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LAWRENCE BLUME
DANIEL L. RUBinfeld
PERRY SHAPIRO

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THE TAKING OF LAND: WHEN SHOULD COMPENSATION BE PAID?*

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The analysis focuses on the question of whether the payment of compensation for land taken by eminent domain is efficient. When the taking decision is independent of land use, zero compensation is efficient, but full compensation is not. When the project decision is no longer independent of land use, and can be affected by investor decisions, neither compensation rule is generally efficient because of the moral hazard problem. With risk-averse consumers and risk-neutral firms, the previous conclusions remain essentially unchanged. However, when the project decision rule involves a budgetary "fiscal illusion," additional compensation may be necessary to correct the incentives facing the project decision-maker.

I. INTRODUCTION

The Fifth Amendment to the U.S. Constitution concludes with the clause "...nor shall private property be taken for public use, without just compensation." Economic arguments have been utilized by a number of authors to provide support for their view about the desirability of compensation when property is taken physically or when there are substantial changes in land values.¹ One useful way to get a sense of the confusion surrounding the compensation issue is to consider the following arguments that have been made to support or oppose the payment of compensation:

1. No compensation is optimal because any compensation paid for losses of market value of current landowners will distort the future investment decisions of landowners, causing them to over-invest in land that is likely to be "taken" by the government.²

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¹See, for example, Bosselman, Callies, and Banta (1973); Michelman (1967); Sax (1971); Berger (1974); Baxter and Altree (1972); Siegel (1977); and Knetsch and Borcherding (1979). For an argument similar to ours that appears in the recent literature on the economics of contract law, see Shavell (1982).

²This reasoning is used by Baxter and Altree (1972) to argue that a first-in-time rule which pays compensation only to those land uses in effect prior to a government investment (in fact, prior to any discussion of such an investment) will be efficient.
2. When private firms purchase land in efficient competitive markets, they pay market value. If efficiency is to be achieved when the government takes land for public investment, it ought to pay market value as well. According to this logic, therefore, compensation at current market value is necessary for efficiency.\(^5\)

3. Since private insurance against the risk of a taking is not generally available, compensation in the case of taking can increase efficiency in a world of risk-averse investors.\(^4\)

4. Public investment project choices are often made subject to a form of budgetary fiscal illusion in which only dollar outlays are included as costs in its benefit-cost calculation. Compensation will force the government to make correct project choices.\(^6\)

The analysis that follows attempts to explain and clarify each of these arguments. The organization of the paper is as follows. In Section II the basic model with the following features is developed. With some fixed probability an exogenous event will occur that will make a parcel of land sufficiently valuable for public use so as to trigger a government decision to take the land. Prior to the event that triggers the government project, private investors must make a capital investment decision. If the government project is appropriately evaluated, if investors are risk-neutral, and if any compensation paid is independent of land use, private investment decisions are shown to be socially efficient. As a special case, no compensation is also efficient.

At this point, the assumption that compensation is independent of current land use is dropped in favor of the assumption that compensation is based on full current market value. Then, compensation for a taking will be inefficient, since it tends to result in overutilization of capital in the land. This is because the socially appropriate investment would take into account the fact that capital is lost when the land is taken; with compensation the private loss is less (it is zero with full compensation). In effect, the compensation allows investors to bear less than the optimal risk.

In Section III the possibility that the government's project decision will be affected by private investment decisions is raised. It is shown that if the decision to take the land is based on current market value, then there is an additional private motive to overcapitalize the land. In some cases, overinvestment in capital may discourage the government from taking the land. In Section IV, the assumption of risk-neutral investors is changed to an assumption involving risk aversion. This results in little change in the analysis of the appropriate compensation policies. Section V raises the possibility of government fiscal illusion, arguing in such a case that some, but not necessarily full, compensation is required for efficiency. Section VI contains some conclusions, qualifications, and suggestions for future research.

II. THE BASIC MODEL AND ANALYSIS

The Model

The analysis of the taking problem arises from a simple general equilibrium model of land use with one consumer and two firms. We imagine two types of land. Type 1 land is the land subject to a taking. If a taking occurs, then the only return to capital investment on the land is the compensation paid by the government. Type 2 land provides a return to capital investment on the land that is independent of the implementation of any public sector projects. Both land areas are initially undeveloped, with development occurring by investing capital in each of the two types of land.

The model is best described by examining the motives of the three types of economic actors. The first economic actor is the investor-consumer. All capital is initially owned by the one consumer who rents amount \(x\) to the firm on type 1 land and \(y\) to the firm on type 2 land. Once the capital is in place, it is not movable. The total amount of capital stock is taken to be one unit. The proceeds from the rental of capital are used to purchase output from the firms. The consumer has a utility function \(U(q)\) of output, which is concave and strictly increasing. The consumer derives no utility from consuming capital.

