size of α plays the critical role. The regulator will regulate parcels until its budget, α, is exhausted. Although it will tend to regulate parcels with high ratios and allow development on those with low ratios, there is no guarantee that the ratio of 1 will mark the boundary between the two groups of parcels.

For relatively large values of α, overregulation will occur; that is, parcels with a ratio of less than 1 will be regulated because the regulator has more funding than is necessary to compensate only the parcels that would be efficiently regulated. For small values of α, under-regulation will occur; parcels with a ratio of greater than 1 will not be regulated, because the tight budget is not sufficient to compensate all of the parcels that would be efficiently regulated.

Consider a specific example. Suppose there are $n = 5$ parcels with the realized values shown in table 1. If $\alpha = 10$, the regulator will regulate parcels 1 and 2, because they give the most social cost avoidance that is affordable with a budget of 10. However, efficiency would dictate that parcel 3 also be regulated, since its ratio of 1.25 is higher than 1. In this case, therefore, under-regulation occurs. If $\alpha = 20$, then the regulator will choose to regulate parcels 1-4, since the total compensation required, 20, is affordable under the budget constraint, while regulating parcel 5 in addition would not be affordable. In this case, however, overregulation occurs. Parcel 4 has a ratio of less than 1, and efficiency requires that it not be regulated.

Parcel (i)	Private Benefit (p_i)	Investment (I_i)	Compensation ($C_i = p_i - I_i$)	Social Cost (s_i)	Ratio $\left(\frac{s_i}{p_i - I_i}\right)$
1	5	2	3	6	2.0
2	10	5	5	8	1.6
3	7	3	4	5	1.25
4	10	2	8	6	0.75
5	5	1	4	2	0.5

Table 1 – Example with no endogenous tax

Case 2 – No Exogenous Funding

Suppose that $\alpha = 0$, $\beta > 0$, and $\gamma > 0$. This case could represent the situation of the government as a whole, which has taxed the maximum amount possible from sources unrelated to the use of the land in question and already allocated that money to other

spending. Thus, the government must raise any funds necessary for compensation by taxing the private or social benefits arising from those parcels. The regulator's problem is expressed as $\underset{r_i}{\text{Max}} - \sum_n (1 - r_i) s_i - t_s \sum_n r_i s_i$, subject to the budget constraint

$$\sum_n r_i (p_i - I_i) \leq t_s \sum_n r_i s_i + t_p \sum_n (1 - r_i)(p_i - I_i).$$

PROPOSITION 7: Under case 2 of the extended model, the regulator will regulate property i if and only if $\frac{s_i}{p_i - I_i} > 1 + \gamma$.

Choosing to regulate another parcel under a binding budget constraint implies that the regulator must raise taxes (t_s) on the rest of society not only to pay the compensation on that parcel but also to replace the lost revenue from taxing that parcel's private benefit. Recall that the efficient decision rule is to regulate if and only if $\frac{s_i}{p_i - I_i} > 1$. Under-regulation occurs because $1 + \gamma > 1$; the regulator will not regulate some parcels that would be regulated under an efficient rule, those with a ratio between 1 and $1 + \gamma$.

Consider again the numerical example, presented in table 2 with additional information on revenue from a tax on net private benefits. Assume $t_p = \gamma = 0.5$.[6] The net private-benefit tax on some parcels can be used to pay compensation to regulate others, even without a tax on the social benefit of the regulated parcels. Parcels 1-2 can be regulated with the compensation covered by the taxes levied on parcels 3-5, which are allowed to be developed. Tax revenues on parcels 3-5 total 8, which is equal to the total

[6] As shown in the proof of Proposition 7 (see appendix), the regulator will tax private benefits at the maximum rate, under the fiscal illusion assumption.

compensation required for regulating parcels 1-2. The regulator considers whether to regulate parcel 3 also. Changing that parcel from development to regulation decreases tax revenue by 2 and increases compensation due by 4, for a total budget impact of 6. This can be accommodated only by raising taxes on the social benefit. Since the incremental social benefit is only 5, the regulator will not regulate that parcel, even though the social value outweighs the net private value. This tradeoff is captured conveniently by the decision rule: regulate if and only if $\frac{s_i}{p_i - I_i} > 1 + \gamma$. Since parcel 3's ratio is 1.25, which is less than $1 + \gamma = 1.5$, parcel 3 (as well as parcels 4 and 5) will not be regulated. Since parcel 3 would be regulated under an efficient rule (1.25 > 1), under-regulation occurs.

