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Private Takings

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Abstract

This paper examines the implications associated with a recent Supreme Court ruling, *Kelo v. City of New London*. *Kelo* can be interpreted as supporting eminent domain as a means of transferring property rights from one set of private agents—landowners—to another private agent—a developer. Under voluntary exchange, where the developer sequentially acquires property rights from landowners via bargaining, a holdout problem arises. Eminent domain gives all of the bargaining power to the developer and, as a result, eliminates the holdout problem. This is the benefit of *Kelo*. However, landowners lose all their bargaining power and, as a result, their property investments become more inefficient. This is the cost of *Kelo*. A policy of eminent domain increases social welfare compared to voluntary sequential exchange only when the holdout problem is severe, and this occurs only if the developer has very little bargaining power. We propose an alternative government policy that eliminates the holdout problem but does not affect the bargaining power of the various parties. This alternative policy strictly dominates a policy of eminent domain, which implies that eminent domain is an inefficient way to transfer property rights between private agents.

1 Introduction

A recent Supreme Court decision, *Kelo v. City of New London* (2005), reaffirmed that the public-use criterion from the takings clause of the Fifth Amendment of the US constitution[1] can be fulfilled even when a government takes property from one private agent and gives it to another. Although the Court has long rejected a literal

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[1] "[N]or shall private property be taken for public use, without just compensation."

interpretation of public use,[2] the *Kelo* decision generated a fair amount of controversy both among the judiciary and the public. Perhaps it is because the public purpose[3] of the taking that underlies *Kelo* is less transparent than previous important Court rulings.

In the landmark case of *Berman v. Parker* (1954), the owners of a non-blighted department store had their property taken as part of a large scale redevelopment plan to rid parts of Washington D.C. from blight and slums. The redevelopment plan, provided by the District of Columbia Redevelopment Act, included the condemnation of non-blighted buildings. The Court unanimously ruled that private property can be taken for public purpose as long as owners receive just compensation. Furthermore, it ruled that it is up to lawmakers—not courts—to decide what is in the public's best interest.[4] In *Berman v. Parker*, the public purpose of the taking is easy to visualize: It turns something that is ugly and dangerous into something that is beautiful and safe.

In another important case, *Hawaii Housing Authority v. Midkiff* (1984), the Hawaiian legislature proposed to regulate an oligopoly in the housing market by taking away the property rights from a few large landowners, with compensation, and distributing them to many new owners. As in *Berman v. Parker*, the Court deferred to the legislature as to whether the public purpose was being served, and unanimously ruled in favor of the legislature's actions. Given that governments have made a practice of regulating industries that exhibit market power for many years, it is plausible to envision that the taking served a public purpose.

Qualitatively speaking, the basic facts of *Kelo* are not so different from the above cases. The city of New London formulated an economic development plan that would benefit the city and its residents by providing growth opportunities and increased tax revenues. As in *Berman v. Parker* and *Midkiff*, the city's plan required the taking of private property that would ultimately be owned by other private parties. The Court ruled in favor of the city of New London. However, unlike *Berman v. Parker* and *Midkiff*, the Court rendered a split 5-4 decision. And there was a vigorous public debate regarding the appropriateness of the decision. Much of the debate focused on whether taking property for private economic development serves a public purpose. Even though the Court deferred to the legislature regarding the public purpose in *Midkiff*, it did not absolve itself from interfering when the public purpose was at question: "A purely private taking could not withstand the scrutiny of the public use requirement; it would serve no legitimate purpose of government and would thus

[2]In *Fallbrook Irrigation Dist. v. Bradley* (1896) and *Clark v. Nash* (1905), the Court ruled in favor of a taking that only benefitted a small set of private landowners. A short summary of relevant cases regarding the definition of public use, some of which we refer to, can be found in Rolnick and Davies (2006).

[3]In *Mt. Vernon-Woodberry Cotton Duck Co., v. Alabama Interstate Power Co.* (1916), the Court only required that a taking serve a public purpose.

[4]"[W]hen the legislature has spoken, the public interest has been declared in terms well-nigh conclusive ... ," (Berman at 32).

be void ... The court's cases have repeatedly stated that 'one person's property may not be taken for the benefit of another private person without a justifying public purpose, even though compensation be paid, " (Midkiff at 245 and 241, respectively). Evidently, in the minds of a great number of people, the case that private economic development serves a public purpose was not made in *Kelo*. In response to the *Kelo* decision, 43 states changed their eminent domain laws that placed limitations and/or restrictions on municipalities' use of eminent domain when the stated public purpose was economic development.

From an economic perspective, some sort of market failure or friction must exist if a government taking is to be part of the solution for a redevelopment project. For example, market solutions to redevelop blighted areas may fail because of a free-rider externality, see, e.g., Grossman and Hart (1980) and O'Flaherty (1994). In a blighted area, property owners may be reluctant to sell their properties to developers at "low" prices—even though these prices are appropriate for the properties in their current state—because they anticipate the value of their properties will increase as the area is redeveloped. Because of this, the market will deliver redevelopment projects that are too small from a social perspective. A government taking, along with just compensation, can internalize this externality, and result in socially preferable outcomes. The *Berman v. Parker* decision can be rationalized along these lines.

It would be difficult, however, to justify the *Kelo* decision by appealing to a free-rider argument. For starters, the proposed redevelopment area in New London was not blighted or run-down. Given this, how would Suzette Kelo's property value be affected if the redevelopment project proceeded without the sale of her property? Being close to a new shopping area would be beneficial, since it would be convenient for running errands, dining etc. But the new shopping area and a major research facility would bring about increased traffic and congestion, which would be costly. Since it is not at all obvious which effect would dominate, it would not be unreasonable to assume that property values would be unaffected by the redevelopment. That is, there are no external benefits associated with the taking. One can interpret the dissenting opinion of Justice Day O'Connor being consistent with such a view, "Any property may now be taken for the benefit of another private party ... the beneficiaries are likely to be those citizens with disproportionate influence and power in the political process, including large corporations and development firms" and the decision eliminates "any distinction between private and public use of property — and thereby effectively delete[s] the words 'for public use' from the Takings Clause of the Fifth Amendment," (Kelo at 12-13 and 2, respectively, O'Connor, J., dissenting). If a free-rider externality argument cannot be used to support the *Kelo* decision, then how can the majority decision of the supreme court be justified from an economic perspective?

One possible justification for the Kelo decision, which we explore in this article, is that the existence of bargaining frictions prevent the level of redevelopment from being efficient. Bargaining endows both the developer and seller with pricing powers that can lead to an inefficient level of redevelopment. Inefficiencies associated with redevelopment can—but need not—be exacerbated because of a holdout problem that arises when a developer negotiates with many property owners. In particular, the holdout problem—where each owner attempts to extract additional surplus from the developer—can arise due to the sequential nature of bargaining between the developer and landowners. Ideas related to bargaining have been explored in Munch (1976) and Eckart (1985). These authors rely on informational asymmetries to generate an inefficiency in land assembly. Absent these informational asymmetries, there would be no role for government takings. We specify a simple and intuitive bargaining environment that is free of informational asymmetries. Because bargaining frictions prevent private agents from implementing efficient allocations, we examine if government policy can improve matters. One obvious government policy to consider is eminent domain.

Once the possibility of a government taking that transfers property rights from one private agent to another is introduced, then, almost by definition, property rights become less secure. As pointed out by Rolnik and Davies (2006) and Garrett and Rothstein (2007), when property rights are not secure, inefficiencies in land use will arise. We believe this to be a rather important aspect associated with a government taking, so we appeal to a model environment—first proposed by Blume, Rubinfeld and Shapiro (1984)—that emphasizes it.

In the model, a policy of ED effectively gives all of the bargaining power to the developer. As a result, the holdout problem disappears since landowners have no bargaining power. This is the benefit of a policy of ED. However, landowners will invest more resources in their properties when their bargaining power declines. Since landowners are overinvesting under voluntary exchange, eminent domain exacerbates the overinvestment problem. This is the cost of a policy of eminent domain. A policy of eminent domain is socially beneficial only if the benefit associated with the elimination of the holdout problem exceeds the cost associated with increasing the overinvestment problem, and this occurs only when the developer has very little bargaining power.

We propose an alternative government policy that, like eminent domain, removes the holdout problem by eliminating the sequential nature of bargaining. However, this policy does not affect the bargaining power of the various parties. The policy can be interpreted as "locking" the developer and all of the landowners whose properties the developer wants "in a room" and requiring them to collectively determine a set of prices for the transference of the property rights. Since this *collective bargaining* policy eliminates the holdout problem but does not affect the various parties' bargaining powers, it strictly dominates the eminent domain policy. Hence, a *private* taking—i.e., using eminent domain to transfer property rights of one set of private agents to another—is *never* socially efficient.

The remainder of the article is as follows. The next section examines a simple redevelopment and takings environment with one developer and one tract of land owned by a single landowner. Since there is only one landowner and one tract of land, a holdout problem does not arise. In a very simple way, this section establishes a connection between the holdout problem and the policy of eminent domain: If there is no holdout problem, then a private taking—i.e., using eminent domain—can only lower social welfare. In Section 3, the environment is extended to many owners. Because of the sequential nature of voluntary exchange, a holdout problem arises under voluntary exchange because the developer bargains sequentially with landowners. We examine the effect that two government policies—private takings and collective bargaining—have on social welfare. Section 4, provides examples and the final section summarizes and concludes.

2 One tract of land

A landowner, or simply the owner, is endowed with capital K_ℓ and property rights to a tract of land. He invests x on his property and $K_\ell - x$ in a safe asset. The safe asset provides a gross rate of return $R > 1$. The property investment provides a payoff of $f(x)$, where $f(0) = 0$, $0 < f'(0) < \infty$, and $f'' < 0$.[5]

A developer is endowed with capital K_d. He can redevelop the owner's property and can invest in the safe asset. If the property is redeveloped, then the investment x and its potential payoff, $f(x)$, are destroyed. Redevelopment entails an expenditure, y. Redevelopment generates a payoff of $F(1, y)$, where

$$F(1,y) = \begin{cases} F(1,\bar{y}) & \text{if } y \geq \bar{y} \\ 0 & \text{if } y < \bar{y} \end{cases} .$$

The '1' in F denotes that one tract of land is being redeveloped. If there is redevelopment, then the payoff structure implies that the developer spends exactly $\bar{y}$ on redevelopment.

The developer must acquire property rights to redevelop. These rights can be voluntarily transferred via bargaining from the owner to the developer for a price p. The price p is determined by a simple *two-stage proposal game*. In the first stage, the developer makes an offer to the owner, which he either accepts or rejects. If accepted, the owner transfers the property rights and gets p. If rejected, then agents move to the second stage, where, with probability β, the developer makes a take-it-or-leave-it offer to the owner and, with probability $1-\beta$, the owner makes the offer. If the second stage offer is accepted, then the property rights are transferred to the developer at the agreed upon price; if it is rejected, then the game ends, and redevelopment does not take place. One can interpret β $(1-\beta)$ as the developer's (owner's) bargaining power.