The second pair of economic actors are the two profit-maximizing (risk-neutral) firms—one firm on land of each type. We let \(f(x)\) and \(g(y)\) denote the production functions of the firms on type 1 land and type 2 land, respectively. Both functions are strictly
converge, twice differentiable, and strictly increasing. As long as \( f', g', \) and \( U' \) are positive, all capital will be used in production. Furthermore, \( \lim_{x \to 0} f'(x) = \lim_{x \to 0} g'(x) = +\infty \), which is a standard condition guaranteeing an interior solution to the optimization problems.

The third economic actor is the government. The government decides whether or not to take type 1 land. In the event of a taking, the capital on type 1 land is destroyed. The government may then compensate the capital owner and the landowner according to a predetermined rule.

In the first version of the model, we shall assume that the taking decision is made without regard to the size of the capital stock on type 1 land. The potential net benefits of taking type 1 land (project benefits minus costs not related to the taking) are so large that they exceed the loss due to scrapping any conceivable amount of capital. In the next section of the paper, we complicate the analysis by letting the taking decision be sensitive to the amount of capital in place on type 1 land. This alters the government's incentive, thereby adding an interesting element to the analysis.

We make the assumption that immediately after capital is in place, the event which triggers the taking of the land occurs with probability \( \alpha, 0 < \alpha < 1 \). We call this state \( T \). Thus, with probability \( 1 - \alpha \), economic conditions are such that the land is not taken. We call this state \( N \). In state \( T \), the land is taken; and the contemplated project will generate net benefits \( B \). B is measured in units of private output and is perfectly substitutable for that output. In the more complicated moral hazard model of Section III, the value of any forgone output from type 1 land may or may not exceed \( B \), and the project may or may not be undertaken. We reiterate that the sequence of events is crucial. In this model capital is first invested in the two types of land, and thus represents a sunk cost. With knowledge of this immobile capital, the government decides whether or not to take the type 1 land and pays any required compensation.

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6. The project might include the construction of a dam or a highway.
7. \( \alpha \) represents the investor's uncertainty about future states of the world. As an example, suppose that if the price of energy becomes sufficiently high in the future, society will wish to build a hydroelectric project that will flood a valley. Then \( \alpha \) might represent the probability that such an event will occur that makes the project desirable (e.g., the price of oil exceeding a certain price). The analysis is substantially simplified by assuming that \( \alpha \) is fixed and known to all parties. Thus, the model abstracts from the question of optimal compensation when the probability of a project decision occurring is a function of the capital investment made.
8. We could, of course, make \( B \) stochastic and \( \alpha \) a function of the realization of \( B \), or we could add a time dimension to the analysis. However, this would substantially complicate matters.

Consider for a moment the optimizing decisions of investors and consumers ex ante, i.e., prior to the announcement of whether the project is or is not to be undertaken. If all markets were complete, investors would be able to enter into contracts for the purchase of capital that would involve the payment of different prices of capital depending upon whether the project is undertaken (state \( T \) occurs) or not undertaken (state \( N \) occurs). In particular, the total return to capital investment will be lower ex post if a taking occurs than if one does not.

In a similar manner, consumers will be able to enter ex ante into contracts to purchase the consumption good, with the price and amount of consumption dependent upon the project decision. Presumably a higher price would be paid and less consumed if the project was undertaken. In this complete markets case the welfare analysis would be easy. Since there would exist a full set of markets, the competitive equilibrium would be Pareto efficient, and any compensation scheme that was not lump sum would distort relative prices and result in a nonefficient allocation of resources.

However, in this model markets are not complete, since capital is immobile, and there is no market for state-contingent capital. We assume that all capital is purchased ex ante at price \( r \). Were state \( T \) to occur, the demand for capital (ex post) on type 1 land would be zero. In addition, there would be an excess demand for capital to be used on type 2 land at the market price. If capital were perfectly mobile, the price of capital to be invested in type 2 land would rise (and the price of type 2 land would fall), and capital would move from type 1 to type 2 land. With immobile capital, however, the excess demand remains, and the market does not clear ex post. A similar analysis would apply if state \( N \) were to occur. A more profitable capital arrangement than the ex ante arrangement might exist, but capital immobility would prevent it.

We do allow trading in state-contingent claims for the consumption good. In this model, therefore, there are three markets: one market for capital, and two markets for the consumption good—one in each state. We have denoted \( r \) as the price of capital. In addition, let \( p_c \) represent the price of a claim on consumption in the event that the project is not taken, and \( p_r \) represent the price of a claim on consumption in the event that the project generates net benefits \( B \). We shall normalize these prices so that \( p_c + p_r = 1 \). Of
course, with a missing contingent capital market, a first-best allocation of resources cannot be achieved. Our analysis will involve the search for "second-best" solutions—those resource allocations that maximize social welfare given the missing market.