Parcel (i)	Private Benefit (p_i)	Investment (I_i)	Compensation ($C_i = p_i - I_i$)	Private Tax $\gamma(p_i - I_i)$	Social Cost (s_i)	Ratio $\left(\frac{s_i}{p_i - I_i}\right)$
1	5	2	3	1.5	6	2.0
2	10	5	5	2.5	8	1.6
3	7	3	4	2.0	5	1.25
4	10	2	8	4.0	6	0.9
5	5	1	4	2.0	2	0.5

Table 2 – Example with no exogenous funding

Without restrictions on the values of β and γ, a full-compensation rule will generally lead to under-regulation. However, if the government can be precluded from taxing the private benefits of development, $\gamma = 0$, and it is able to tax a high proportion of

the social benefits of regulation,[7] then efficiency can be achieved. Unfortunately, such a proposition is likely easier said than done. Limiting the tax on net private value may be possible, although it could mean eliminating the property taxes that are an important part of many state and local tax structures. Empowering the government to tax the social benefits of regulation would likely prove extremely difficult. The political opposition to such a tax could be tremendous, and implementing a method for measuring such benefits and apportioning the tax among taxpayers is fraught with peril.

Conclusions

The previous literature on compensation for regulatory takings is nearly unanimous in finding that a full-compensation rule, requiring unconditional compensation equal to the market value lost to regulation, leads to inefficient overinvestment on the part of the land owner. Despite this result, several states have considered or enacted legislation implementing such a rule. This behavior raises the question whether such legislation is merely serving special interests at the cost of efficiency or whether it can be justified as efficient under models different from those in the previous literature.

A simple model shows that, under an alternative sequence of events, a full-compensation rule can be efficient. The key element of this sequence is that owners are barred from investment until the regulation question is resolved. This pre-emptive regulation induces efficient choices by the land owner. The full-compensation rule similarly induces efficient regulatory choices, even in the face of fiscal illusion, since the

[7] The ability to tax the entire social benefit, $\beta = 1$, in conjunction with $\gamma = 0$ would be sufficient, although not necessary, to achieve efficiency. The necessary condition for efficiency is a β high enough, but possibly less than 1, that setting $t_s = \beta$ just causes the budget constraint to bind.

owner's private benefit is internalized. Thus, a full-compensation rule may be efficient under some circumstances. If a state is committed to using such a rule, perhaps because of its simplicity, these results suggest that implementing a pre-emptive restriction that may be waived once the relative private and social values can be compared would be complementary to a full-compensation rule, increasing overall efficiency.

Next, the model (using the alternative sequence) is extended to incorporate a budget constraint and limited taxation of the private and social values. The nature of the budget constraint and taxation powers greatly affects the efficiency of a full-compensation rule. If an individual agency has a relatively small budget and no taxation authority, then it will be forced to prioritize its regulatory choices. This outcome has the desirable property that the regulations enforced will those contributing most to aggregate welfare. However, if the budget is not linked in some way to the aggregate welfare generated by the regulation, then either over- or under-regulation could occur.

The government as a whole can be thought of as raising revenue from the taxation of the private and social benefits of land use in order to finance any necessary compensation. Under realistic assumptions about these taxation powers, however, such a design will lead to under-regulation. Even under the favorable environment envisioned in scenario 2, a full-compensation requirement will lead to inefficiency when considerations of budgets and taxation are considered. If a state remains committed to such a rule, then the results of the extended model may provide some guidance for moderating the inefficiency of the rule.

Appendix

Proof of Proposition 1

At time 2, the investment level is given. If no investment was made, then only the undeveloped land use is possible, for an aggregate welfare of 0. If I was invested to permit development, then the planner must assess whether to proceed with such development. Development will yield aggregate welfare of $p - s - I$, while leaving the land undeveloped yields aggregate welfare of $-I$. Therefore, the social planner will maximize aggregate welfare by proceeding with development (if possible) at time 2 if and only if $p - s > 0$.

At time 1, the planner must choose whether to invest I for potential development, knowing the rule she will follow at time 2. She will proceed will development at time 2 only if $p - s > 0$, so investing I yields an expected aggregate welfare of $\int_{-\infty}^{\infty} g(s) \int_{s}^{\infty} f(p)(p-s)dpds - I$, while not investing yields an expected aggregate welfare of 0. Thus, the planner will invest at time 1 if and only if $\int_{-\infty}^{\infty} g(s) \int_{s}^{\infty} f(p)(p-s)dpds > I$. This decision rule maximizes expected aggregate welfare by balancing the expected private benefits from development in excess of social costs against the investment cost required to allow the development option.