[5] We depart from the standard INADA condition that $f'(0) = \infty$ because in the numerical examples that we provide below, $f'(0)$ is finite. We assume, however, that $f'(0)$ can be arbitrarily large.

There exists a government that can condemn and expropriate, or *take*, the property via its power of eminent domain, ED. The law requires the government provide "just compensation" to the owner in the event that his land is taken. In this article, just compensation will be defined as $f(x)$, i.e., the value of the property in the event that it is not taken. The government must balance its budget. We assume that if property is taken, the government sells the property rights to the developer for $f(x)$.

The timing of events is as follows. At date 0, the owner is born; he invests x in his property and $K_\ell - x$ in the safe asset. At date 1, the developer is born; he decides whether or not to redevelop the owner's property. If he chooses to redevelop, then he either bargains with the owner, or the government takes the owner's property rights and sells them to the developer. If there is redevelopment, then the developer spends $\bar{y}$ on redevelopment and invests $(K_d - \bar{y})$ in the safe asset; otherwise he invests K_d in the safe asset. At date 2 all investments pay off, payments are exchanged, and the owner and developer consume.

The objectives of the owner and the developer are to maximize their expected payoffs. The timing of the births of the owner and developer prevent them from interacting before the owner makes his investment decision. This timing assumption is designed to reflect the real world fact that developers enter the scene long after initial investments are undertaken.

2.1 Social optimum

Social welfare is defined as the sum of all agents' payoffs. Because redevelopment destroys investment x, if it is optimal to redevelop, then $x = 0$. The payoff to society in the event of redevelopment is $F(1, \bar{y}) + (K_d - \bar{y}) R + K_\ell R$. If property is not redeveloped, then the investment x that maximizes social welfare is given by

$$\arg\max_x \{f(x) + K_d R + ((K_\ell - x) R)\},$$

or $x = x_n$, where $f'(x_n) = R$—the 'n' in x_n stands for "no redevelopment."

It is socially optimal to redevelop property if

$$F(1, \bar{y}) + (K_d - \bar{y}) R + K_\ell R > f(x_n) + K_d R + (K_\ell - x_n) R$$

or if

$$F(1, \bar{y}) - \bar{y} R > f(x_n) - x_n R. \tag{1}$$

If (1) does not hold, then it is not optimal to redevelop.

2.2 Redevelopment under Voluntary Exchange

Let S represent the total surplus the owner and developer share if there is redevelopment, where

$$S(x) = F(1, \bar{y}) - f(x) - \bar{y} R. \tag{2}$$

Note that $S'(x) < 0$, and that (1) can be expressed as $S(x_n) > -x_n R$. Define the critical value x_c by $S(x_c) \equiv 0$.

If there is redevelopment, then each agent's share of the surplus is determined by p. The developer's payoff is $F(1,\bar{y}) - \bar{y}R - p$, and the owner's is $p - f(x)$.[6]

Suppose that redevelopment occurs. Then, in the second stage of the two-stage proposal game, if the developer makes the take-it-or-leave-it offer, he will offer $f(x)$ for the owner's land, which the owner accepts. If the owner makes the offer, he will offer $\bar{y}R$ and his land in exchange for the total value of the redevelopment, $F(1,\bar{y})$, which the developer accepts. Let p_1 be the first-stage offer in the two-stage proposal game. The developer makes a first-stage offer so that the owner is indifferent between accepting and rejecting it. Hence, the equilibrium first-stage offer—which the owner accepts—is

$$p_1 = \beta f(x) + (1-\beta)(F(1,\bar{y}) - \bar{y}R), \tag{3}$$

since, in the second stage, the developer makes the offer with probability β and the owner makes the offer with complementary probability $1-\beta$. The equilibrium first-stage offer, (3), can be rewritten as

$$p_1 = f(x) + (1-\beta) S(x). \tag{4}$$

If there is redevelopment, then, in equilibrium, the developer receives a fraction β of the total surplus $S(x)$, and the owner receives a fraction $1-\beta$ of the total surplus in addition to his reservation payoff $f(x)$. (A reservation payoff is what an agent receives in the event of "disagreement," i.e., when redevelopment does not take place. The developer's reservation payoff is zero.) The developer will redevelop only if $S(x) > 0$ or, equivalently, if $x < x_c$.

We now consider the owner's investment decision, x. First, suppose that the owner correctly believes $S(x) > 0$ for his choice of x. Then, in equilibrium, there will be redevelopment, and the investment decision is given by

$$\arg\max_x p_1 + (K_\ell - x)R = \arg\max_x f(x) + (1-\beta)S(x) + (K_\ell - x)R. \tag{5}$$

The solution, x_r, is characterized by

$$\beta f'(x_r) = R, \tag{6}$$

where "r" stands for "redevelopment." Equation (6) implies that $x_r > 0$.[7]

[6] At the time of bargaining, the investment x is sunk, but $\bar{y}$ is not. This is why the term "$\bar{y}R$" shows up in the developer's net surplus function and there is no comparable term in the owner's net surplus function.

[7] Since we assume that $f'(0)$ is arbitrarily large and finite, there exists sufficiently small β's for which condition (6) does not hold, i.e., $\beta < \beta^*$where β^* is defined by $\beta^* f'(0) = R$. In what follows, we assume that the developer's bargaining power is not too small, i.e., $\beta > \beta^*$.

Now suppose that the owner correctly believes that $S(x) < 0$ for his choice of x. Then, in equilibrium, the developer does not redevelop and the investment decision is given by

$$\arg\max_{x} f(x) + (K_\ell - x) R. \tag{7}$$

The solution of (7) is characterized by

$$f'(x) = R, \tag{8}$$

which implies that $x = x_n$, the efficient level of investment when it is not socially optimal to redevelop. Comparing (6) and (8), we see that $x_n > x_r$. Since $S'(x) < 0$, we have

$$S(x_r) > S(x_n).$$

The surplus function provides us with a lot of information regarding agents' decisions. If $S(x_n) > 0$, i.e., $x_n < x_c$, then the developer always redevelops. Hence, if $S(x_n) > 0$, then the owner's problem is given by (5) and he invests x_r. If $S(x_r) < 0$, i.e., $x_r > x_c$, then the developer never redevelops, and the owner's problem is given by (7), i.e., he invests x_n. Finally, if $S(x_r) > 0$ and $S(x_n) < 0$, then the owner's investment, x, determines whether or not there will be redevelopment. If the owner invests x_r, then there will be redevelopment; if he invests x_n, there will not. If

$$f(x_n) - x_n R > f(x_r) - x_r R + (1 - \beta) S(x_r), \tag{9}$$

then the owner invests x_n, and the developer will not redevelop; otherwise, the owner invests x_r, and there will be redevelopment.

In many cases the allocation generated by voluntary exchange is socially inefficient. For example, if it is socially efficient to redevelop and redevelopment occurs under voluntary exchange, then the allocation of resources is inefficient since the owner invests $x_r > 0$. Or, if condition (9) does *not* hold, then there will be redevelopment even when it is not socially efficient. Proposition 1 provides conditions under which voluntary exchange results in a socially efficient allocation of resources.

Proposition 1 *If $S(x_n) < -x_n R$ and condition (9) holds, then voluntary exchange implements a socially efficient allocation characterized by no redevelopment and $x = x_n$; otherwise voluntary exchange is always socially inefficient.*

Proof. See Appendix 1. ■

When there is redevelopment, the owner ends up investing too much because the sale price, p, depends on the level of his investment. This investment distortion depends on the owner's share of the surplus, $1 - \beta$; the larger the share, the smaller the distortion. The developer's (property) acquisition decision, however, is always efficient given the level of investment undertaken by the owner. This is because the developer acquires the property only if the surplus associated with redevelopment is positive.

Since voluntary exchange can be associated with inefficiencies, perhaps an alternative method of transferring property rights—e.g., ED with just compensation—may improve matters. We now examine this issue.

2.3 Government Policy

Voluntary exchange generates socially inefficient outcomes. Perhaps a government policy of ED can improve matters.[8] Under ED, the owner receives $f(x)$ if his property rights are taken. This means that the owner's share of the surplus associated with redevelopment is zero. The owner's investment decision, x, is simply $\arg\max_x f(x) + (K_\ell - x) R$, or $x = x_n$.

Many commentators claim that ED can be used to promote redevelopment. We find that the only time ED can improve matters is when it *prevents* redevelopment from occurring.

Proposition 2 *ED can improve social welfare only by preventing redevelopment when redevelopment is inefficient; otherwise, ED (weakly) decreases social welfare, compared to voluntary exchange.*

Proof. See Appendix 1. ■

If redevelopment is optimal, then using ED to transfer property rights is always a bad idea since more investment is destroyed under ED than under voluntary exchange. The investment distortion is exacerbated under ED because the owner does not care about the total surplus. Instead, his objective is to adjust his 'just compensation' value, $f(x)$, so as to maximize his payoff.

2.4 Discussion

The analysis so far seems to indicate that the recent Supreme Court decision on *Kelo v. New London* is wrong-headed: ED, in conjunction with just compensation, can never be associated with an increase in redevelopment. If anything, it's associated with a decrease in redevelopment activity. The reason is straightforward. ED implies that owners will invest more; this reduces total surplus and makes redevelopment less attractive.

Some of our results are reminiscent of those from the property rights and nuisance literature, especially Pitchford and Snyder (2003). Transferring property rights by voluntary exchange is equivalent to a first-party injunctive rights regime. A first-party injunctive rights regime means that after making his investment decision, the owner gets to choose whether or not to sell his property; hence, he must receive at least $f(x)$ if he is to sell. And transferring property rights by ED is equivalent to

[8] Since there is only one owner, the alternative government policy that we discussed in the Introduction is equivalent to voluntary exchange.

a first-party damage rights regime. In this regime, the owner is compensated for exactly what he loses, $f(x)$, if he chooses to sell to the developer. Pitchford and Snyder (2003) demonstrate that both regimes are characterized by over-investment and there is less over-investment in a first-party injunctive rights regime, which are precisely our results above. In addition, both parties will make the same *ex post* decision,[9] and, given x, this decision is *ex post* optimal. We shall see, however, that the nice equivalence between our results and those of the property rights and nuisance literature will break down when the developer can acquire more than one property and bargains with more than one owner.

There are (at least) two ways to restore social efficiency under government takings.[10] One way, as suggested by Hermalin (1995), is to transfer the entire surplus S to the owner. This scheme is equivalent to giving the owner all of the bargaining power.[11] When the owner has all of the bargaining power, then the owner's decision problem is given by (5) with $\beta = 0$ and the solution is $x = 0$. A second way to restore efficiency, as suggested by Blume, Rubinfeld and Shapiro (1984) and Blume and Rubinfeld (1984), is to give a fixed payment c—perhaps equal to zero—to the owner. For this scheme, assuming there is redevelopment, the owner's investment problem (5) can be rewritten as

$$\max_x c + (K_\ell - x) R.$$

The solution to this problem is $x = 0$.