We simplify distributional issues by assuming that all land is owned by the consumer.\(^{19}\) The consumer collects from the firms economic rents equal to the expected profits of the firms. We shall assume first that there are no alternative activities to which the land could be put that would yield higher returns in either state of nature than the returns generated by the two firms (and the public project).\(^{11}\) Finally, we assume that the size and distribution of economic rents do not affect the optimal allocation of capital between the two types of land. The analysis begins with the assumption that agents are risk-neutral. In Section III we ask how the policy conclusions would be changed if consumers were risk-averse.

The Analysis—Risk Neutrality

If consumers are risk-neutral, utility is a linear function of consumption, so that we may set \(U(q) = q.\)\(^{12}\) The socially optimal investment on types 1 and 2 land for given \(\alpha\) and \(B\) is found by solving the following problem:

\[
\max_{x,y} (1 - \alpha)q_N + \alpha(q_T + B)
\]

subject to

\[
q_N = f(x) + g(y)
\]

\[
q_T = g(y)
\]

\[
x + y \leq 1,
\]

where \(q_T\) is output in the event of a taking and \(q_N\) is output if no taking occurs.

Since \(f', g' > 0\) and since capital generates no utility, no solution to this problem can involve \(x + y < 1.\) Otherwise, utility in each state can be increased by increasing \(y,\) a feasible alternative. Thus, the problem can be rewritten as

\[
\max \ S(x) = g(1 - x) + (1 - \alpha)f(x) + \alpha B.
\]

The first-order condition for this problem is

\[
(1 - \alpha)f'(x) - g'(1 - x) = 0.
\]

While equation (1) characterizes the optimal allocation of capital, the competitive allocation is determined by the consumer's demand for (contingent) claims on the consumption good and the firms' demand for capital. The consumer's demand function is given as the solution to the following optimization problem:

\[
\max_{q_T, q_N} \alpha(q_T + B) + (1 - \alpha)q_N
\]

subject to

\[
p_N q_N + p_T q_T \leq r + \pi,
\]

where \(p_N\) and \(p_T\) are the contingent claims prices, \(\pi\) is the (ex ante) sum of profits realized from the sale of contingent claims on the output of the two firms, and \(r\) is the return on the sale of the unit of capital. As is common, we have returned the profits of the firms lump sum to the consumer, but they play no allocative role in the model. Since there is some product in both states, the only contingent prices that could be an equilibrium are those that satisfy (from the first-order conditions)

\[
p_T/p_N = \alpha/(1 - \alpha).
\]

And, with our normalization that \(p_T = 1 - p_N,\) it also follows that \(p_T = \alpha\) and \(p_N = 1 - \alpha.\) In other words, the equilibrium price ratio is equal to the marginal rate of substitution between expected consumption in the event of a taking and expected consumption in the no-taking case, which is equal to the odds of a taking's occurring.

In this world the firms maximize their expected profits. The firm that uses type 1 land can sell state contingent claims only to output for the state in which there is no taking. For this they receive revenues of \(p_Nf(x) = (1 - p_T)f(x).\) If there is a taking, their only

\[1\text{.} 13\text{. The boundary assumption that } \lim_{x \to \infty} f'(x) = \lim_{x \to \infty} g'(x) = +\infty \text{ guarantees that there are no corner solutions.} \]
revenue is the compensation paid them by the state. It is common practice for courts to interpret just compensation as the value of the land and the structures thereon, where land value is the present value of profit (rent) from the land. Full compensation would involve payment of \( f(x) \) in real terms to replace the lost output. In order to treat the question of the “appropriate” compensation rule more generally, we let the compensation function be represented as \( C = C(x) \), where compensation is paid in consumption goods.

The profit of the type 1 firm is received ex ante from the sale of contingent claims is

\[
P_1(x) = (1 - p_r) f(x) + p_r C(x) - rx.
\]

The firm using type 2 land can sell consumption claims on output in both states. For its sale of state \( N \) (no taking) claims it receives 
\[ p_N g(1 - x) = (1 - p_r) g(1 - x), \]
and for its sale of state \( T \) (taking) claims it receives 
\[ p_T g(1 - x). \]
As a result, its profits are

\[
P_N(1 - x) = g(1 - x) - r(1 - x).
\]

The first-order conditions for profit maximization are

\[
(1 - p_r) f'(x) + p_r C'(x) - r = 0
\]

for the type 1 firm, and

\[
g'(1 - x) - r = 0
\]

for the type 2 firm.

Using (5), (6), and (1), we can now show that when consumers are risk-neutral, no compensation, or, more generally, any lump-sum compensation rule, is efficient.