Proof of Proposition 2

The regulator's problem is $\underset{r}{\text{Max}} -(1-r)s - rC$. Under the assumption of fiscal illusion, the regulator chooses r to maximize the aggregate social benefit excluding the property

owner's private benefit, less any compensation required. Under the no-compensation rule, $C = 0$, so she must choose r to maximize $-(1 - r)s$. Thus, she will regulate ($r = 1$) at time 2 whenever $s > 0$, without regard for the value of p.

Under a full-compensation rule, $C = p$, so the regulator must choose r to maximize $-(1 - r)s - rp$. Thus, she will regulate ($r = 1$) at time 2 if and only if $s > p$, which is equivalent to the social planner's rule.

Proof of Proposition 3

The owner's problem is $\underset{d}{\text{Max}}\ d\text{E}\left[(1-r)p + rC - I\right]$. Under a no-compensation rule, $C = 0$, so the private owner maximizes $d\text{E}[(1 - r)p - I]$ knowing the regulator will choose $r = 1$ whenever $s > 0$. Since $s > 0$ is always true by initial assumption, the owner maximizes $d(-I)$. Thus, he will choose $d = 0$ in all cases.

Under the full-compensation rule, $C = p$, so the owner chooses d to maximize $d\text{E}[p - I]$, since he receives $p - I$ if he chooses to develop the land, regardless of the subsequent regulation decision. Thus, he will choose development ($d = 1$) if and only if $\bar{p} - I > 0$, which is true by initial assumption. Thus, he will always invest for development.

Proof of Proposition 4

Development will yield aggregate welfare of $p - s - I$, while leaving the land undeveloped yields aggregate welfare of 0. Therefore, the social planner will proceed with development if and only if $p - I - s > 0$.

Proof of Proposition 5

The regulator's decision problem is again expressed as $\underset{r}{\text{Max}} -(1-r)s - rC$, where $r = 1$ when the regulator chooses to regulate (i.e. prevent development) and $r = 0$ otherwise. In scenario 2, a full-compensation rule takes the form C = $p - I$, since the loss due to regulation is adjusted for avoiding the investment cost. Under this rule, the regulator chooses r to maximize $-(1 - r)s - r(p - I)$. Thus, she will allow development at time 3 if and only if $p - I > s$.

Proof of Proposition 6

The planner's problem is expressed as $\underset{r_i}{\text{Max}} -\sum_n (1-r_i)s_i + \sum_n (1-r_i)(p_i - I_i)$. The planner is not subject to the budget constraint. The derivative of the objective function with respect to r_i is $s_i - p_i + I_i$. Thus, the planner will regulate ($r = 1$) if and only if $s_i - p_i + I_i > 0$, which is equivalent to $\frac{s_i}{p_i - I_i} > 1$.

Proof of Proposition 7

The regulator's problem is expressed as $\underset{r_i}{\text{Max}} -\sum_n (1-r_i)s_i - t_s \sum_n r_i s_i$, subject to the budget constraint $\sum_n r_i (p_i - I_i) \le t_s \sum_n r_i s_i + t_p \sum_n (1-r_i)(p_i - I_i)$. Since t_p does not affect the objective function, the regulator will tax private benefits of land use at the maximum rate, $t_p = \gamma$. She will also lower t_s until the budget constraint binds with equality, $\sum_n r_i (p_i - I_i) = t_s \sum_n r_i s_i + \gamma \sum_n (1-r_i)(p_i - I_i)$. Substitution of the binding budget

constraint into the objective function simplifies the problem to

$$\underset{r_i}{\text{Max}} -\sum_n (1-r_i)s_i - \sum_n r_i(p_i - I_i) + \gamma \sum_n (1-r_i)(p_i - I_i).$$

The derivative of the objective function with respect to r_i is $s_i - (p_i - I_i) - \gamma(p_i - I_i)$. So the regulator will choose $r = 1$ if and only if $s_i - (p_i - I_i) - \gamma(p_i - I_i) > 0$, and $r = 0$ otherwise. This condition is equivalent to the decision rule to regulate ($r_i = 1$) if and only if $\frac{s_i}{p_i - I_i} > 1 + \gamma$.

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