In practice, it is unlikely that either one of these schemes could be implemented. When a government uses ED it probably wants to provide incentives for redevelopment. Giving developers zero surplus might have the opposite effect. An arbitrary fixed payment c would probably not pass a "just compensation" criterion (most of the time).

3 Many tracts of land

We now generalize the environment so that the developer can acquire multiple tracts of land for redevelopment and his spending on redevelopment is not exogenous. A holdout problem emerges under voluntary exchange, where the developer sequentially bargains with many owners for their property rights.

The model in Section 2 is modified in the following way. There are $N > 1$ contiguous tracts of land located around a circle. In Section 2, it's obvious which

[9]For this article, the *ex post* decision is to redevelop or not; in Pitchford and Snyder (2003) the *ex post* decision is regarding *ex post* investments.

[10]Given that the landowner and developer cannot contract prior to the investment decision, x, it is not obvious how one can restore efficiency under voluntary exchange, while at the same time maintaining the notion that exchange is voluntary.

[11]It is also equivalent to a second-party injunctive rights regime.

tract of land is to be redeveloped since there is only one. When $N > 1$, we assume that any redevelopment must include a specific—or *required*—tract of land, and if redevelopment uses more than one tract of land, then all the redeveloped properties must be adjacent to one another. In particular, the second property must be clockwise adjacent to the required tract, the third must be clockwise adjacent to the second, and so on. The idea here is that once the required tract is determined, the sequence in which particular tracts can be used for redevelopment is also determined. This implies that the owners of these tracts have bargaining power *vis á vis* the developer.

The total value associated with redevelopment is given by $F(A, y; P)$, where A represents the tracts of land acquired for redevelopment (which includes the required tract), y represents total spending on redevelopment, and P represents total factor productivity. We assume that $F(A, y; P)$ is strictly increasing in its arguments—$F_A, F_y > 0$ and for $P_2 > P_1$, that $F(A, y; P_2) > F(A, y; P_1)$—and that $F_i(A, y; P_2) > F_i(A, y; P_1)$, $i = A, y$. Throughout the analysis P is fixed; so when it causes no confusion, the total factor productivity argument, P, in $F(\cdot)$ will be suppressed. We also assume that the redevelopment value function $F(A, y)$ is strictly concave, $F_{AA} - F_{Ay}^2/F_{yy} \equiv G(A, y) < 0$, with $F_A(0, y) = F_y(A, 0) \to \infty$ for $y, A > 0$, and that

Assumption 1: $G_A(A, y) - G_y(A, y) F_{Ay}(A, y) / F_{yy}(A, y) > 0$.

Assumption 1 imposes restrictions on the third derivative of F. A standard Cobb-Douglas function $PA^{\alpha}y^{\gamma}$ with $\alpha + \gamma < 1$, satisfies all of the restrictions that we have imposed on F. In addition to the restrictions that we have imposed on $f(x)$, we add

Assumption 2: $f'''(x) f'(x) - 2f''(x)^2 \leq 0$.

Assumption 2 also places restrictions on the third derivative of f. Functions such as $b\ln(1 + x)$ or $a - b/(b/a + x)$ satisfy the restrictions that we have imposed on $f(x)$, where the former function satisfies Assumption 2 with an equality and the latter function with a strict inequality.

The timing of events is as follows: At date 0, N owners are born, each owning property rights to a tract of land. Each owner has capital K_ℓ, invests x in his tract of land and $(K_\ell - x)$ in the safe asset. Owners do not know where the required (for redevelopment) tract of land is located; at the time they make their investment decision, each tract is equally likely to be required for redevelopment. At date 1, the developer is born and the required tract is revealed to all. The developer decides the number of properties, A, he wishes to acquire and redevelop, where $0 < A \leq N$. The developer then identifies the set of owners associated with the A tracts of land, and either bargains with them—sequentially under voluntary exchange or simultaneously if the government imposes the collective bargaining policy—or has the government take away their property rights and sell them to him if the government imposes the ED policy. The details of the bargaining procedures—both sequential and simultaneous—are provided below. The developer pays either the sum of all bargained prices or $Af(x)$ (at date 2), depending upon whether he bargains or purchases via

ED, respectively, to acquire the property rights for the A tracts of land. The developer spends y on redevelopment and invests the rest of his capital, $K_d - y$, in the safe asset. At date 2, all investments pay off, payments are exchanged, and the owners and the developer consume.

3.1 Social Optimum

We first characterize the social optimum. Let $W(A, x, y)$ represent social welfare, which is the sum of the payoffs of all agents in the economy. The socially efficient levels of property acquisition, A, investment, x and redevelopment spending, y, are given by the solution to

$$\max_{x,y,A} W(A, x, y) = \max_{x,y,A} (N - A) f(x) + F(A, y) + N(K_\ell - x) R + (K_d - y) R. \quad (10)$$

When the investment decision x is made, it is not known where the required (for redevelopment) tract of land is located. Therefore, each tract of land—and there are N of them—receives the same level of investment, x, and the remainder of the owners' capital is invested in the safe asset. Since A properties will be acquired and redeveloped, the total payoff to the owners' investments is $(N - A) f(x)$. The developer spends y on redevelopment so the payoff to redevelopment is $F(A, y)$. The developer places $K_d - y$ in the safe asset. The necessary conditions to problem (10) are,

$$\begin{cases} \frac{N-A}{N} f'(x) = R & \text{if } A \leq \ell^* \\ x = 0 & \text{if } A > \ell^* \end{cases}, \quad (11)$$

$$F_y(A, y) = R, \quad (12)$$

and

$$F_A(A, y) = f(x), \quad (13)$$

where ℓ^* solves

$$\frac{N - \ell^*}{N} f'(0) = R.$$

Conditions (11) and (12) simply say that the expected returns to investment x and spending y equal the opportunity cost of capital, R.[12] Condition (13) says that properties will continue to be acquired until the value of the last property equals the (social) cost of redevelopment, which is the value of the destroyed investment, $f(x)$. The conditions that identify an interior maximum to problem (10) are given by (11)-(13) and,

$$F_{yy} < 0 \quad (14)$$

$$F_{yy} F_{AA} - F_{Ay}^2 > 0 \quad (15)$$

$$(N - A) f''(x) \left[F_{yy} F_{AA} - F_{Ay}^2 \right] - F_{yy} f'(x)^2 < 0. \quad (16)$$

[12] The second line in (11) says that the expected return is less than R at $x = 0$ when $A > \ell^*$; hence, no investment is undertaken.

Conditions (14)-(16) are all satisfied since $F(A,y)$ and $f(x)$ are strictly concave. Let (A^*, x^*, y^*) represent the solution to (11)-(13).

It will be useful to diagrammatically characterize the social optimum in (x, A) space. The slope of the locus of points described by (11) for $x > 0$ is negative and given by

$$\frac{dA}{dx} = \frac{f''(x)}{f'(x)^2} NR < 0, \tag{17}$$

and the derivative of (17) with respect to x is

$$\frac{d^2 A}{dx^2} = \frac{f'''(x) f'(x) - 2f''(x)^2}{f'(x)^3} NR \leq 0, \tag{18}$$

owing to Assumption 2. In our diagrams we will assume that (18) holds with strict equality, which means that (11) is linear in (A, x) space for $x > 0$. Equation (11) is depicted in Figure 1 as $\ell^* x_{\max}$, where 'ℓ' stands for landowner. Note that the allocation $(x_{\max}, 0)$ lies on locus $\ell^* x_{\max}$, where $x_{\max}$ solves $f'(x_{\max}) = R$, i.e., this is the condition for investment, (11), when there is no redevelopment, i.e., when $A = 0$.

The slope of the locus of points described by (13), conditional on efficient redevelopment spending y, (12), is also negative in (x, A) space and is given by

$$\frac{dA}{dx} = \frac{f'(x)}{F_{AA} - \frac{F_{Ay}^2}{F_{yy}}} = \frac{f'(x)}{G(A,y)} < 0, \tag{19}$$

since, from (12), $dy = -F_{Ay}/F_{yy} dA$ and $F(A,y)$ is strictly concave. The derivative of (19) with respect to x is

$$\frac{d^2 A}{dx^2} = \frac{f'' G(A,y) - \left[(f')^2 / G(A,y)\right] \left[G_A(A,y) - G_y(A,y) \frac{F_{Ay}}{F_{yy}}\right]}{G(A,y)^2} > 0$$

thanks to Assumption 1. This means that locus (13), conditional on (12), is strictly convex. Figure 1 depicts equations (12) and (13) as $d^* D^*$, where "d" stands for developer.

In Figure 1, the $\ell^* x_{\max}$ and $d^* D^*$ loci intersect twice.[13] Social welfare is maximized at allocation $a^* = (x^*, A^*)$, where the slope of the $\ell^* x_{\max}$ curve is steeper than that

[13] For these loci to intersect at all requires that total factor productivity, P, be not "too big." If P is too big, and the loci do not intersect, then the socially optimal outcome is that all N tracts of land are redeveloped and $x = 0$. That it is socially optimal to develop *all* private property, however, does not appear to describe the world in which we live. Hence, we assume that P is not too big, which implies that the two loci intersect twice.

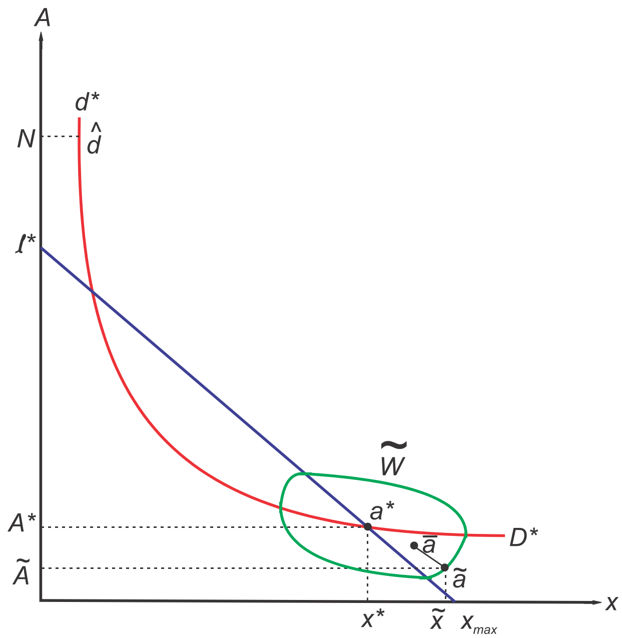

Figure 1: Social Optimum

of the d^*D^* curve. To understand this, note that condition (16) can be rewritten as

$$\frac{f'(x)}{F_{AA} - \frac{F_{Ay}^2}{F_{yy}}} > \frac{f''(x)}{f'(x)}(N - A).$$

This condition says that the local interior maximum occurs where the $\ell^* x_{\max}$ curve is steeper than that of the d^*D^* curve, i.e., compare (17) and (19).