**Theorem 1.** If the consumer is risk-neutral, lump-sum compensation and, in particular, no compensation, is efficient.

**Proof of Theorem 1.** Lump-sum compensation is characterized by the condition \( C'(x) = 0 \) for all \( x \). No compensation is the special case in which \( C'(x) = 0 \) for all \( x \) as well.

The necessary condition for optimality is given by (1)

\[
g'(1 - x) = (1 - \alpha) f'(x).
\]

The strict concavity of \( g(\cdot) \) and \( f(\cdot) \) implies that this is also a sufficient condition.

Combining (5) and (6) with \( C'(x) = 0 \) shows that in the competitive equilibrium with profit maximization,

\[
g'(1 - x) = (1 - p_r) f'(x).
\]

但我们，utility maximization requires that \( \alpha = p_r \), so that

\[
g'(1 - x) = (1 - \alpha) f'(x),
\]

which is the necessary and sufficient condition for efficiency. Q.E.D.

We have shown that if consumers are risk-neutral, compensation is not necessary for efficiency. The intuition for this conclusion can be established by recalling that the social welfare function is

\[
S(x) = g(1 - x) + (1 - \alpha) f(x) + \alpha B.
\]

It is not difficult to show that the competitive equilibrium is the solution to a similar maximization problem.

The risk-neutral consumer maximizes

\[
\alpha(q_T + B) + (1 - \alpha) q_N,
\]

subject to the condition

\[
(1 - p_r) q_N + p_r q_T = g(1 - x) + (1 - p_r) f(x) + p_r C(x).
\]

Recall that (from (2)) for equilibrium prices \( p_r = \alpha \). Therefore,

\[
(1 - \alpha) q_N + \alpha q_T = g(1 - x) + (1 - \alpha) f(x) + \alpha C(x).
\]

The competitive equilibrium can be characterized, then, as the maximization of the firms’ profit function:

\[
P(x) = g(1 - x) + (1 - \alpha) f(x) + \alpha C(x) - r.
\]

Notice that, as drawn in Figure 1, \( P(x) + r \) is equivalent to \( S(x) - \alpha B \) for \( C(x) = 0 \). And, in fact, each function achieves a maximum at the same value, \( x = x^* \), for any lump-sum compensation. The difference between the two curves is \( \alpha B - \alpha C(x) \) which is constant if \( C(x) \) is a lump-sum rule. Any compensation scheme for which \( C'(x^*) \neq 0 \) must be inefficient because it implies that \( P(x) \) achieves a maximum at a value of \( x \) other than \( x^* \). In fact, this can be stated with precision as a corollary to Theorem 1.

**Corollary 1.** If the consumer is risk-neutral, all efficient compensation schemes must have the property that \( C'(x^*) = 0 \), where \( x^* \) is the socially efficient level of capital investment on type 1 land.

Although no compensation is optimal, full compensation \( C(x) = f(x) \) is required by law. In preparation for the analysis of Section IV, it will be useful to look at compensation schemes other
than no compensation. While a large variety of schemes can be considered, we restrict our attention to those arrangements in which compensation paid is proportional to forgone rents and capital. Specifically, a \((\delta, \gamma)\) compensation scheme pays
\[
C(x) = \delta(p_N f(x) - rx) + \gamma rx.
\]
(7)

Here \(\delta\) is the compensation rate for rents (lost profits), and \(\gamma\) the compensation rate for capital costs \((p_N\) represents the price of output that would occur if there were no taking). We are particularly interested in the cases of no compensation \((\delta = \gamma = 0)\) and full compensation \((\delta = \gamma = 1)\).

The next theorem states that, when the consumer is risk-neutral, the only compensation schemes are those that compensate for lost rents.

**Theorem 2.** If the consumer is risk-neutral, then the only efficient \((\delta, \gamma)\) rules are those for which \(\gamma = 0\).

**Proof of Theorem 2.** If the efficient allocation \(x^*\) of capital is to be a competitive equilibrium, then \(C'(x^*) = 0\), and \(p_T = \alpha, p_N = 1 - \alpha\). For an arbitrary \((\delta, \gamma)\) rule,
\[
C'(x^*) = \delta p_N f'(x^*) + (\gamma - \delta) r,
\]
or
\[
C'(x^*) = \delta (1 - \alpha) f'(x^*) + (\gamma - \delta) r = 0.
\]
(8)

From (5), and using the fact that \(C'(x^*) = 0\),
\[
r = (1 - \alpha) f'(x^*).
\]
We note that substitution into (8) gives
\[
\gamma (1 - \alpha) f'(x^*) = 0,
\]
and since \(\alpha < 1, f'(x^*) > 0, \gamma = 0\).

Q.E.D.

It is easy to see that efficiency imposes no constraint on \(\delta, \) the compensation rate for profits. This confirms the usual intuition that taxes (or, in this case, subsidies) on rents do not create distortions.

**Corollary 2.** If the consumer is risk-neutral, full compensation is efficient.

**Proof of Corollary 2.** With full compensation \(\delta = \gamma = 1\).

Q.E.D.

With full compensation the private welfare function becomes
\[
P(x) = g(1 - x) + f(x) + \alpha_B - r.
\]

The competitive allocation \(x\) equates the marginal products of capital: \(f'(x) = g'(1 - x)\). From the concavity of the production functions, we can conclude that too much capital is invested in type 1 land. This corollary is illustrated in Figure II. The suboptimality of the full compensation scheme is not surprising. Full compensation provides full-coverage insurance to the private investor against the risk of the taking, with no premium paid. As a result, the private investor does not take into account the loss to society if the project is undertaken and the capital invested in type 1 land is lost.

**III. Optimal Compensation When Project Choice Is Dependent Upon Current Land Use**

Up to this point it has been assumed that the decision to undertake the project and take the land is independent of what private owners do. Such an assumption is not realistic in many cases because
public works projects are rarely undertaken on the most expensive land or on land that has valuable structures or has been recently improved. Highway plannings, for instance, often appear to choose routes as if they believe slum clearance is a side benefit of their route choices. Therefore, in this section we incorporate the possibility that the taking decision depends on the private investment decision.

Consider the problem of project choice facing the government. When state $T$ occurs, net benefits of the project are $B$. However, given that private investment has occurred prior to state $T$, it will be socially desirable for the project decision to take into account any lost output associated with the taking. Under the assumption that all capital on the type 1 land is lost when the taking occurs, and that public benefits and private output are commensurate, a reasonable project choice criterion, given private investment is to do the project whenever $B = f(x)$.

Given such a criterion, the project decision will obviously depend on the current capital investment in type 1 land. To make this choice explicit, assume that there exists an $\bar{x}$, $0 \leq \bar{x} < 1$ such that $B = f(\bar{x})$. For $x > \bar{x}$ the benefits of the project are smaller than the value of the output lost on type 1 land, and it will not be socially beneficial for the government to undertake the project. Likewise when $x \leq \bar{x}$, the project will be undertaken. To simplify the discussion, we consider only the risk-neutral case. In this situation the first-best problem can be solved by finding the value of $x$ that maximizes the social welfare function: $S(x) = \max \{ f(x) + g(1 - x), (1 - \alpha) f(x) + g(1 - x) + \alpha B \}$. Since our focus is on the distinction between the taking–no-taking states, it will be useful to rewrite $S(x)$ as follows:

$$S(x) = \begin{cases} 
(1 - \alpha) f(x) + g(1 - x) + \alpha B & x \leq \bar{x} \\
 f(x) + g(1 - x) & x > \bar{x}
\end{cases}$$

The private profit function in such a case will be

$$P_1(x) = \begin{cases} 
p_N f(x) + p_r C(x) - rx & x \leq \bar{x} \\
f(x) - rx & x > \bar{x}
\end{cases}$$

$P_2(x) = g(1 - x) - r(1 - x)$

(recalling that $p_N + p_r = 1$). In each instance $x < \bar{x}$ represents the outcome when a taking occurs in state $T$, and $x \geq \bar{x}$ when no taking occurs in state $T$.

With project choice dependent upon the value of $B = f(x)$, a moral hazard problem arises because the private land use decision on type 1 land can alter the project choice. As a result, it will be useful to consider two possible situations, each of which calls for a different policy prescription. In the first situation, the socially optimal policy is one in which the land should not be taken, while in the second case a taking is optimal.

In the first case (shown in Figure III) our results are given by the following theorem:

**Theorem 3.** If consumers are risk-neutral and social welfare is maximized when the land is not taken, then no compensation ($\delta = \gamma = 0$) and full compensation ($\delta = \gamma = 1$) are both efficient.

**Proof of Theorem 3.** So long as the compensation rule does not alter the decision to take the land, an efficient outcome will be achieved. The proof simply assures that with no compensation and full compensation such will be the case. Note that the social welfare function is never maximized at $\bar{x}$ (since $(1 - \alpha) f'(\bar{x}) - g'(1 - \bar{x}) < f'(x) - g'(1 - x)$, unless $f'(\bar{x}) - g'(1 - \bar{x}) = 0$, and so an optimum always satisfies $S'(x^*) = 0$, where $x^*$ is the socially optimal level of capital. The first-order condition satisfied by $x^*$ is $f'(x^*) = g'(1 - x^*)$. In the case of full compensation, $P_1(x) = f(x) - rx$ for all $x$, and so the competitive allocation $\hat{x}$ will satisfy $f'(\hat{x}) = g'(1 - \hat{x})$. In the case of no compensation, observe that if the equilibrium allocation exceeds $\bar{x}$, then $p_N$ and $p_r$ are not uniquely determined. Any pair of nonnegative prices (that sum to 1) will support the equilibrium allocation. But if $C(x) = 0$, then $P_1(x) = f(x) - rx$ for any pos-