Moving away from allocation $a^* = (x^*, A^*)$ *along* either curve $\ell^* x_{\max}$ or d^*D^* unambiguously lowers social welfare. Assuming that condition (12) holds, the slope of a social welfare indifference curve is given by

$$\frac{dA}{dx} = \frac{(N - A) f'(x) - NR}{f(x) - F_A}.$$

For allocations on the $\ell^* x_{\max}$ curve, the slope of the social welfare indifference curve is zero and for allocations on the d^*D^* curve, it is infinite. A typical social welfare indifference curve that intersects allocation $\tilde{a}$ (where $\tilde{A} < A^*$ and $\tilde{x} > x^*$) is given by the ellipse denoted $\tilde{W}$ in Figure 1. Note that for allocations that are south-east of allocation $a^* = (x^*, A^*)$ and that lie in between (but not on) the $\ell^* x_{\max}$ and d^*D^* curves—such as allocation $\tilde{a}$—the slopes of the social welfare indifference curves are all strictly positive and finite. This implies that if two allocations lie in the cone given by $x_{\max} a^* D^*$ and a line that connects the two allocations has a strictly negative slope—such as allocations $\bar{a}$ and $\tilde{a}$ in Figure 1—then the allocation that has higher redevelopment and lower investment will generate a higher level of social welfare, i.e., the social welfare associated with allocation $\bar{a}$ exceeds that of $\tilde{a}$.[14]

3.2 Redevelopment under Voluntary Exchange

If the developer wants to acquire property rights from A owners he can do so by sequentially bargaining with them. In particular, the developer and A owners play the following *A-stage sequential bargaining game*. First, each of the A owners are placed in a bargaining queue. Let $i \in \{1, \ldots, A\}$ represent the place in the queue held by a particular owner, owner i. An owner's place in the queue is determined by the sequence in which particular tracts can be used for redevelopment as described above, i.e., the first person in the queue owns the required tract, the second person in the queue has his property clockwise adjacent to the required tract, and so on. Since the owner knows the location of his own property as well as the location of the required tract, he knows his position in the bargaining queue. The developer sequentially bargains with each of the A owners: The developer bargains first with owner $i = 1$, second with owner $i = 2$, and so on. The A-stage bargaining game between the developer and A owners can be viewed as a sequence of the two-stage proposal game described at the beginning of Section 2. That is, in stage i of the A-stage game, the developer and owner i play the two-stage proposal game. The developer can proceed from stage i to stage $i + 1$ in the A-stage bargaining game only if he has reached an agreement with the first i owners. If the developer and owner i do not reach an agreement, i.e., the owner rejects the developer's initial offer and the second stage offer is also rejected, then the A-stage bargaining game ends, all the agreements with the previous $i - 1$ owners are extinguished or invalidated, and no redevelopment takes place. This means that once the developer chooses the number of tracts of land to redevelop, A, and owners to bargain with, the developer either acquires the property rights for all A tracts and redevelops them, or there is no redevelopment.[15]

At date 0, each of the N owners invests x on his tract of land and at date 1, the developer decides on the number of properties to acquire, A, and bargains with

[14] Note that in Figure 1 the developer's locus, d^*D^*, extends beyond N. Feasibility requires that $A \leq N$. Therefore, the *feasible* developer's locus is given by locus $D^*\hat{d}N$ in Figure 1. This implies that the feasible developer's locus intersects the owner's locus at $(0, N)$, in addition to the two intersections already described. Our numerical exercises indicate that it is possible to have social welfare at allocation $(0, N)$ exceed that of allocation a^*. This happens when total factor productivity, P, is "sufficiently large." We shall assume that P is not too big so that social welfare attains its maximum value at allocation a^*. The numerical examples that we generate are all consistent with social welfare being maximized at allocation a^*.

[15] One can imagine a different bargaining game, where if agreement is not reached for a particular owner, then the size of the redevelopment is reduced by one tract. So, if the developer initially chooses to redevelop A tracts of land and fails to reach an agreement with $a < A$ owners, then $A - a$ tracts of land will be redeveloped. We take the all-or-nothing approach because we want the results to be directly comparable to those in section 3.3.2.

A owners. Let p_i represent the equilibrium price that the developer pays to the i^{th} owner in the bargaining queue. The equilibrium price, p_i, which is determined by the A-stage sequential bargaining game, is given by

$$p_i = f(x) + (1-\beta)\beta^{i-1}[F(A,y) - yR - Af(x)], \; i = 1, \ldots, A. \tag{20}$$

See Appendix 2 for the derivation of p_i. The equilibrium price, p_i, provides owner i with his reservation value, $f(x)$, plus a share of the redevelopment surplus, $F(A,y) - yR - Af(x)$. Define $S(A,x,y) \equiv F(A,y) - yR - Af(x)$. Note that the share of each owner's surplus depends on his place in the bargaining queue. In particular, $p_i > p_{i+1}$ for all $i = 1, \ldots, A-1$, so there is an "early-mover" advantage for the owners. The average price per tract of land that the developer pays is

$$\sum_{i=1}^{A} \frac{p_i}{A} \equiv p = f(x) + \frac{\left(1-\beta^A\right)}{A} S(A,x,y). \tag{21}$$

When an owner makes his investment decision, x, he does not know if his land will be acquired by the developer and, if it is, what place in the bargaining queue he will occupy. Given these informational restrictions, the typical owner's investment decision is given by

$$\arg\max_x \frac{N-A}{N} f(x) + \frac{A}{N} p + (K_\ell - x) R. \tag{22}$$

The function in (22) has the following interpretation: With probability $(N-A)/N$, the owner's property rights will not be acquired by the developer, in which case his payoff is $f(x)$, and, with complementary probability, his property rights will be acquired for an expected (or average) price of p, given by (21). The solution to the owner's problem (22) is given implicitly by

$$\begin{cases} \left(\frac{N-\left(1-\beta^A\right)A}{N}\right) f'(x) = R, & \text{if } A \leq \ell_V \\ x = 0 & \text{if } A > \ell_V \end{cases} \tag{23}$$

where the "V" in ℓ_V stands for "voluntary exchange," and ℓ_V solves

$$\left(\frac{N - \left(1-\beta^{\ell_V}\right)\ell_V}{N}\right) f'(0) = R.$$

The slope of the locus of points described by (23) for $x > 0$ is

$$\frac{dA}{dx} = \frac{f''(x)}{f'(x)^2}\left[1 - \beta^A\left(1 + A\ln(\beta)\right)\right]^{-1} NR < 0, \tag{24}$$

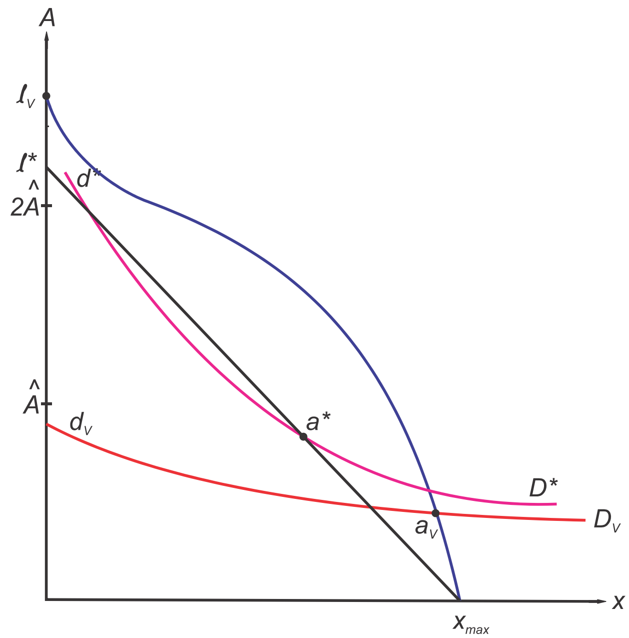

Figure 2: Voluntary Exchange

since $1 - \beta^A (1 + A \ln(\beta)) > 0$.[16] The solution to the owner's decision problem (23) is illustrated in Figure 2 by the line $\ell_V x_{\max}$. For comparison, the socially efficient owner's decision line, $\ell^* x_{\max}$, is also illustrated in Figure 2. Notice that since $0 < 1 + A \ln(\beta) < 1$, the slope of the owner's decision curve under voluntary exchange, (24), is greater in absolute value than that of the owner's socially efficient decision curve, (17).

The developer's acquisition and spending choices, A and y, respectively, are given by the solution to

$$\max_{A,y} F(A, y) - pA + (K_d - y) R, \tag{25}$$

where the price per tract of land, p, is given by (21). Substituting (21) into the developer's problem and rearranging, we get

$$\max_{A,y} \beta^A S(A, x, y) + K_d R. \tag{26}$$

The solution to the developer's problem (26) is given by

$$F_y(A, y) = R, \tag{27}$$

and

[16]In Appendix 3, we demonstrate that $1 + A \ln(\beta) > 0$. We also show that the curve described by (23) is strictly concave for all $x > 0$ and $A < 2\hat{A}$, where $\hat{A}$ solves $1 + A \ln(\beta) = 0$, and strictly convex for all $x > 0$ and $A > 2\hat{A}$.

$$F_A(A,y) = f(x) - \ln(\beta) S(A,x,y). \tag{28}$$

Although the developer's spending decision, y, is efficient for the level of acquisition, A, that he undertakes, (27), it follows from (28) that his property acquisition decision is not. As we shall see, the inefficient property acquisition decision is due to the holdout problem that arises from the sequential nature of bargaining between the developer and owners. Because of the holdout problem, the developer's property acquisition decision is distorted in the direction of purchasing too few properties since $F_A(A,y) > f(x)$.

The slope of the locus of points described by (28) is given by[17]

$$\frac{dA}{dx} = f'(x) \frac{1 + A\ln(\beta)}{G(A,y) - \ln(\beta)^2 S(A,y,x)} < 0, \tag{29}$$

since $1 + A\ln(\beta) > 0$ for all $x > 0$ and $G(A,y) < 0$.[18] The solution to the developer's decision problem, (27) and (28), is illustrated in Figure 2 by the curve $d_V D_V$. Diagrammatically speaking, since $F_A > f(x)$, curve $d_V D_V$ lies below the efficient curve $d^* D^*$; and, the smaller is β,the bigger is the downward shift of $d_V D_V$ from $d^* D^*$. Figure 2 illustrates that when the developer bargains sequentially with owners, there is unambiguously too much investment and too little redevelopment compared to what is socially efficient. Notice that in Figure 2, the $d_V D_V$ curve lies everywhere below $\hat{A}$: In Appendix 3, we show that $d_V D_V$, which is given by the solution to (28), is bounded above by $\hat{A}$, where $\hat{A}$ solves $1 + \hat{A}\ln(\beta) = 0$.

We can summarize the above discussion in the following proposition,

Proposition 3 *Voluntary exchange results in an allocation characterized by too much investment and too little redevelopment compared to what is socially optimal.*

Proof. Compare allocation a_V with allocation a_{ED} in Figure 2. ■

3.3 Government Policy

Voluntary exchange generates socially inefficient outcomes. Perhaps government policies can improve matters. We consider two government polices. One policy is eminent domain, ED. The other policy, which we call *collective bargaining*, CB, has the government forcing the developer and the all A property owners to bargain simultaneously with one another.

[17] Of course, we are assuming that $F_y(A,y) = R$. Henceforth, to avoid repetition, we always assume that $F_y(A,y) = R$.

[18] Since the developer's problem (26) is highly non-linear, the locus of points described by (28) is not necessarily a convex function in (x, A) space. In Appendix 3, we document that the solutions to the developer's and owners' problems are well behaved.

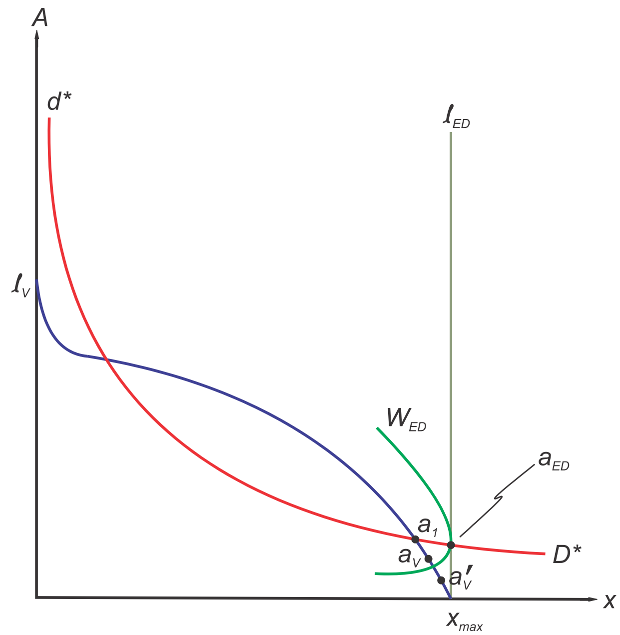

Figure 3: Eminent Domain

3.3.1 Eminent Domain

Under ED, the owner receives "just compensation" if his property is taken. This implies that each owner gets $f(x)$ whether or not his property rights are taken, i.e., $p_i = f(x)$ for all $i = 1, \ldots, A$. Alternatively, ED can be interpreted as giving all of the bargaining power to the developer, i.e., if $\beta = 1$, then (20) implies that $p_i = f(x)$ for all $i = 1, \ldots, A$.

When $p = f(x)$ in (22), the owner's investment decision problem is

$$\arg\max_{x} \frac{N-A}{N} f(x) + \frac{A}{N} f(x) + (K_\ell - x) R. \tag{30}$$

The solution is given implicitly by $f'(x) = R$ or $x = x_{\max}$. The locus of points that describe the owner's optimal investment decision under ED is described by the perpendicular line $\ell_{ED} x_{\max}$ in Figure 3.

The developer pays $f(x)$ for each property he acquires. His decision problem is given by the solution to (25), which under ED can be simplified to

$$\max_{A,y} \; S(A, x, y) + K_d R. \tag{31}$$

Hence, the developer maximizes the surplus S associated with redevelopment. Since the social welfare function (10) can be rewritten as

$$W(A, x, y) = S(A, x, y) + N f(x) + N (K_\ell - x) R + K_d R, \tag{32}$$

the developer's objective under ED, (31), for a given x, coincides with maximizing social welfare. As a result, the developer's spending, y, and acquisition, A, decisions are efficient, and are given by (12) and (13), respectively. The developer's decision regarding the level of redevelopment is given by the socially optimal locus d^*D^* in Figure 3. The allocation associated with an ED regime, a_{ED}, is illustrated by the intersection of the d^*D^* and $\ell_{ED}x_{\max}$ loci in Figure 3, and the level of social welfare associated with this allocation is given by the curve W_{ED}.

A policy of ED eliminates the holdout problem because it gives all of the bargaining power to the developer. And, since the developer has all of the bargaining power—he receives all of the surplus—he has an incentive to maximize total surplus or social welfare. Although an ED policy eliminates the holdout problem, it creates another: It exacerbates the owners' overinvestment in their properties. As Figure 3 illustrates, owners undertake the maximum investment in their properties, $x_{\max}$, which exceeds the level of investment undertaken by voluntary exchange, x_V, described by allocation $a_V = (x_V, A_V)$.[19]

Is a policy of ED socially desirable? In Figure 3, social welfare associated with ED is given by W_{ED}. Suppose that under voluntary exchange, the developer's decision locus (which is not illustrated) intersects the owner's decision locus, $\ell_V x_{\max}$, at a_V in Figure 3. In this situation, social welfare associated with allocation a_V exceeds that associated with ED, W_{ED}. Hence, from a social perspective, ED would be an inappropriate policy. Although ED eliminates the holdout problem—which is beneficial from a social welfare perspective—the increase in overinvestment that results ultimately reduces social welfare compared to voluntary exchange. Suppose, instead, that the holdout problem is more severe than that depicted in Figure 3. (The holdout problem can be made more severe by lowering the developer's bargaining power β.) Then, it is possible that the developer's decision locus intersects the owner's decision locus, $\ell_V x_{\max}$, below the intersection of W_{ED} with the owner's decision locus, say at allocation a'_V. In this situation, a policy of ED increases social welfare. The following definition is helpful.

Definition 4 *The holdout problem is said to be* ***severe*** *if the developer's decision locus under voluntary exchange intersects the $\ell_V x_{\max}$ locus below the intersection of W_{ED} and $\ell_V x_{\max}$ curves in Figure 3.*

We can summarize the above discussion by the following proposition,

Proposition 5 *A necessary condition for welfare associated with ED to exceed that of voluntary exchange is that the developer's holdout problem is "severe." As well, investment under ED always exceeds investment under voluntary exchange.*

[19] Allocation a_V is determined by the intersection of the owner's locus $\ell_V x_{\max}$ and the developer's locus $d_V D_V$ (which is not illustrated in Figure 3). Depending on the developer's bargaining strength $\beta \in (0, 1)$, voluntary exchange allocation, a_V, will lie somewhere on locus $\ell_V x_{\max}$ between points a_1 and $(x_{\max}, 0)$ in Figure 3.

Proof. Given Definition 4, compare allocation a_{ED} with allocation a'_V in Figure 3. Investment under ED, a_{ED}, always exceeds investment under voluntary exchange, a_V. Investment under ED takes on its maximum possible value, $x_{\max}$; for all $\beta < 1$, investment under voluntary exchange is strictly less than this maximum value, see Figure 3. ■

We are, however, unable to make any general claims regarding the level of development. To see why, notice that decreasing β shifts the developer's decision locus down from d^*D^*; holding the owner's locus constant, a reduction in β increases investment x, see Figure 3. However, decreasing β, decreases the slope of the owner's decision locus $\ell_V x_{\max}$, which effectively causes it to pivot at $x_{\max}$ toward the origin; holding the developer's decision locus constant, a reduction in β decreases investment x, see Figure 3. The decisions of owners and the developer work in opposite directions regarding changes in the level of redevelopment brought about by changes in β. As a result, the level of redevelopment under ED may be greater than or less than that under voluntary exchange. Note, however, we were unable to generate any examples where the level of redevelopment under voluntary exchange exceeded that under ED, (more on this in Section 4).

3.3.2 Collective Bargaining

We now consider an alternative government policy that requires the developer and all of the A owners to bargain *simultaneously* over the transference of property rights. Intuitively, the government gets the developer and A owners into a room and tells them to collectively determine the price(s) for the transference of the owners' property rights to the developer. In the model, the government's collective bargaining, CB, policy specifies a simultaneous bargaining game that agents play.

The collective bargaining game is similar to the two-stage proposal game—which involves 2 players—but is augmented to accommodate $A + 1$ players. After the developer chooses the A tracts of land that he wants to acquire for development, the two-stage collective bargaining game has the developer making A simultaneous offers to each of the owners, where each owner simultaneously either accepts or rejects the offer. If all owners accept, then property rights are transferred between the owners and the developer at the terms of trade specified in the bargain. Suppose, instead, that one or more of the owners reject the developer's offer. Then, with probability β, the developer gets to make A take-it-or-leave-it offers to the owners. In this case, the developer will, in equilibrium, offer $f(x)$ to each of the A owners; since owners are indifferent between accepting and rejecting, they all accept. With probability $1 - \beta$, one of the owners is randomly chosen and gets to make A take-it-or-leave-it offers to the $A - 1$ other owners and the developer. The probability that a particular owner gets to make the offer is $1/A$. In this case, the owner will, in equilibrium, offer $f(x)$ to each of the $A - 1$ other owners and Ry to the developer, where y solves $F_y(A, y) = R$; since the owners and developer are indifferent between accepting and rejecting, they all accept. Hence, the equilibrium price that the developer offers to each of the A owners in the first stage, p, is given by

$$\begin{aligned} p &= \beta f(x) + (1-\beta)\left\{\frac{1}{A}\left[F(A,y) - yR - (A-1)f(x)\right] + \frac{A-1}{A}f(x)\right\} \quad (33) \\ &= f(x) + \frac{1-\beta}{A}S(A,x,y). \end{aligned}$$

Since all A owners are indifferent between accepting and rejecting the first-stage offer p, (33), they will all accept. Notice that the collective bargaining price, (33), is lower than the average price associated with voluntary exchange, (21). This implies that collective bargaining mitigates the holdout problem since, on average, owners receive a smaller share of the surplus that is generated through redevelopment compared with voluntary exchange. (In fact, the government policy of collective bargaining *eliminates* the holdout problem.)

Under the policy of collective bargaining, an owner's investment decision, x, is given by the solution to

$$\arg\max_{x} \frac{N-A}{N}f(x) + \frac{A}{N}p + (K_\ell - x)R, \quad (34)$$

where p is given by (33). The solution to (34) is (implicitly) given by,

$$\begin{cases} \frac{N-(1-\beta)A}{N}f'(x) = R & \text{if } A \leq \ell_{CB} \\ x = 0 & \text{if } A > \ell_{CB} \end{cases} \quad (35)$$

where "CB" in ℓ_{CB} stands for "collective bargaining," and ℓ_{CB} solves

$$\frac{N-(1-\beta)\ell_{CB}}{N}f'(0) = R.$$

The developer's acquisition and spending choices, A and y, respectively, are given by the solution to (25). In light of (33), the developer's problem can be rewritten as

$$\max_{A,y} \beta S(A,x,y) + K_d R. \quad (36)$$

Hence, the developer's objective is to maximize surplus, $S(A,x,y)$, which implies that the developer's objective is consistent with maximizing social welfare, *taking x as given.* Therefore, the developer behaves efficiently, and his spending, y, and acquisition, A, decisions are given by (12) and (13), respectively. Notice that since the developer receives the same share of the total surplus, β, independent of the number of properties that are acquired and redeveloped, he does not face a hold-out problem.