![Figure III](image_url)

14. The equilibrium analysis of this model for arbitrary rules is tedious. No problems arise so long as $\delta \leq 1/\alpha$ and $\delta < \alpha + 1$. This includes the cases of $\delta = \gamma = 0$ and any proportional ($\delta = \gamma$) rule, if $\delta = \gamma \leq 1/(1 - \alpha)$. 
possible pair of state-contingent prices. From the equilibrium condition, \( r = g'(1 - x^*) \), where \( x^* > \overline{x} \). Then from the first-order optimality conditions, it follows that \( x^* \) maximizes \( f(x) - rx \). Then \( P(x^*) = f(x^*) - rx^* > f(x) - rx = P(x) \) for all \( x > x^* \), and so \( x^* \) maximizes profits for the firm on type 1 land. From the optimality conditions, \( 1 - x^* \) maximizes type 2 profits. It is easy to check that supply equals demand for the consumer good, and so \( x^* \) is an equilibrium allocation.

Q.E.D.

The second case to consider is that in which the social benefit is maximized at \( x^* = \overline{x} \). This occurs when \( S(x^*) \) is greater than \( S(x) \) for all \( x > \overline{x} \). In this case (which is illustrated with \( P(x) = P_1(x) + P_2(x) \) in Figure IV) it is socially desirable for the government to undertake the project when private resources are optimally allocated. Here, the problem of moral hazard arises with respect to the behavior of the private investor. In this case, it might be beneficial for the private sector to invest more than is socially optimal in type 1 land in order to affect the probability that the government project will be undertaken.

The firm located on type 1 land needs simply to compare its profits at the optimum assuming that a taking occurs (and \( C(x) = 0 \)), \( (1 - \alpha)f(x) - rx \) (for \( x < x^* \)) with the profits that it achieves at \( x > \overline{x} \), \( f(x) - rx \), by averting the taking. If the latter profits are higher than the former, the firm will rent more capital than would be socially optimal. This can be seen in Figure IV. \( S(x) \) is greater than \( P(x) + r \) (aggregate profits with \( C(x) = 0 \)), when the project will be undertaken with probability \( \alpha \); i.e., when \( x = \overline{x} \). However, for \( x > \overline{x} \), the project will not be undertaken, and \( S(x) = P(x) + r \). Clearly, since the profit-maximizing value of \( x \) occurs when \( x > \overline{x} \), private investors will be encouraged to "overcapitalize" the type 2 land sufficiently to discourage the government from taking the land.

Thus, in certain cases if the government's decision about the taking of land is a function of current market value, then without compensation there exists a private motive to increase capital investment in type 1 land, to affect the project decision. This result suggests that while the project choice criterion is correct given private investment decisions, the criterion does not induce socially efficient behavior. The proper criterion would involve a comparison of net benefits \( B \) and the opportunity cost of the taken land in its most efficient use, i.e., \( f(x^*) \). Such a criterion will clearly yield a social optimum because there will be no moral hazard problem. This suggests that government decision-makers ought to base their calculations on what the market value of the land would have been without any information about the project under consideration. What it suggests in terms of the appropriate compensation scheme is a related, but distinct, issue.

Clearly, any compensation that induces efficient private behavior will lead to socially correct project decisions as well. One obvious policy is to compensate landowners only if they invest the optimal amount of capital in the land. This policy has serious practical problems, however, so that it is of interest to ask whether there exist other compensation schemes that will induce first-best or even second-best behavior. A number of definitions will prove useful. First let \( \pi = \sup \{ P(x); x = \overline{x} \} \). Also, let \( x^* \) be the socially optimal value of \( x \). Notice from Figure IV that for \( x < \overline{x} \) both \( S(x) \) and \( P(x) \) achieve their maximum value at \( x^* \). Let \( C^* = \pi - P(x^*) \) be the difference between the maximal value of \( P \) and its value at the socially optimal level of investment.

One way to achieve a Pareto optimal investment \( x^* \) on type 1 land is to offer a lump-sum compensation \( C = C^*/\alpha \) (or higher). From (9), (10), and Figure IV, we can see that using only lump-sum compensation at this level the value of private benefits at \( x^* \) is equal to \( \pi \). The private entrepreneur will achieve the same expected profit by investing in a socially optimal manner. Furthermore, \( x^* \) maximizes \( P(x) \) for \( x < \overline{x} \) because lump-sum compensation leaves all marginal conditions unchanged.