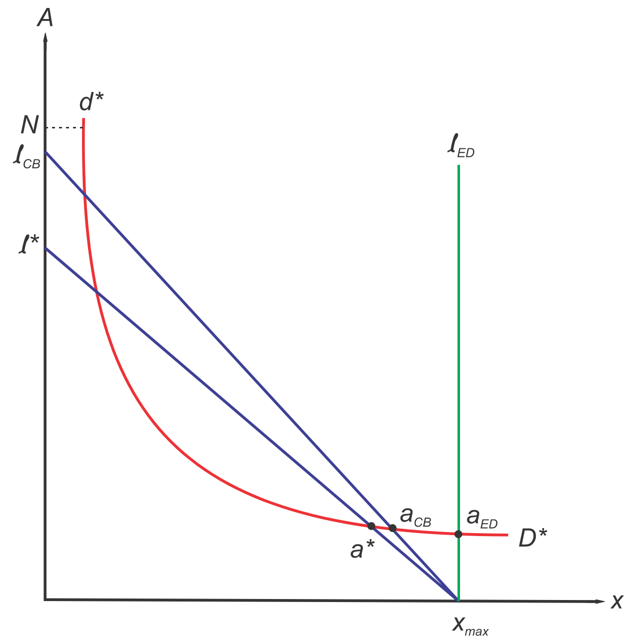

Figure 4: Collective Bargaining

The developer's decision is described by locus d^*D^* in Figure 4, which is identical to the locus d^*D^* in Figure 1. The locus of points that describe the owner's investment decision, (35), is depicted in Figure 4 by $\ell_{CB}x_{\max}$ for $x > 0$ and the locus that describes the socially efficient decision, (11), is depicted by $\ell^*x_{\max}$. (Comparing (35) with (11), note that locus $\ell_{CB}x_{\max}$ is steeper than locus $\ell^*x_{\max}$, as depicted.) The equilibrium collective bargaining outcome, $a_{CB} = (x_{CB}, A_{CB})$, is given by the lower intersection of the $\ell_{CB}x_{\max}$ and d^*D^* curves, and the socially efficient outcome is a^*. As with the policy of ED, the CB policy has too much investment and too little development compared to what is socially efficient.

Figure 4 reveals a rather important policy result,

Proposition 6 *Social welfare is strictly lower under a policy of ED compared to a policy of CB. As well, investment is higher and redevelopment is lower under ED compared to CB.*

Proof. Both the ED and CB allocations lie on the efficient developer's decision locus d^*D^*, see Figure 4. Since welfare decreases when moving away from the efficient allocation, a^*, along the locus d^*D^*, the welfare associated with allocation a_{CB} is greater than that associated with allocation a_{ED}. To see that investment is higher and redevelopment is lower under ED compared to CB, compare allocations a_{CB} and a_{ED} in Figure 4. ■

The economic intuition that underlies this proposition is straightforward: Both policies eliminate the holdout problem, which is beneficial from a social perspective. However, a policy of ED leads to more overinvestment than a policy of CB. Proposition 6 implies that the government should only entertain a policy of collective bargaining; the government should never pursue a policy of ED.

3.3.3 Optimal Policy

Given Proposition 6, the government should never choose a policy of ED because it is dominated by the CB policy. Is a policy of CB socially desirable? In Figure 5, social welfare associated with CB is given by W_{CB} which, in turn, is determined by the intersection of the owner's decision locus, $\ell_{CB}x_{\max}$, and the developer's decision locus, d^*D^*. Suppose that under voluntary exchange, the developer's decision locus (which is not illustrated in Figure 5) intersects the owner's decision locus, $\ell_V x_{\max}$, at a_V in Figure 5.[20] In this situation, social welfare associated with allocation a_V exceeds that associated with CB, W_{CB}. Hence, a policy of CB will lower social welfare. Although CB eliminates the holdout problem—as was also the case with the ED policy—the resulting increase in overinvestment that results from the CB policy leads to a decrease in social welfare compared to voluntary exchange. Suppose, now that the holdout problem under voluntary exchange is worse than depicted in Figure 5. Then, it is possible that the developer's decision locus intersects the owner's decision locus, $\ell_V x_{\max}$, below the intersection of W_{CB} with the owner's decision locus at allocation a'_V. In this situation, a policy of CB increases social welfare. The following definition is needed for what follows.

Definition 7 *The holdout problem is said to be **significant** if the developer's decision locus under voluntary exchange intersects the $\ell_V x_{\max}$ locus below the intersection of W_{CB} and $\ell_V x_{\max}$ curves and above the intersection of the W_{ED} and $\ell_V x_{\max}$ curves in Figure 5.*

We can summarize this discussion by the following proposition,

Proposition 8 *A necessary condition for welfare associated with CB to exceed that of voluntary exchange is that the developer's holdout problem is "significant."*

Proof. Given Definition 7, compare allocation a_{CB} with allocation a'_V in Figure 5. The condition is not sufficient because the welfare associated with CB exceeds that of voluntary exchange if the holdout problem is "severe." ■

The allocation and social welfare associated with the ED policy is illustrated in Figure 5 by a_{ED} and W_{ED}, respectively. Consider the voluntary exchange allocation a'_V. Notice that for this allocation the holdout problem is significant but not severe. In the subsequent section, we provide examples of the various outcomes described in Figures 2, 4 and 5.

[20] The owner's decision locus, $\ell_{CB}x_{\max}$, lies above the voluntary exchange for all $A > 1$. We assume the model parameters are such that the developer wants to redevelop multiple tracts. If, instead, the developer only wants to redevelop one tract, then the results of Section 2 apply.

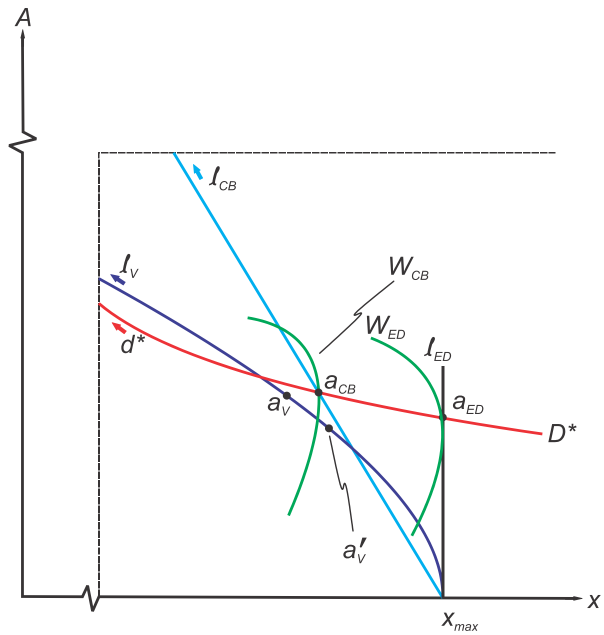

Figure 5: Desirability of a CB Policy

4 Examples

Intuitively, compared to voluntary exchange, transferring property rights by either the CB or ED policy eliminates the holdout problem but worsens the investment distortion. Whether social welfare increases or decreases under either of these policies depends on which of these effects dominate, which, in turn, depends on important model parameters values such as β, a measure of the developer's bargaining power. We construct a number of examples to illustrate these ideas. Although Proposition 6 tells us that the government should never pursue a policy of ED, we characterize the payoffs associated with this policy in our examples: The *Kelo* ruling pertains to the ED policy and, because of this, we are interested in the circumstances where a policy of ED is better than voluntary exchange.

The examples are constructed using the following functional forms and parameters. Let $f(x) = 11 \cdot \log(1+x)$, $F(A, y; P) = 23 \cdot A^{.44} y^{.36}$, $N = 30$, and $R = 1.05$. In Table 1 we report the levels of redevelopment, A, investment, x,[21] the developer's payoff, Π^d, the owner's payoff, Π^ℓ, and social welfare, W, under voluntary exchange, V, eminent domain, ED, and collective bargaining, CB, for different values of β. The socially optimal, SO, levels of investment and redevelopment are also reported in Table 1, as is the socially optimal level of welfare. We identify values for β where the holdout problem is not significant, $\beta = 0.99$, where it is significant, $\beta = 0.966$, and

[21] Economy-wide investment is simply $30x$.

where it is severe, $\beta = 0.894$.[22]

The examples, summarized in Table 1, are consistent with theory. For example, for all values of β investment under voluntary exchange is greater than the socially optimal level and redevelopment under voluntary exchange is less than the socially optimal level as theory—Proposition 3—predicts and as illustrated in Figure 2. Investment under voluntary exchange is less than that under ED—Proposition 5—as illustrated in Figure 3). Notice that redevelopment under ED exceeds that under voluntary exchange for the examples in Table 1. We tried many other parameter values, e.g., having β arbitrarily close to 1, and it was always the case that redevelopment under ED exceeded that under voluntary exchange. Finally, redevelopment (investment) under CB exceeds (is less than) that under ED—Proposition 6—as illustrated in Figure 4.

The examples also demonstrate that the notions that the holdout problem is "not significant," "significant" or "severe" has empirical content.[23] In all of the examples in Table 1—and, in fact, in all of the examples that we generated—the level of redevelopment under CB always exceeds the level of redevelopment under voluntary exchange; theory does not make a prediction regarding this relationship. When $\beta = 0.99$, the holdout problem is not significant in the sense that welfare associated with voluntary exchange exceeds welfare under CB; this situation is depicted in Figure 5 when the voluntary exchange allocation is a_V. When $\beta = 0.966$, the holdout problem is significant because welfare associated with voluntary exchange exceeds the welfare associated with ED; this situation is illustrated in Figure 5 when the voluntary exchange allocation is a'_V. Finally, when the developer's bargaining power is reduced to $\beta = 0.894$, the holdout problem is severe since ED is welfare improving compared to voluntary exchange; this is illustrated in Figure 3 when the voluntary exchange allocation is given by a'_V.

[22] It should be emphasized that the purpose of this example is to illustrate the qualitative features of various equilibrium outcomes. In particular, it demonstrates that there exist bargaining power values such that the holdout problem is not significant, i.e., social welfare is higher under voluntary exchange than under the CB policy, significant, i.e., social welfare is higher under the CB policy than voluntary exchange, and social welfare for voluntary exchange exceeds that under ED, and severe, i.e., social welfare is higher under ED than voluntary exchange. For different model parameters and functional forms, the bargaining power values that describe these hold-out problems could be quite different. To make the welfare comparisons easy, we subtract $500 + r(K_\ell + K_d)$ from the welfare numbers generated by the examples, and then multiply this difference by 1000.

[23] We say that the holdout problem is *not significant* if it is neither significant nor severe.