![Figure IV](image-url)
It is not surprising that a first-best optimum can be achieved with a lump-sum compensation plan. It is not obvious, however, whether one can achieve the same optimal allocation of capital through a proportional or any other \((\delta, \gamma)\) compensation scheme. From (9) and (10) it can be seen that any Pareto optimal \((\delta, \gamma)\) scheme must satisfy the following two conditions:\(^{15}\)

\[
\begin{align*}
\delta(P_N f(x^\ast) - r x^\ast) + \gamma r x^\ast &> C^\ast / \alpha \\
\delta(P_N f'(x^\ast) - r) + \gamma r &> 0.
\end{align*}
\]

The first condition insures that expected profits at \(x^\ast\) are at least as large as they are at the full private optimum, and the second condition insures that \(x^\ast\) maximizes \(P_A(x)\) for \(x \leq \bar{x}\). However, the equilibrium condition \((f'(x^\ast) = r)\) implies that

\[
\gamma^\ast = 0.
\]

Therefore, (11) becomes

\[
\delta > -C^\ast / \alpha P_N (f'(x^\ast) x^\ast - f(x^\ast)).
\]

The strict concavity of \(f\) implies that the denominator of (14) is negative. Therefore, any Pareto optimal \((\delta, \gamma)\) plan must involve a subsidy to land value at rate \(\delta\) and no tax or subsidy on capital.

Finally, consider the special cases of full compensation, when \(\gamma = \delta\). No such plan can be Pareto optimal since capital is being subsidized. Our results to this point are summarized as follows:

**Theorem 4.** If investors are risk-neutral, and the social optimum requires the taking of land, then no compensation is generally inefficient. However, compensation at full-market value is also inefficient. An efficient outcome can be achieved with certain forms of lump-sum compensation and with a compensation scheme providing a sufficiently large compensation rate on land values or lost profits and no compensation for lost capital.

\(^{15}\) We use the fact that if \(x = \bar{x}\) is an equilibrium, \(P_N = (1 - \alpha), P_T = \alpha\).

IV. **Risk Aversion**

In this section we briefly treat the analysis of the previous sections when the investor-consumer is risk-averse and there is no moral hazard. This allows us to treat analytically the argument that compensation is necessary to counter the effects of the risk introduced when a taking is contemplated. We shall see that with risk-neutral firms and a risk-averse consumer the conclusions of the previous sections are not altered.

In order to account for risk aversion, we assume that individual preferences are not state contingent and can be represented by a concave utility function \(U(q)\). The socially optimal allocation is found by solving the maximization problem,

\[
\max (1 - \alpha) U(q_N) + \alpha U(q_T + B)
\]

subject to

\[
\begin{align*}
q_N &= f(x) + g(1 - x) \\
q_T &= g(1 - x),
\end{align*}
\]

or with \(U' > 0, 0 \leq x \leq 1\), the following social welfare function is maximized:

\[
S(x) = (1 - \alpha) U(f(x) + g(1 - x)) + \alpha U(g(1 - x) + B).
\]

The resulting first-order condition is

\[
(1 - \alpha) U'(q_N)(f'(x) - g'(1 - x)) - \alpha U'(q_T + B) g'(1 - x) = 0,
\]

or rewriting, we have

\[
f'(x) - g'(1 - x) = \frac{\alpha}{1 - \alpha} \frac{U'(q_T + B)}{U'(q_N)} g'(1 - x) = 0.
\]

The consumer demand is found by maximizing

\[
(1 - \alpha) U(q_N) + \alpha U(q_T + B)
\]

subject to

\[
p_N q_N + p_T q_T = r + w,
\]

where the variables are defined as they were previously. It is easy to see that this yields the competitive equilibrium,

\[
\frac{p_T}{p_N} = \frac{\alpha U'(q_T + B)}{(1 - \alpha) U'(q_N)}.
\]

Since firms are risk-neutral, the competitive allocation of capital will satisfy

\[
p_N f'(x) + p_T C'(x) = (p_N + p_T) g'(1 - x)
\]

from (5) and (6). Dividing equation (12) by \(p_N\) and using (11), we see that the competitive equilibrium condition reduces to
(18) \[ f'(x) - g'(1 - x) + \frac{\alpha U'(q_x + B)}{(1 - \alpha)U'(q_N)}(C'(x) - g'(1 - x)) = 0. \]

This result proves the following theorem:

**THEOREM 5.** If the consumer is risk-averse and there are markets for consumption in the two possible states, the compensation rule is efficient if and only if \( C'(\bar{x}) = 0 \), where \( \bar{x} \) is a competitive allocation.

**Proof of Theorem 5.** Compare (16) with (18).

Note that lump-sum compensation is efficient but that full compensation is not. This may seem surprising at first to those who believe that compensation can provide insurance, but in this model there is no need for additional insurance. The consumers are purchasing consumption insurance through contingent claims markets.