β		SO	V	CB	ED
0.990	x	8.67755	9.4624	9.4690	9.4762
	A	2.28702	1.9923	2.0509	2.0490
	W	1650	794	787	772
	Π^d	–	23.6118	23.8415	24.0669
	Π^ℓ	–	15.9061	15.8982	15.8902
0.966	x	8.67755	9.4357	9.4518	9.4762
	A	2.28702	1.8608	2.0555	2.0490
	W	1650	776	823	772
	Π^d	–	22.5727	23.2995	24.0669
	Π^ℓ	–	15.9401	15.9175	15.8902
0.894	x	8.67755	9.3935	9.3996	9.4762
	A	2.28702	1.51567	2.0697	2.0490
	W	1650	257	929	772
	Π^d	–	19.8826	21.6644	24.0669
	Π^ℓ	–	16.0125	15.9755	15.8902

Table 1

Notice that social welfare may either increase or decrease when moving from a voluntary exchange regime to either an ED or CB regime. In particular, both CB and ED begin to look attractive, from a welfare perspective, when the developer's bargaining power, β, becomes lower. As β falls, not surprisingly, the developer's payoff decreases and the owners' payoffs increase. The examples also inform us as to how owners and the developer fare when moving from voluntary exchange to ED or CB. It is straightforward to demonstrate that, independent of how social welfare changes, owners are always made worse off when moving from voluntary exchange to ED. To see this, note that under voluntary exchange when $\beta < 1$, it is optimal for the representative owner to invest $x_V < x_{\max}$, where x_V solves (23) and $x_{\max}$ solves $f'(x_{\max}) = R$ (which is the investment level associated with ED). The representative agent *could* invest $x_{\max}$ but chooses not to because his expected payoff is higher with an investment of x_V. *If* the representative owner did invest $x_{\max}$, then under voluntary exchange he would receive a payoff of $f(x_{\max})$ with positive probability, and a payoff of $p > f(x_{\max})$ with complementary probability, see (22). Note that under an ED regime, the representative owner receives a payoff of $f(x_{\max})$ with probability one. Hence, his ED payoff is strictly lower than what he would receive if he invested $x_{\max}$ under voluntary exchange, which implies that the representative owner is strictly worse off under an ED regime compared to voluntary exchange. If social welfare increases when moving from voluntary exchange to ED, then, clearly, the developer is made strictly better off. This situation is illustrated in Table 1 when $\beta = 0.894$. However, the examples indicate that the developer is made better off moving from voluntary exchange to ED even when welfare falls, as is the case for either $\beta = 0.990$ or $\beta = 0.966$.[24] Furthermore, the examples indicate that the payoffs to owners decrease when moving from voluntary exchange to a CB policy and decrease further when moving from a CB policy to an ED policy; the payoffs to the developer increase in these circumstances. Hence, developers "like" government policy, compared to voluntary exchange, because these policies eliminate the holdout problem, which is beneficial for developers.

In light of our results and examples, it is perhaps not that surprising that ED is widespread and popular with local governments and developers. If local governments want large scale redevelopment for their communities, then ED is a tool that can be used to increase the level of redevelopment, compared to voluntary exchange. The developers are more than happy to go along with such a scheme because, independent of whether large scale redevelopment is a good or bad idea for society as a whole, their payoffs will be higher under ED. Regarding a policy of CB, the developer prefers it to voluntary exchange, but prefers a policy of ED to that of CB.

4.1 Discussion

In defending the state's right to take property from one private agent and give it to another private agent, proponents of the *Kelo* decision—who are often local governments—point to the increased benefits associated with higher levels of redevelopment, such as more employment and higher taxes collected. Although it may be the case that the use of ED will increase the level of redevelopment—and other activities associated with it—it is not obvious that this translates into higher social welfare. For example, allocation a_{ED} in Figure 5 has a higher level of redevelopment compared to either voluntary exchange allocations a_V or a'_V, but a lower level of social welfare. (See also Table 1 for $\beta = 0.99$ and 0.966.) If local governments equate higher levels of employment and tax revenue—that usually accompany higher levels of redevelopment—with a higher level of social welfare, then allowing communities to use ED to promote redevelopment can lead to bad outcomes. For example, if local governments use their power of ED when the holdout problem is not severe, then there will be a negative impact on social welfare compared to voluntary exchange.

If government policy can improve matters, it is not obvious that using ED is the most efficient way to do it. We have shown that an alternative policy of collective bargaining dominates ED. One may argue that this dominance result depends on the precise specification of the simultaneous bargaining game. Perhaps, but the big insight is that collective bargaining, in general, does not dilute the bargaining power of the owners, as does ED. This implies that the owners' incentive to overinvest is mitigated compared to ED. And this insight is important because the benefit of both the ED and CB policies is the elimination of the holdout problem. But the cost to

[24] In an earlier version of the paper, using different functional forms, we were able to show numerically that the developer's payoff could *decrease* when moving from voluntary exchange to ED if he has "almost all" the bargaining power; otherwise, his payoff would increase.

both policies is the tendency to increase the level of overinvestment, and the incentive to overinvest is lessened under CB compared to ED.

5 Concluding Comments

A government policy that allows developers to purchase as many properties that they want for "just" compensation will promote redevelopment compared to a situation where developers obtain property rights by bargaining with owners that have an incentive to create a holdout problem.[25] However, such a policy also results in landowners further increasing their already inefficient levels of investment on their properties. From a social perspective, eminent domain is a good policy only if the former—redevelopment—effect dominates the latter—overinvestment—effect. The general *Kelo* ruling, which allows communities to transfer property rights from one private agent to another with just compensation, can be justified from a social perspective only if it is *always* the case that the holdout problem is "severe" (in the sense described in Definition 4). It is unlikely, however, that in all instances developers face severe holdout problems. The general *Kelo* ruling makes for bad public policy on two counts. First, in many applications of the Kelo ruling, social welfare will fall because the holdout problem is not severe. Second, there exist other policies, such as the collective bargaining policy outlined above, that strictly dominate eminent domain. The latter implies that eminent domain should *never* be used to transfer property rights of one private agent to another private agent. Similarly, an unconditional policy of collective bargaining is not optimal since such a policy will lower social welfare if the holdout problem is not "significant" (in the sense described in Definition 7). An optimal policy requires that the government first accesses the magnitude of the holdout problem that the developer faces and then to impose a policy of collective bargaining only if the holdout problem is significant; otherwise, the government should allow voluntary exchange to determine the level of redevelopment in its community.

[25] Although theory gives an ambigous relationship between redevelopment under ED and voluntary exchange, all of the examples we generated featured this outcome.

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7 Appendix 1: Proofs

Proposition 1 *If $S(x_n) < -x_n R$ and condition (9) holds, then voluntary exchange results in a socially efficient allocation characterized by no redevelopment and $x = x_n$; otherwise voluntary exchange is always socially inefficient.*

Proof to Proposition 1. Assume first that $S(x_n) < -x_n R$. This condition implies that it is not socially efficient to redevelop, see condition (1). If, in addition, condition (9) holds, then the owner invests x_n. Since $S(x_n) < 0$, redevelopment does not occur under voluntary exchange. In this case both the investment and redevelopment decisions are socially optimal. In all other cases, the allocation will be socially inefficient.

If condition (9) does not hold (and $S(x_n) < -x_n R$), then the owner invests x_r. But this implies that $S(x_r) > 0$ and there will be redevelopment, which is socially inefficient.

Assume now that $S(x_n) > -x_n R$, which means that it is socially efficient to redevelop. If $S(x_n) > 0$, then redevelopment occurs, which is socially efficient. However, the level of investment, x_n, is too high from a social perspective. If $S(x_n) < 0$ and condition (9) holds, then redevelopment does not occur, which is socially inefficient. If $S(x_n) < 0$ and condition (9) does not hold, then redevelopment occurs but the level of investment, x_r, is socially too high. ■

Proposition 2 *ED can improve social welfare only by preventing redevelopment when redevelopment is inefficient; otherwise, ED (weakly) decreases social welfare, compared to voluntary exchange.*

Proof. Suppose that $S(x_n) < -x_n R$, $S(x_r) > 0$ and condition (9) is not valid. Then, under voluntary exchange, redevelopment will occur, even though it is socially inefficient. Under ED, the developer pays $f(x)$ to obtain the property. In this situation, the owner, directly or indirectly, receives $f(x)$ from his property investment. Hence, he will invest x_n since $f(x_n) + (K_\ell - x_n) R > f(x) + (K_\ell - x) R$ for all $x \leq x_n$. Since $S(x_n) < 0$, the developer is not redevelop the property and the outcome is socially efficient.

Suppose now that $S(x_n) < -x_n R$ and condition (9) is valid. Under voluntary exchange the owner invests x_n and no redevelopment occurs, which is socially efficient. Under ED the owner will continue to invest x_n (independent of the developer's redevelopment decision). The developer will not redevelop since $S(x_n) < 0$; the introduction of ED has no effect on welfare in this case.

Finally, suppose that $S(x_n) > 0$; then it is always socially efficient to redevelop. Under voluntary exchange or ED, redevelopment will always occurs since $S(x_r) > S(x_n) > 0$. However, under voluntary transfer, the investor invests x_r but under ED he invests $x_n > x_r$. Compared to voluntary transfer, social welfare falls under ED because the owner invests more and the investment is destroyed, (it is socially efficient to invest zero). ■

8 Appendix 2: Derivation of $\mathbf{p_i}$

Suppose the developer wants to redevelop A tracts of land. He selects A owners and plays an A-stage bargaining game with them. At stage i of the A-stage game, the developer plays the two-stage proposal game with owner i. Suppose that owner j can observe the accepted offers of the previous $j-1$ owners. If redevelopment is to occur, the developer must reach an agreement with each of the A owners; if not, redevelopment does not occur. If redevelopment does not occur, then, at date 2 all N owners receive the payoff $f(x) + (K_\ell - x) R$ and the developer gets $K_d R$.

Consider the last owner, owner A, that the developer bargains with. Suppose that owner A rejects the developer's first-stage offer. Then with probability $1-\beta$, owner A makes the second stage take-it-or-leave-it offer. The offer will make the developer indifferent between accepting and rejecting. Hence, the offer is yR, which implies that owner A gets $F(A, y) - yR - \sum_{i=1}^{A-1} p_i$, since the developer has promised to pay the first $A-1$ owners $\sum_{i=1}^{A-1} p_i$. With probability β, the developer makes the second stage offer, and offers $f(x)$, which owner A accepts. Therefore, the equilibrium first-stage offer that the developer makes to owner A is

$$p_A = \beta f(x) + (1-\beta)\left(F(A, y) - yR - \sum_{i=1}^{A-1} p_i\right).$$

Consider now owner j and suppose that the owner rejects the developer's first-stage offer. If the developer makes the second-stage offer, he offers $f(x)$, which owner j accepts. If owner j makes the second-stage offer, he offers $yR + \sum_{i=1}^{j-1} p_i + (A-j) f(x)$, i.e., the offer compensates the developer for his redevelopment costs, yR, his promised payments to the first $j-1$ owners, $\sum_{i=1}^{j-1} p_i$, and sufficient resources to pay the remaining $A-j$ owners their reservation values, $(A-j) f(x)$. Therefore, the equilibrium first stage offer that the developer makes to owner j is

$$p_j = \beta f(x) + (1-\beta)\left(F(A, y) - yR - \sum_{i=1}^{j-1} p_i - (A-j) f(x)\right). \tag{37}$$

Using (37), the first-stage offer that the developer makes to the first owner in the bargaining queue, p_1, is

$$p_1 = \beta f(x) + (1-\beta)\left(F(A, y) - yR - (A-1) f(x)\right). \tag{38}$$

which can be rearranged to

$$p_1 = f(x) + (1-\beta) S(A, x, y), \tag{39}$$

where $S(A, x, y) = F(A, y) - yR - Af(x)$.

Again, using (37), the first-stage offer that developer makes to owner 2, p_2, is

$$p_2 = \beta f(x) + (1-\beta)(F(A,y) - yR - p_1 - (A-2) f(x)). \quad (40)$$

If (39) is substituted into (40), then p_2 can be rearranged to

$$p_2 = f(x) + (1-\beta)\beta S(A,x,y). \quad (41)$$

Continuing in this manner, a simple induction argument implies that if the developer wants to redevelop A tracts of land, then the first-stage offer that he makes to owner j, p_j, $j = 1, ..., A$, is

$$p_j = f(x) + (1-\beta)\beta^{j-1} S_A. \quad (42)$$

9 Appendix 3

Slope of developer's decision curve is negative. It must necessarily be the case that $1 + A\ln(\beta) > 0$ for all $x > 0$, which implies that (29) is negative. To see this, suppose that there exists an $x_0 > 0$ such that $1 + A_0 \ln(\beta) < 0$, where (x_0, A_0) satisfies (28), (and where y_0 is determined by (27).) Now, choose an $\tilde{A} < -1/\ln(\beta)$. From (28), there exists an $x = \tilde{x}$ that satisfies $A = \tilde{A}$. If x is reduced from $\tilde{x}$, by (29), A will increase from $\tilde{A}$. Since the developer's decision functions (27) and (28) are continuous and "well behaved" in (x, A, y) and since there exists an $x_0 > 0$ such that $1 + A_0 \ln(\beta) < 0$, A will continue to increase as x decreases until $A = \hat{A} = -1/\ln(\beta)$. Define the x associated with $\hat{A}$ as $\hat{x}$. Since (29) is negative for all $x > \hat{x}$, it must be the case that $x_0 < \hat{x}$. Now, consider increasing x from x_0. Since $A_0 > \hat{A}$ and the developer's decision functions (27) and (28) are continuous in (x, A, y), A must increase from A_0. In other words, equation (29) implies that A is an increasing function of x for all $x \in (x_0, \hat{x})$, and that $A(\hat{x} - \varepsilon) > \hat{A}$ for $\varepsilon > 0$, where ε is arbitrarily small. Hence, there is a discontinuity in (27) and (28) at $\hat{x}$, i.e., A and the corresponding y must "jump" when x is reduced slightly from $\hat{x}$. But all of the developer's decision functions (27) and (28) are continuous and well behaved in (x, A, y); a contradiction. Hence, $1 + A\ln(\beta) > 0$. Note also that the absolute value of the slope of the developer's decision locus (29) is strictly less than that of the developer's efficient decision locus (19).

Owner's decision curve is strictly convex over the economically relevant range. The derivative of (24) with respect to x is

$$\frac{d^2A}{dx^2} = \frac{f'''(x) f'(x) - 2f''(x)^2}{f'(x)^3}\left[1 - \beta^A(1 + A\ln(\beta))\right]^{-1} NR + \frac{f''(x)}{f'(x)^2}\frac{\ln(\beta)\beta^A(2 + A\ln(\beta))}{\left[1 - \beta^A(1 + A\ln(\beta))\right]^2}\frac{dA}{dx} NR. \quad (43)$$

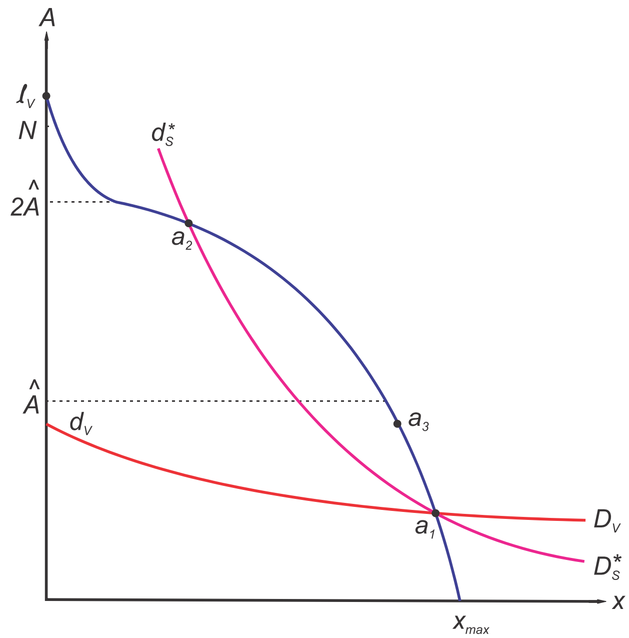

Figure 6: Voluntary Exchange Equilibrium

The first term on the right side of (43) is negative by Assumption 1; the second term is strictly negative for $A \in (0, -2/\ln(\beta))$ and strictly positive for $A > -2/\ln(\beta)$. Therefore, the owner's locus (23) is strictly concave for all $A \in (0, -2/\ln(\beta))$. Recall that the developer's decision curve is bounded from above by $-1/\ln(\beta)$; therefore, the owner's decision curve is strictly convex over the economically relevant range.

Developer's curve is not convex. The derivative of (29) with respect to x is

$$\begin{aligned}\frac{d^2A}{dx^2} = -f'(x)\left(1 + A\ln(\beta)\right)\Bigg\{\left[G_A - G_y\frac{F_{Ay}}{F_{yy}}\right]\frac{dA}{dx}/D^2 \\ -\ln(\beta)^2\left[\left[\left(F_A - f(x)\right)\right]\frac{dA}{dx} - Af'(x)\right]/D^2\Bigg\} \\ + f''(x)\left(1 + A\ln(\beta)\right)/D + f'(x)\ln(\beta)\frac{dA}{dx}/D,\end{aligned}$$

where $D = G(A, y) - \ln(\beta)^2 S(A, y, x)$. This condition cannot be signed: the last term is negative, while all the other terms are positive.

In principle, then, the owner's decision locus, (23), and the developer's decision locus, (28), may intersect more than twice.[26] We believe, however, that such an outcome is highly unlikely. If anything, we find that, unless the developer has virtually all of the bargaining power, these loci will intersect only *once*. This finding is a result of the combination that: (i) the developer's 'holdout' locus (28) lies below the

[26] Although this may happen in principle, we were unable to construct such examples.

efficient locus (13); (ii) the slope of the developer's holdout locus (29) is strictly less in absolute value than that of the efficient locus (19); and (iii) the maximum value of A that the developer chooses in the holdout environment is finite and less than $\hat{A} = -1/\ln(\beta)$. Intuitively, compared to the developer's efficient locus (13), his holdout locus (28) is, in (x, A) space, "pushed down," "flattened out" and "constrained in its height." A simple example and diagram might be helpful here. Suppose that $\beta = 0.95$ and $N = 50$. The developer's decision locus, which we denote as $d_V D_V$ in Figure 6, intersects the A axis at a value that is strictly less than $\hat{A} = 19.5$, i.e., $\hat{A} = -1/\ln(\beta)$.[27] When $\beta = 0.95$ (and assuming that $f'(0)$ is "large") the owner's decision locus, which we denote as $\ell_V x_{\max}$ in Figure 6, intersects the A axis at a value that exceeds $N = 50$. The owner's decision locus is strictly concave for all $A < 2\hat{A}$. Note that the owner's decision locus intersects the A-axis at a level that is significantly higher than where the developer's locus intersects. This is in direct contrast to the CB or ED environments, where the developer's locus tends to infinity as x tends to zero. The developer's and owner's decision loci intersect at allocation $a_1 = (x_1, A_1)$ in Figure 6. Since the absolute value of the slope of the developer's decision locus $d_V D_V$ is less than that of the efficient decision locus, for comparison purposes, we shift down the developer's efficient locus, (13), in Figure 6 until it intersects allocation a_1, and denote this locus as $d_s^* D_s^*$, ('s' for shift). In Figure 6, locus $d_s^* D_s^*$ intersects the owner's locus $\ell_V x_{\max}$ twice; at allocations a_1 and a_2. If the developer's locus $d_V D_V$ is to intersect the owner's locus at least twice, the second and subsequent intersections would have to lie north-west of allocation $a_2 = (x_2, A_2)$ (since locus $d_V D_V$ is less steep than locus $d_s^* D_s^*$). But this is not possible in Figure 6 since $A_2 > \hat{A}$. One could, however, imagine that locus $d_s^* D_s^*$ is actually much steeper than what is depicted in Figure 6 so that it intersects the owner's locus $\ell_V x_{\max}$ at, say, allocation a_3, where $A_3 < \hat{A}$. It is then possible for the developer's curve to intersect the owner's locus $\ell_V x_{\max}$ at an allocation where the number of tracts that are redeveloped is less than $\hat{A}$. For this to happen, the slope of the developer's locus would have to be only slightly less in absolute value than that of the efficient locus as x is reduced from x_1; but then the slope would have to dramatically flatten out after it intersects the owner's locus $\ell_V x_{\max}$ for a second time in order to ensure that $A < \hat{A}$ for all possible choices of x. Such a characterization, however, is not feasible. If the values of the slopes of the holdout and efficient loci are very close to one another—and, hence, as well as the loci themselves—then this implies that β is arbitrarily close to 1 and $\hat{A}$ is arbitrarily high. In this situation, the CB policy and voluntary exchange environments will deliver similar equilibrium outcomes since the holdout problem is "not that important," i.e., when β is arbitrarily close to 1, $\ln(\beta)$ is arbitrarily close to 0 and the developer's decision problem is characterized by $F_A(A, y) \approx f(x)$. In such a case, the $\ell_V x_{\max}$ and $d_V D_V$ loci in the voluntary exchange environment will intersect twice, and the lower intersection will deliver a higher level of social welfare.[28]

[27] Exactly where it intersects will depend on the model parameters.

[28] All of our numerical exercises indicate that if β is arbitrarily high, the developer's and the

So unless β is arbitrarily close to 1, the $\ell_V x_{\max}$ and $d_V D_V$ loci will only intersect once.

owner's loci will intersect only twice and that the lower intersection generates the higher level of social welfare.

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