It should be apparent that the other results about compensation rules in the absence of moral hazard also hold in the case of risk aversion. And, the results on moral hazard carry over in a similar manner.

**V. COMPENSATION WHEN THE PROJECT DECISIONS ARE SUBJECT TO FISCAL ILLUSION**

One argument for government compensation presumes that the government suffers from budgetary fiscal illusion when the project decision is made. In the extreme case, only dollars actually paid enter as costs in the cost-benefit calculation. In this case, and in the more general case in which costs not on the budget are partially discounted, Berger [1974], Johnson [1977], and others argue that payment of full compensation will lead to a first-best social outcome. In this section the earlier analysis is modified by assuming that the project decision-maker consistently discounts the lost revenues of the private investor when a taking occurs. To simplify, we assume risk neutrality. We also assume that private investors are aware of the decision-making criterion used by the government, and can (in some cases) alter their capital allocation decision so as to influence the project evaluation. In such an environment no compensation is suboptimal, but so is the payment of full compensation. In fact, full compensation may be less desirable than no compensation. Finally, there will, in general, exist a lump-sum compensation plan that is first best. Since there are a variety of distinct cases that can occur, we have chosen to examine two particular cases carefully.

The social welfare function remains unchanged, but the project decision-maker is assumed to use the criterion that chooses project (a) when state \( T \) occurs; and (b) when

(19) \[ B - C > \theta(f(x) - C). \]

Here \( C \) is any compensation that is paid when the taking occurs, and \( 0 \leq \theta \leq 1 \) represents a measure of the fiscal illusion of the project decision-making unit.

The project choice criterion given in (19) allows us to consider a range of alternative assumptions about the form of the fiscal illusion. When \( \theta = 1 \), the choice criterion becomes \( B = f(x) \) as before, and no fiscal illusion is present. Therefore, we restrict our consideration to the case in which \( \theta \) is strictly less than 1. Note that when \( \theta = 0 \), the criterion becomes \( B > C \), the extreme case in which the government counts as costs actual compensation paid, but takes no account of the lost value of output on type 2 land. In the intermediate case, compensation is included as a full budgetary cost when paid, but is discounted when it is perceived to reduce the net losses to private investors when the land is taken. The same story can be restated in a somewhat different light by rewriting (19) as follows:

(20) \[ B - C(1 - \theta) > \theta f(x). \]

Here compensation paid out is valued at rate \( (1 - \theta) \), whereas private investment losses are valued at rate \( \theta \).

Note that if \( C \) is chosen equal to \( f(x) \) (a full proportional compensation plan), then (20) becomes \( B > f(x) \), and the analysis of Section III of the paper applies. The decision rule is different, but this choice of \( C \) yields the same outcome as the full proportional compensation plan. If the production function is as illustrated in Figure III, the private market will not be able to choose an \( x \) large enough to assure that the project is not undertaken. But since compensation will be paid for both lost land and capital value, too much capital will be used on the type 1 land. If the production function is given in Figure IV, the private market can block the project by putting at least \( x \) capital on the valley land. This would lead to overinvestment on type 1 land.

Our result is summarized in Theorem 6.

**THEOREM 6.** If investors are risk-neutral and the project decision-maker suffers from fiscal illusion, then no compensation will generally be inefficient.

It is interesting to notice that if there is pure fiscal illusion, \( \theta = 0 \), and the government is allowed to take without compensation,
distortions are lump-sum and pure profit rules. Arguments suggesting that the government should act like a private entrepreneur are correct, but private market land values reflect only forgone profit.

The analysis has implications beyond the taking question, however. Rather than looking for an optimal compensation rule given a particular project choice criterion, one might ask what the appropriate decision rule is, given a particular compensation rule. Further thought suggests the first-best result—to the extent that compensation is given (it need not be) the compensation should be equal to (or more generally a function of) the value of lost output on the land when the land is optimally utilized (i.e., \( f(x^*) \)). The appropriate project criterion is to do the project if net benefits outweigh the value of the optimally lost output. In such a case, private investors cannot distort project choice, nor does consumption affect marginal investment decisions.

This line of thought has direct and interesting implications for the use of cost-benefit analysis of projects in which land is purchased or taken. Under our assumptions the current value of the output on the land is an inappropriate measure of cost, and suboptimal decisions will be made when current value is used. The problem of determining the appropriate value is, of course, a difficult one, given the dynamics of land markets and of cost-benefit analysis. The problem arises because current value is a function of expected future values. The evaluation of cost-benefit analysis as a project criterion in a dynamic model of this sort under varying assumptions about the availability of information and about the formation of investor expectations appears to be a fruitful topic for further research.

University of Michigan
University of California, Berkeley
University of California, Santa Clara

REFERENCES


